Project Completion Report

Development of a Green Innovations Framework for the Manufacturing Sector

Implemented by
Dr. H.S. Srivatsa
Professor
Faculty of Management and Commerce
M S Ramaiah University of Applied Sciences
#470-P, Peenya Industrial Area
Peenya 4th Phase, Bangalore - 560 058

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Preface

Focus on the environment and its conservation has never been emphasized upon as much as it is being done today across the globe. Stringent norms, heavy penalties, and exhaustive awareness campaigns are being imposed and exercised by nations across the world for making their citizens conscious about the surrounding environment and the impact of their actions on its well-being. In India alone, over the last five years, the Government has been taking up wide spread initiatives for the conservation of environment; Swachh Bharat mission, plastic ban and introduction of BS-6 norms for automobiles are a notable few. Therefore, it is important that in order to sustain these initiatives, every entity across the country strive towards providing a cleaner and greener India for the future generations.

When it comes to the industries, manufacturing sector is the one that uses the maximum amount of resources in the form of raw materials, machines and energy. It is also this sector that releases the maximum amount of non-biodegradable and harmful wastes to the environment. Industries that belong to the chemical, pharmaceutical, automotive and earth-moving sectors are at the forefront when one analyses the release of harmful wastes from industries to the environment. Therefore, there is a need to curb the practices that harm the environment in these industries. Various organizations have been taking up initiatives in this direction. ISO-14000 series focuses purely on the international standards that need to be maintained for protecting the environment from the operations of industries. One of the trending areas of research pertaining to this area is green manufacturing. Green manufacturing is concerned with adopting environment friendly operations and processes for the production of goods. The purpose of this research project is to develop a green innovations framework for the manufacturing sector – specifically to those belonging to the automotive and earth-moving sector. The project was carried out during the period April 2017 – August 2019 and has been executed by collecting data of 70 companies belonging to the automotive and earth moving sector.

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Executive Summary of Project Entitled "Development of a Green Innovations Framework for Manufacturing Sector"

1. The world is moving towards greener production to achieve environmental sustainability and most of the countries have acknowledged this and taken up as their challenge to bring in better environmental sustainability.
2. In India, Manufacturing industries are among the most polluting and among them automotive and earthmoving segments offer huge scope to exhibit better environmental measures through green manufacturing techniques.
3. The earthmoving and automotive segments being one of the major contributors to Indian economy among the manufacturing segment have not been assessed or studied in terms of their green manufacturing methods.
4. Among them, there are companies that are pioneers in green manufacturing methods and they are on a journey towards green innovation by adopting incremental or greater changes to green manufacturing methods.
5. The automotive and Earthmoving sectors are influenced by best practices due to governmental regulations and competition. In and around Bengaluru, there are a number of small and medium enterprises in these two sectors along with large scale mature companies (OEMs) who are following Green manufacturing practices. This provides us an ample opportunity to compare companies who are following green manufacturing practices and those who are not following (this would include both Indian and foreign companies operating from Bengaluru and surrounding region).
6. Initial qualitative pilot studies amongst automotive and earthmoving sectors in and around Bengaluru revealed that there is a mixed group among those companies that follow green manufacturing practices. Some companies are ahead in their green manufacturing practices while some are lagging

behind. This opportunity offered a scope for an in-depth analysis of this phenomenon so that results of this study could be shared across many companies in India for a larger and broader benefit.

7. Given these, it was essential to survey and assess the current status of cooperative/ standalone framework for innovations in green manufacturing practices: Automotive and earthmovers in and around Bengaluru, to categorise companies based on innovations in green manufacturing practices and do a comparative study, to evaluate critical factors that impact practices of green innovation in automotive and earthmover sector, to develop green innovation framework for automotive and earthmovers, to recommend a phase wise roadmap for cooperative green innovations, and to Create a platform through a shared approach which can benefit larger number of stakeholders.
8. The scope of this study is confined to manufacturing companies in automotive and earthmoving in and around Bengaluru. Many of these companies are concentrated in areas of Peenya Industrial area, Bidadi Industrial area, Hoskote Industrial area and a few other areas in and around Bengaluru.
9. A total of 120 automotive parts companies and 94 earthmoving parts companies in Small and medium sector and Original Equipment Manufacturers (OEM) were identified using various sources like Peenya Industrial Association, Hosur Industrial association, OEM's listed in internet sources, Confederation of Indian Industry (CII), Indian Construction Equipment Manufacturers Association (ICEMA), Automotive Component Manufacturers Association of India (ACMA) and a few other sources, companies were identified that belonged to the targeted sampling group.
10. Out of the companies identified, a total of 90 companies (60 – automotive and 30 – earthmoving) were contacted and out of which, 70 companies agreed to provide data and provided the data. The data was collected from 44 automotive companies and 26 Earthmoving companies. Companies included suppliers of parts and OEM. Companies included suppliers of parts and OEM. Of the 70 companies, 16 of them were large companies, and they had to be studied as they were perceived to be advanced in quality systems. The other 54 companies belonged to Small and Medium sector.

11. The respondents for questionnaire were leaders/ plant heads/ managers in production and were the ones who led green manufacturing or who were well aware of green manufacturing practises in their companies.
12. Standalone Frameworks as per this research is described as a quality framework being adopted in a company but not through a cooperative platform (by collaborating with peer group). They could be ISO certifications, TS and others.
13. Out of total 70 companies surveyed, 69 companies (98 %) had standalone frameworks. Out of which 43 were automotive companies and 26 were Earthmoving suppliers. One company did not have any standalone framework. This meant that 97.7% of automotive companies surveyed and 100 % of Earthmoving companies surveyed followed quality standards.
14. The descriptive analysis indicated, of the companies that exhibited standalone framework (total = 69) , 75.36 % of the companies were more than 10 years, 50.72 % were having a turnover of more than INR 700 lakhs and 43.47 % were having an employee strength of more than 200. This meant that among the companies that followed Standalone framework, there were more companies that were older, having a higher sales turnover and higher workforce.
15. Cooperative Framework was tested based on response to the following questions: a) how often the companies participated on a cooperative platform to exchange green manufacturing ideas with other manufacturing units? b) their opinion on - if companies should share their green manufacturing knowledge with others?
16. Of the 70 companies surveyed, there are more number of companies that participate on cooperative framework (34.28 %) than those that do not participate (28.5%). Most companies (90 %) believed that companies should share green manufacturing knowledge with others. Companies that were more than 16 years in existence exhibited a positive response to frequent participation in cooperative frameworks and they constituted 27.1 %. Companies that had employees of more than 150 exhibited a positive

response to frequent participation on cooperative platforms and they constituted 24.28 %. Companies that have a turnover of more than INR 700 Lakhs exhibit a positive response to frequent participation on cooperative platforms and they constituted 22.85 %.

17. The 16 large companies had the following characteristics – 13 companies were more than 20 years old, one company was between 16 and 20 years, one was between 11 and 15 years and one was between 6 to 10 years. All the 16 companies had an employee strength of above 200 employees. 13 companies had a turnover of more than INR 1000 lakhs, one had a turnover between INR 700 and 1000 lakhs, one had a turnover between INR 300 and 700 lakhs, and one had a turnover between INR 100 and 300 lakhs.
18. Companies were categorized based on summated score of the scaled variables used that indicated their value on the proposed green innovation index. The process of categorization was achieved by adding all the scores obtained by respective samples across their scaled questions that measured their journey from green awareness towards Green Innovation.
19. The variables considered for categorization were selected based on feedbacks taken from industry experts and academic experts. These variables essentially measured the awareness about green innovations, budgets allocated for green manufacturing policy, extent of design towards green aspects, usage of renewable energy for manufacturing processes, extent of reuse, recycle, support to / from stakeholders for recycling, recovery management, proportion of green value chain (raw materials to shipping of finished goods), energy audits, budgets for green manufacturing, alignment of strategy for green manufacturing, participation on green platforms and knowledge sharing.
20. The minimum score achieved by a company was 112 and maximum score was 217. The minimum score indicated that company had the lowest value of green innovation index and maximum score indicated the highest value of green innovation index. This range provided a continuum of scores achieved by companies on the proposed Green innovation index. The median value of 168 was taken as the mid-

point for categorising the companies into two groups. Hence Companies that scored more than 168 were categorized as those that were more innovative in green manufacturing and was grouped under '1' (also called 'Leaders') for the purpose of this research. Companies that scored equal to and less than 168 were grouped under '2' (called 'followers') for the purpose of this research.

21. The key variables that differentiated the 'leaders' from 'followers' are - Recycling policy to take back products from customers, Encouragement to suppliers to use recycled materials, Support to Suppliers in Green Initiatives, Alignment of Strategies towards Green Initiatives, Extent of Economic advantage due to green manufacturing practices.
22. This meant that the leaders in green manufacturing emphasized more on recycling aspects, encouraged their suppliers in green initiatives, aligned their business strategies towards green initiatives, and derived economic advantage through their green initiatives.
23. This also pointed to the fact that if companies have to successfully move towards green manufacturing innovation, they have to align their strategy towards green manufacturing and support their stakeholders like suppliers to a greater extent.
24. Eleven Important factors explained the phenomenon of green manufacturing innovations and they are - Green Value Chain, Recyclability, Green design, Recovery Management, Cost and resource assessment, Green Stakeholder support, Strategic Alignment towards Green manufacturing, Green Commitment of Employees, Refurbishment, Re-use and 3R implementation.
25. The factors directly point towards importance of economic gains to be acquired by adopting green manufacturing practices followed by factors that require alignment of systems, strategy and people with green manufacturing practice. Hence while propagating green manufacturing across the community of manufacturers, it is necessary that they be made aware of economic gains and then how to align systems, strategy and people with green manufacturing.

26. Linear regression brought out the relative importance of factors. Calculated Green Index value was considered as the dependent variable and the factors scores were considered as independent variables. Factors in order of importance are - Recyclability, Recovery Management, Green Stakeholder support, Green Commitment of Employees, Green Value Chain, Cost and Resource measurement, Green Design, Strategic alignment towards green manufacturing, Reuse and 3R implementation.
27. This study has made an important contribution to research in terms of identifying the important factors that explain the green manufacturing innovations among the Automotive and Earthmoving sector and proposing a framework based on these factors.
28. Considering the factors identified, the green Innovations framework has been proposed using three stages – Green Commitment, Green Systems and Green culture and excellence.
29. Green commitment: In this stage, importance is given to creation of awareness of advantages of green manufacturing and seeking commitment of stakeholders towards creation of green manufacturing policy.
30. Green Systems and Practices: This stage involved establishment of Practices, tools and techniques for green manufacturing. A well-defined system that focuses on green manufacturing system will have measurement system (KPIs), tools and techniques, standards and reporting mechanism.
31. Green Culture and Excellence: Green culture emphasizes on green practices as a part of organisational culture. Green excellence is a journey towards becoming best in class and guide to others towards a sustainable business enterprise both economically and ecologically.
32. In order to implement the green innovations framework, the proposed roadmap was discussed with manufacturing units and has the following stages of journey: Green Commitment, Green Practices, Green systems, Green culture and Green Innovation.

33. Our University – M S Ramaiah University of Applied Sciences actively supports research and has established various research centres. Among them is Innovation and entrepreneurship research centre. Under this centre, we propose to establish a centre for excellence in Green Innovations.
34. The aim of the proposed Centre is to provide a strategic inputs to conduct and disseminate research in Green manufacturing and Green Business. It is expected that the proposed research centre will create a viable platform to showcase M S Ramaiah Group's research contribution towards its Mission of becoming an entity of International Stature and Global Relevance.
35. This centre will bring all stakeholders across all categories of green innovation maturity to participate in knowledge sharing workshops and will involve in dissemination of research. It plans to bring in global experts from industry and academia, to share the platform with Indian experts and novices in Green manufacturing and services and foster green innovation and sharing of green manufacturing ideas in the process.
36. Policy recommendations have been arrived at: to identify the companies that are willing to participate on cooperative platforms for knowledge sharing. Based on green manufacturing framework developed, a phase wise road map can be developed for such companies that are willing to embark on journey of green innovations with support coming from various stakeholders like leading companies in green manufacturing, green manufacturing experts and researchers, industry bodies and the Government. Our University will be able to host a research centre to facilitate the same

Chapter 1 Introduction

'Go Green' is one of the most happening trends in today's world. Large hoardings of saving planet earth and conservation of environment are a common sight across metropolitan cities in India. There are many NGOs and public organizations working towards conservation of the environment and Mother Nature.

In the manufacturing sector, a number of companies is working towards embracing environmental friendly practices in order to gain a distinctive advantage in the market. Especially in the automobile sector, it can be observed that there is cut-throat competition in providing environment friendly products. For example, Honda have introduced Honda Eco-Technology (HET) for all their two wheelers which facilitates high fuel efficiency and hence lesser pollution. Similarly, Hero has launched Splendor-iSmart which comes with a feature of the engine getting automatically switched off when the bike is stationary. Thus environment friendly practices are gaining momentum in the manufacturing sector and sooner or later all manufacturing industries will be having 'Go Green' as one of their business objectives. This initiative is termed as 'Green Manufacturing'.

1.1. Green Manufacturing

Green Manufacturing is defined as a system that integrates product and process design issues with issues of manufacturing planning and control in such a manner to identify, quantify, assess, and manage the flow of environmental waste with the goal of minimizing the environmental impact while trying to maximize resource use efficiency (Kannan Govindan et.al, 2015). Green manufacturing is a philosophy to optimize natural resource usage and minimize waste and pollution in operating process. It is a business strategy that focuses on profitability through saving manufacturing cost by adopting eco-efficient and eco- friendly operating processes (see Figure 1.1).

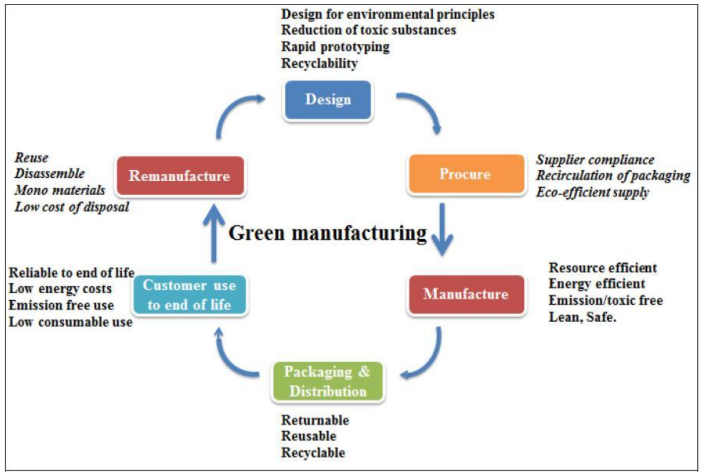

Figure 1.1: Model of Green manufacturing **Source: Frost & Sullivan, 2009**

Green Manufacturing (GM) is a term used to describe manufacturing practices that do not harm the environment during any stage of manufacturing process. Green manufacturing addresses a number of key manufacturing issues covered under 7R's - Reduce, Reuse, and Recycle, Remanufacturing, Redesign, Recover, and Refuse. Green manufacturing involves transformation of industrial operations in three ways: (1) Using Green energy, (2) Developing and selling Green products and (3) Employing Green processes in business operations.

In order to embrace green manufacturing, it is necessary that the companies move away from traditional manufacturing processes and move towards lean manufacturing. Lean manufacturing is a culture that considers the utilization of resources for any purpose that does not add value to the company's bottom-line as waste. When resources are utilized only for adding value to the organization, it results in the release of lesser number of carbon footprints and hence leads to promoting green manufacturing (Pampanelli et.al, 2014). Therefore, lean practices drive green manufacturing. Hence, companies should aim at going lean and develop innovative products and processes with a focus on green manufacturing. In this report, the innovations with a focus on green manufacturing are referred to as green innovations.

1.2. Green Manufacturing Model

Green manufacturing is an endless pursuit towards sustainable manufacturing along with business results. Green manufacturing starts with green awareness, green systems and practices, green culture and green excellence. The green manufacturing reference model is proposed as seen in Figure 1.2

Green Awareness	Green Systems	Green Culture	Green excellence

Figure 1.2 Green Manufacturing Model

1. Green Awareness: Importance of green manufacturing
2. Green Systems: Practices, tools and techniques for green manufacturing
3. Green Culture: Behaviour towards green manufacturing
4. Green Excellence: Benefits and levers for green manufacturing

1.2.1. Green Awareness

Green manufacturing practices offer not only environmental advantages but makes the company operations more lean. Reduced - energy consumption, raw materials and resources are great promoters to implement a green manufacturing system.

1.2.2. Green Systems and Practices

A well-defined system that focuses on green manufacturing system will have measurement system (KPIs), tools and techniques, standards and reporting mechanism.

1.2.3. Green Culture

Green culture emphasizes on green practices that are followed without system level monitoring and appraisal in the company.

1.2.4. Green Excellence

Green excellence is a journey towards becoming best in class and guides others towards a sustainable business enterprise both economically and ecologically.

Manufacturing companies in India are at various stages along the green manufacturing model as depicted in figure 2. Some of the Original Equipment Manufacturers are evolved in terms of their green manufacturing practices and are also innovating in terms of their green manufacturing practices. This can be attributed to availability of resources, access to expertise in this area and the positive attitude towards green manufacturing. On the other end of the spectrum are the manufacturing companies which have not even adopted green manufacturing due to various constraints. This observation can be made in the context of Manufacturing SME sector in India.

1.3. Green Innovations

Defining green innovation is not an easy task although several attempts have been made in the literature (Carrillo-Hermosilla et al., 2010). Klemmer et al. (1999) determined the environmental innovations as a subset of innovations that lead to an improvement of ecological equality. Green innovation is defined as a software or hardware innovation that is related to green products and processes including the innovation in technologies that are involved in energy-saving, pollution-prevention, waste recycling, green product designs (Chen et al. 2006,). According to Halila and Rundquist (2011), the term, eco-innovation (environmental innovation, green innovation or sustainable innovation), is often used to identify those innovations that contribute to a sustainable environment through ecological improvements.

Green manufacturing innovations can be described as a process of making changes, large or small, radical or incremental to products, processes and services that result in the introduction of something new for the organization that adds value to customers and contributes to the knowledge store of the organization. Value for the customer is being created by providing the customer with environmental friendly products and services. Value for the company is being created by improvement in processes, design, energy consumption etc. which can result in cost savings, regulatory compliance and sustainability. This new knowledge that is being created acts a platform for further innovations.

1.4. Manufacturing SME and Green manufacturing

According to a classification provided by SME chamber of India[1], the manufacturing SMEs are classified based on investment in plant and machinery. The small enterprises have an investment of INR 25 lakhs and above and up to INR 5 Crores. The medium Enterprises have an investment above INR 5 Crores and upto INR 10 Crores. This is the Government of India definition, and you cannot quote it as if it is a Chamber definition. As SMEs form the chunk of India's industrial sector and Micro, Small and Medium Enterprises (MSMEs) together contribute more than 40% of India's manufacturing output[2], it is necessary that they are provided with sufficient support and encouragement from the government to develop green innovations. It is important that the SMEs are made aware of the direct as well as the indirect benefits of green innovations. The SMEs can develop green manufacturing solutions which will not only benefit the environment and the society, but will also serve the monetary objectives of the organization. But again, where does the manufacturing SMEs stand along the green manufacturing model? If they are following Green manufacturing practices, are they following

[1] https://www.smechamberofindia.com/about-msme-in-india.php
[2] http://www.iamwire.com/2017/09/importance-of-msme-sector-in-india/166912

any framework for practices, why are they practising? what are the benefits they are able to derive by practising? The purpose of this research proposal is to develop a robust framework for commercializing green innovations in two of the Indian manufacturing sectors: automotive and earthmoving.

1.5 Gaps from Literature Survey

The following gaps have been identified from the surveyed literature:

- Literature reviewed does not reveal much on environment management practices adopted by companies especially by Small and Medium enterprises in the manufacturing sector
- Literature review revealed that factors responsible for green manufacturing have been studied. But these studies have not focussed on specific sectors in the manufacturing segment. Each sector of manufacturing requires a different approach as their characteristics are different, for example, Chemical industries are different from automotive as their processes are very different in terms of inputs, throughputs and outputs. Hence review of literature indicated the scope for development of sector specific frameworks for green innovations.

1.6 Sectors for the research work

Two sectors were identified for carrying out the study – Automotive sector, Earthmover manufacturers (both assemblers and component manufacturers). The automotive sector is influenced by best practices due to governmental regulations and competition. In and around Bengaluru, there are a number of small and medium enterprises in these two sectors along with large scale mature companies (OEMs) who are following Green manufacturing practices. This provided us an ample opportunity to compare companies who are following green manufacturing practices and those who are not following (this would include both Indian and foreign companies operating from Bengaluru and surrounding region).

1.7 Objectives of the research project

1. To survey and assess the current status of cooperative/ standalone framework for innovations in green manufacturing practices: Automotive and earthmovers, in and around Bengaluru
2. To categorise companies based on innovations in green manufacturing practices and do a comparative study
3. To evaluate critical factors that impact practices of green innovation in automotive and earthmover sectors
4. To develop green innovation framework for automotive and earthmovers
5. To recommend a phase-wise roadmap for cooperative green innovations and deduce Key Performance Indices (KPIs) for appraisal and sustenance
6. To Create a Landing platform through a shared approach (public-private partnership) which can benefit a larger number of stakeholders

1.8 Limitations of research project

The area in and around Bengaluru (Bangalore) is known for established manufacturing hubs and prominent among them are – Peenya Industrial area, Hosur Industrial area, Bidadi Industrial area and Hoskote Industrial area. Many of the internationally and nationally well-known automobile manufacturers and Earthmoving Equipment manufacturers are located in and around Bengaluru. Prominent among them are TVS Motors, Toyota Kirloskar Motors (TKM), Volvo Earth Equipment, L and T Earth Equipment, Bharath Earthmovers Limited etc. To supply parts to the OEM and also the aftermarket, there exist a good number of ancillary units that are located in these industrial areas and otherwise. Hence, the scope of this study is confined to automotive and Earthmoving equipment manufacturers and suppliers manufacturing in and around Bengaluru.

Many of these companies are concentrated in areas of Peenya Industrial area (PIA), Bidadi Industrial area and Hoskote Industrial area and a few elsewhere. A total of 120 automotive parts companies and 94 earthmoving parts companies were identified using various sources – Peenya Industrial Association, Hosur Industrial association, Automotive Component Manufacturers Association of India (ACMA) and sources from the Internet.

Chapter 2 Review of Literature

2.1. Introduction

A review of literature related to innovations in green manufacturing practices and implementation approaches were studied. In this literature it is evident that green manufacturing practices not only provide environmental advantages but also reduces the cost and makes the organizations to lead their stakeholders towards innovation in green manufacturing. The following literature review brings out recent developments in green innovation and manufacturing practices:

Dief (2011) has stated that green manufacturing paradigm is an outcome of market and technological drivers. Higher global awareness of environmental risks due to new green movement has resulted in new customer requirements across the globe. The author has explored three main factors as the drivers for implementing green manufacturing practices viz. (1) increased efficiency: consume fewer resources and produce equal or better results, (2) greater market share: provide opportunity to increase local and global market share, (3) Government support and regulations: enforcement of severe regulations and penalties for violation of pollution norms has forced many enterprises to embrace green manufacturing.

With these drivers in mind, the author has developed a system model for implementation of green manufacturing practices for a painting line. The model mainly included four steps viz. (1) Assessment of current condition: capturing the utilization of different additives of paints, (2) Preparation of the brush: reducing the consumption of resources and energy from the current level, (3) Painting it green: Identifying the scope for improvement in the resources being used and carry out kaizen activities, and (4) Keeping it green: Sustaining the model by providing the necessary and required training to employees along with strict monitoring of the as is condition. Even though this framework was developed only for a paint line, it provides a stepping stone for adopting the green manufacturing model by specifically addressing the end application.

This paper has provided an initial framework for green manufacturing that can be used as a part of the proposed research where green innovation is the major area of focus, to prepare the roadmap.

Tsai et al. (2013) has developed a unique framework that integrates Activity Based Costing, Theory of Constraints (TOC) and Mixed Integer Programming model, for a mixed production model using green manufacturing techniques. This framework for the mixed production model was developed by the following sequence of steps:

(a) Activity Based Costing (ABC) was used and cost of each component of every activity was calculated which helped in the prioritization of activities.

(b) TOC was used to identify the bottleneck, so that the operation which needed to be focused on, was prioritized without affecting the throughput of the line.

(c) Mixed Integer Programming (MIP) was used to sequence the jobs in such a way that the final output of the line remains unaffected.

In order to incorporate the principles of green manufacturing in the model, a few characteristics were built into the model viz. Environmental regulatory costs and Volatile Organic Compounds (VOC) emission quantity and cost, facility level activity cost and consideration of capacity expansions for direct labor and machine hours. This model will select a product mix with a higher level of pollution with the only objective of maximizing the profit of a product mix based on the most constrained resources. Although the model does not explicitly select an optimal product mix that emits fewer VOC emissions, we can use the related constraints to restrain VOC emission quantity within certain limits. Thus, the products which cause greater harm to the environment can be segregated from the lesser harmful products. Therefore, this model not only supports eco-friendly manufacturing, but also helps in optimizing the manufacturing cost.

This business model is unique in such a way that it not only helps the organization to work towards environment friendly practices, but also ensures that the commercial interests of the organization are not compromised.

Singh et al. (2013) have proposed a framework for determining the major factors that have an influence on following environmental management practices in Indian firms. The study focused on distinct aspects related to firms' characteristics, Environmental Management Practices and relationship with diverse stakeholders, environmental issues and polices. The questionnaire survey was carried out across 1225 industries which included SMEs as well as large enterprises from different sectors. Out of these, only 104 enterprises completed the questionnaire which meant that the response rate was a meagre 8.5%.

The response data were compiled and analyzed with respect to the statistical significance, distributions which the data follow, mean, median and standard deviation. The analysis revealed that larger firms adopt more comprehensive Environment Management Practices as compared to SMEs. However, the difficulties faced by SMEs to implement environment management practices could have been studied in detail. The findings also indicate that the newer firms are more orientated to adopt proactive environmental activities compared to older firms. The incorporation of sectored variables showed that relative to service sector, firms in agriculture, chemical and manufacturing sectors are more likely to adopt comprehensive proactive Environment Management Practices. A regression model revealed that internal pressure from 'Holdership' and 'Employee' and market pressures from 'Business Chain' have significant positive effects on the proactive environmental behaviour of the firms. Thus the pressures from regulatory and societal stakeholders, household consumers were found to be statistically insignificant and do not explain the proactive environmental behaviour of Indian firms. This paper has provided guidelines on the factors which have to be considered while preparing a green innovation roadmap in SMEs. The paper has revealed that if systematic procedures are followed, SMEs can also adopt environment management practices as systematically as large enterprises.

Kesting and Jensen (2015) have emphasized on the significance of incorporating innovation as a key ingredient in the business model of an organization. It is the innovations which play a critical role in increasing the utility level of the resources and pave the way for the development of an organization and towards this end, a framework incorporating innovations as a part of the business model is developed. The five strategies that are discussed in the framework are (1) uncovering additional functions of the product, (2) identifying strategic benefits for third parties, (3) taking advantage of economies of scope, (4) utilizing cross-selling opportunities, and (5) involving users and the crowd. These five strategies, in turn, lead to a systematic development of a new product or service.

The author explains the effect of innovation on the two primary dimensions of any business model – revenue and costs. The revenue dimension does not prioritize increasing the sales revenue by selling more products of the existing business. It rather focuses on identifying and realizing new revenue streams beyond the existing business domain. Similarly cost dimension does not imply cost cutting from the existing business. It means entering new activities that induce stakeholders to either take over costs directly or take over efforts that reduce the costs of the main business - sentence is not clear.

Thus, the five strategies along with a focus on the two dimensions viz. revenue and costs, would ensure the development of new products and lead a company to release innovative products into the market. Further, by following this framework, a company can successfully achieve its innovation objectives. This paper has provided an insight into the framework that focuses on including innovations as a part of the company's business model. If the effect of this framework on the environment is analysed and the necessary precautions are taken, it would provide suitable guidelines for green innovations in companies.

Chen et al. (2012) have carried out a study on exploring two types of innovations – Proactive and Reactive green innovations. The authors emphasize that irrespective of the type of green innovation, correlation between innovation and competitiveness is always positive. The authors divide the factors that have an effect on green innovations into internal and external factors. Internal factors are environmental leadership, environmental culture and environmental capability. The external factors are environmental regulations and environmentalism of investors and clients. As per the findings of the research, reactive green innovations occur because of both internal and external factors while proactive green innovations occur because of only the internal factors. The researchers add that an organization should focus on investing more effort and resources towards strengthening the internal factors rather than investing on the external factors.

This paper has provided information on the classification of green innovations and the critical success factors for each type of green innovations. It has also helped in the understanding of the importance of proactive green innovations and the way it can be enhanced in an organization.

Nulkar (2014) has carried out a study on the environmental friendly practices being followed by Indian SMEs., The author argued that most of the SMEs adopt a reactive approach for green manufacturing which focuses on compliance rather than on sustenance. The manufacturing SMEs play a major role in the Indian economy with a contribution of 8% to the nation’s GDP, 45% to the manufactured output and 40% of the exports. Hence any improvement in terms of green manufacturing practices in SMEs will play a major role in bringing down the organization costs and improving the profitability which will have a direct impact on the nation’s economy. The author states that SMEs focus on lesser utilization of resources and reduction of wastes only when they visualize short term benefits. If there are no temptations of short term benefits, the SMEs would not resort to investing on green manufacturing practices. Therefore, the author has provided a strategic management approach which the SMEs need to adopt for implementing green manufacturing practices in their organizations. The approach begins with the formulation of mission, vision and goals which are a must for any initiative. Once the organization is done with the first step, a situation analysis needs to be carried out which includes the analysis of internal factors as well as the external factors. After analysis of the factors, the strategic factors for the organization have to be identified and the appropriate strategies have to be formulated. Based on the formulated strategy, the green manufacturing practices have to be implemented. Finally, after implementation, evaluation scheme and controls have to be developed for the implemented practices and regular monitoring of the same have to be done.

This paper has provided an approach for implementing green manufacturing practices. The major learning from this paper is that the notion that SMEs cannot afford to focus on green manufacturing practices has been proved wrong.

Paul et al. (2014) stressed that green manufacturing is an essential part of the business strategy as it not only focuses on environment friendly manufacturing practices, but also helps in cost reduction and optimized utilization of resources. The authors emphasize that all the functions of an organization right from design till dispatch have to focus on green manufacturing practices, energy conservation and development of products that consume lesser amount of energy. The authors further stated that manufacturing organizations should focus on the 3Rs – Reduce, Reuse and Recycle and opt for products with shorter life cycles with an efficient design. It has been highlighted that supply chain function of an organization can also play a vital role in ensuring the reduction in carbon footprint of an organization.

This paper has helped in learning the fact that green manufacturing need a holistic approach and all functions have to work together in unison to make the green initiatives of an organization a success.

Mittal and Sangwan (2014) have carried out a study on the identification of the barriers for green manufacturing. The authors highlighted that the so called motivational factors for industries to take up green manufacturing, like increased pollution rate, depletion of natural resources and increased global warming, are actually the factors that are hindering (or acting as barricades for) the implementation of green manufacturing practices. In order to mitigate these barricades, it is important to analyze each of these hindrance factors and prioritize them based on the impact they have on hampering green manufacturing initiatives in an organization.

A multi-criteria decision model called TOPSIS has been developed using fuzzy logic to prioritize the barriers based on environmental, social and economic perspective. The results that were obtained from this prioritization was that lack of awareness/knowledge, technological risk and weak legislation are the most important barriers for green initiatives in an organization.

This paper has helped in understanding the major barriers for green initiatives in a manufacturing organization and based on these factors, precautionary measures will be taken while developing the framework for green innovations.

2.2. Green Efforts by Government of Karnataka

The Industrial policy (2014-19) of Government of Karnataka focuses on promoting industries to adopt a sustainable green industrial growth strategy in order to protect the natural resources of Karnataka state. The various divisions of State government like Karnataka State Pollution Control Board (KSPCB), Department of Industries and commerce (DIC), etc. have been instructed to take part in this initiative and educate and train the MSMEs on the significance and benefits of embracing green culture. Department of Industries & Commerce (DI&C) intended to initiate a study to develop a strategic framework for the state to identify and prioritize specific interventions required to make green industrial growth sustainable.

A benchmarking study was also to be carried out to map the water consumption pattern, energy consumption pattern, solid waste management practices, discharge practices, etc. of major KIADB industrial areas in the state with international standards and best practices. All new industries will be strictly instructed to comply with these standards to avail incentives under the industrial policy, and existing units will be encouraged to adhere to the new guidelines with special benefits under CSR programs. Department of Industries along with KIADB had also planned to initiate a program for greening of minimum existing industrial areas per annum across the State. Under this scheme, a funding of INR 15 crores was earmarked every year to study the status and implementations of various initiatives. Adequate land was to be compulsorily earmarked in all new industrial areas / estates for setting up Common Effluent Treatment Plant (CETP) and other common environment protection measures. Recycling of electronic waste and setting up of e-waste recycling units will be encouraged and incentivized. Green and non-polluting industries would be given preference over polluting and environmentally unsafe industries in allocation of land in KIADB industrial areas and for allocation of government land.

This information has clearly shown the major initiatives that have been taken up by the Karnataka Government to support green manufacturing and this will provide a guideline in this research work to map the support needed from the government in order to prepare the roadmap.

The following gaps were identified in the surveyed literature:

- Literature reviewed did not reveal much on environment management practices adopted by companies especially by Small and Medium enterprises in the manufacturing sector
- Literature review revealed that factors responsible for green manufacturing have been studied. But these studies have not focussed on specific sectors in the manufacturing segment. Each sector of manufacturing requires a different approach as their characteristics are different. E.g.: Chemical industries are different from automotive as their processes are very different in terms of inputs, throughputs and outputs. Hence review of literature indicated the scope for development of sector specific frameworks for green innovations.

2.3. Sectors chosen for the research work

Two sectors were identified for carrying out the study – Automotive sector, Earthmover manufacturers (both assemblers and component manufacturers). The automotive sector is influenced by best practices due to governmental regulations and competition. In and around Bengaluru, there are a number of small and medium enterprises in these two sectors along with large scale mature companies (OEMs) who are following Green manufacturing practices. This provides us an ample opportunity to compare companies who are following green manufacturing practices and those who are not following (this would include both Indian and foreign companies operating from Bengaluru and surrounding region).

2.4. Selection of manufacturing sectors

To get both financial and environmental advantages, companies have been bringing in the sustainability thinking into their business strategy, operational excellence framework and across the value chain of supplier networks. Green products, green processes and use of green energy becomes vital for companies that are into mass production and particularly companies in automotive and earthmoving sectors. Manufacturing sector is one of the top three contributors for GHG emission after transportation and power sectors, according to Bhattacharya (2011) (Figure 2.1) also, manufacturing sector comprises a variety of sub sectors like primary, secondary and tertiary manufacturing. Under the tertiary manufacturing category there are sub categories like automotive and earthmover. There is a good mix of multinationals, national and regional manufacturing companies that are operating in automotive and earthmovers having both R&D and production facilities across Bangalore. Against this background, a well-defined study will give an opportunity for both academics and industries to learn and cross learn from the best in the class and adopt world class green thinking/practices.

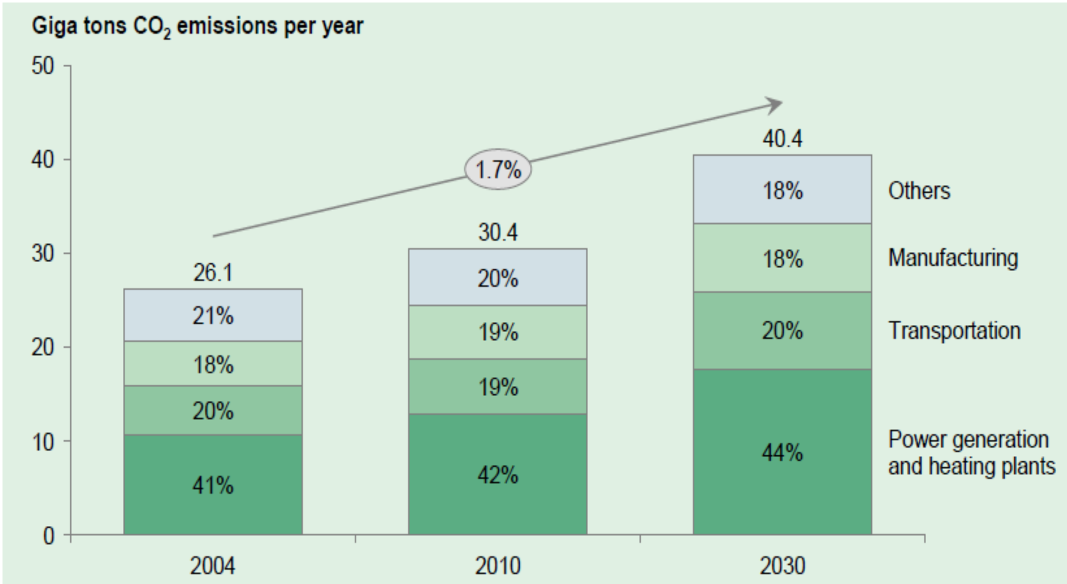

Figure 2.1: Three largest sources of CO2 emissions (International Energy Agency)

Chapter 3 Methodology

To achieve the following objectives as described in table 3.1 , the following methods were used: a) data collection using a well-designed questionnaire, b) analysis of data using descriptive statistics, multivariate methods like discriminant analysis, testing group differences using 't' tests, exploring underlying relationships between variables using Exploratory Factor Analysis, Multiple Linear Regression to identify important factors and c) proposing a green innovations framework and a road map based on interpretation of data analysis.

Table 3.1: Objectives and Methodology

Objectives	Methodology
1. To survey and assess the current status of cooperative/ standalone framework for innovations in green manufacturing practices: Automotive and earthmovers in and around Bengaluru	Collection of primary/ secondary data using interviews/ Focus Group Discussions and questionnaires. Analysing the data using Descriptive statistics to assess the current status of cooperative/ standalone framework
2. To categorise companies based on innovations in green manufacturing practices and do a comparative study	The summated scores of companies on green innovation questions in the designed questionnaire are categorised into two groups and the two groups are compared using 't' tests
3. To evaluate critical factors that impact practices of green innovation in automotive and earthmover sector	Exploratory factor Analysis was conducted to discover the critical factors. Linear regression was conducted to evaluate the important factors

4. To develop green innovation framework for automotive and earthmovers	Based on Factors discovered in factor analysis, develop a green innovation framework
5. To recommend a phase-wise roadmap for cooperative green innovations and deduce Key Performance Indices (KPIs) for appraisal and sustenance	Based on analysis and Discussions with experts and practitioners, a phase-wise roadmap to be developed.
6. To Create a Landing platform through a shared approach (public-private partnership) which can benefit a larger number of stakeholders	To propose a University based research platform to foster advances in green manufacturing and sharing of knowledge with stakeholders for larger benefits

3.1 Design of Questionnaire

Before the questionnaire was designed, qualitative pilot studies were conducted in the following companies to get a better understanding of green manufacturing and how they were being implemented in some of the companies belonging to the sectors being studied.

3.1.1 M/s. Toyota Kirloskar Motors, Bengaluru:

M/s. Toyota Kirloskar Motors (TKM), a Japanese based firm, is one of the leading automobile companies, manufacturing different variants of cars ranging from small hatchback cars to luxurious SUVs and XUVs. Located in Bengaluru city, the company emphasized on continuous improvements and innovations. The observations recorded at TKM are:

- The company had established an Environmental Management System (EMS) at all its affiliates, which helped the company to be eco-friendly and reduced the environmental impact of the organization to the maximum possible extent. The EMS policy is based on three main pillars –
- Ensuring compliance & No complaints
- Minimizing Environmental risk
- Achieving best Environmental performance
- The company carried out various eco-friendly activities like ‘Hasiru Santhe’ (read as Green Fair) – An exhibition of eco-friendly products – and ‘Krishi Mela’ (read as Agriculture Fair) – A farmer development festival – to spread environmental awareness among its employees
- TKM also have a Bio-gasifier plant set up to convert food waste generated at the canteen to biogas, through Bio-methanization process
- The company has set Kaizen targets to its employees with respect to initiatives on reduction of carbon gases from its operations
- The company has built a solar sludge drying facility for hazardous waste sludge, which helps in reduction of carbon gases and reduces waste disposal cost.

TKM has a program called ‘Green Mobility Solutions’ which provides well-defined guidelines to customers and end-users on the usage of its products in an environmentally friendly and sustainable way.

3.1.2 M/s. Man and Hummel Filter Private Limited, Bengaluru:

M/s. Man and Hummel Filter Private Limited is an international leader in filtration technology (for the transport sector). It is based in Germany and operates from close to 60 locations across the world. In Karnataka, it has a manufacturing facility located in Tumkur district and the R&D centre is located in Bengaluru district. Some of the observations recorded in this company are:

- Customers drive green innovation
- Green innovation influenced by regulatory bodies of the country and state
- Emphasis on usage of testing equipment that consume less power
- Continuous focus on lesser energy consumption
- Products designed in such a way so as to control pollution
- The company follows REACH policy (Registration, Evaluation, Authorization and Restriction of Chemicals)
- The company emphasizes on reusability and recyclability
- ‘No Lift day’ is followed in the company on every Thursday to reduce the consumption of electricity
- Reduced usage of papers and carrying out document verification online
- Strive continuously towards achieving an equilateral ‘Green Triangle ‘which comprises the country, company and customers as its three points.

3.1.3 M/s. Searock Precision Products Pvt Ltd, Bengaluru

Searock Precision Products Pvt Ltd is a precision industry located in Kumbalgodu Industrial Estate, Bengaluru. The opinions of the director of operations at Searock are as follows:

- The Government should provide tax benefits for incorporating green manufacturing practices in Industries
- Some of the green practices that can be followed are reducing the size of raw materials, reducing the consumption of coolant, reducing power consumption, go for recycling as much as possible, recycling of packing material etc.
- The usage of machines such that for the type of job being manufactured optimum amount of power is utilized

- End customers should also encourage the suppliers by providing incentives for eco-friendly manufacturing
- Lack of adequate waste disposal facilities lead to unhygienic and unsystematic practices of waste disposal

3.1.4 TVS Motors – Hosur Industrial Area, Tamilnadu

TVS Motors followed a very comprehensive green manufacturing methods spread across different areas.

- The company had well laid out policies and methods to cover various principles of A) Reduce B) Recycle C) Reuse D) Refurbish E) Redesign F) Recover G) Refuse.
- Regular training programmes are organised for employees to create an awareness and sharing of knowledge in green manufacturing methods
- The company had implemented energy saving measures in manufacturing
- It had initiated the process of recovery and reuse of powder coated painting raw material
- Robotisation of manufacturing process had been implemented to reduce the defects rising out of manufacturing processes
- The company had redesigned several products to ensure reduction in costs and energy and had collaborated with vendors on various green manufacturing aspects.
- It had initiated measures to save and nurture natural resources of water and air through various measures like automatic underground water pump switching 'on' and 'off' to reduce? appropriate use of water and electricity, air quality measurement and improvement systems, lush green environment to maintain air quality, development of bio diversity park where the waste water is treated and used and this has attracted birds of various kinds to nest in the tress of the bio diversity park.

Based on Literature review and discussion with experts in green manufacturing during the pilot study visits, the design of questionnaire was envisaged to contain the following sections:

a. **Company Characteristics:** Age, Automotive/ earthmoving, Type of ownership, Turnover, Number of employees, Implementation of quality standard, Green Initiatives in company.
b. **Awareness on Green Manufacturing Innovations:**
    - How can green manufacturing help the company?
    - Factors influencing green manufacturing practices in the organisation
    - 3R awareness
    - Level of awareness of green innovations in the company
    - For what reasons was green manufacturing policy adopted in the company
c. **Green Manufacturing Practice and Systems** – This section covered how companies are practising green manufacturing through the 6R's - Reduce, Reuse, Recycle, Redesign, Recover, and Refuse
d. **Green Manufacturing Culture**: This section covers who drives green manufacturing in the company, involvement of top, middle and entry level workforce in green initiatives, support extended to stakeholders – suppliers, customers, peer groups etc., approach towards green manufacturing - proactive and reactive modes
e. **Green excellence** : This section covers the importance of resource costs in manufacturing, importance of budget in green manufacturing, alignment of green manufacturing with company's strategy, roadmap availability for green manufacturing, how green manufacturing has been beneficial in the company's value chain, importance of employee assessment based on involvement in green ideas and initiatives, extent of participation on green cooperative platforms, intention to share green manufacturing knowledge with others.

3.2 Sampling Design

The study was planned to cover the SMEs (Small and Medium Enterprises) and OEMs (Original Equipment Manufacturers) covering Automotive and Earth Movers in and around Bengaluru, Karnataka. Sample size of 60 was agreed upon with NSTMIS- DST as a deliverable. Many of these companies are concentrated in areas of Peenya Industrial Area (PIA), Bidadi Industrial area and Hoskote Industrial area and a few elsewhere. Exact population of such companies were not easily determinable from the available data sources but they were substantial in number to merit the required sample size.

3.2.1 Sources of Data:

A total of 120 automotive parts companies and 94 earthmoving parts companies were identified using various sources I.e. databases of – Peenya Industrial Association, Hosur Industrial association, OEM's listed in internet sources, Confederation of Indian Industry (*CII*), Indian Construction Equipment Manufacturers Association (ICEMA) and Automotive Component Manufacturers Association of India (ACMA).

3.2.2 Sampling Method:

Based on the company's willingness to provide data through initial telephonic contacts, companies were selected for the administration of questionnaire. We contacted OEMs who also referred us to their vendors and in turn, these vendors referred us to other companies in their sector. Hence there was an element of snow balling method of sampling. Apart from snow balling method, identifying such companies in the data base and checking more details on the internet about these companies also helped us identify such companies. Hence, Convenience method of sampling was the chief method used. The representativeness of the sample was attempted to be maintained by selecting the companies across the automotive and earthmoving sectors, across different industrial regions in and around Bengaluru, and by including companies of different sales turnover (which was evident in the data collected).

A total of 90 companies (60 – automotive and 30 – earthmoving) were contacted successfully and out of which, 70 companies provided data. The response rate has been 77.7 %.

The 70 companies consisted of 44 automotive companies and 26 Earthmoving equipment manufacturing companies. The respondents were leaders/ plant heads/ managers in production and who led green manufacturing or who were well aware of green manufacturing practises in their companies. We also collected data from 10 more companies than what was agreed upon in the project proposal.

Of the 70 companies, 16 companies were large companies and 54 companies belonged to Small and Medium sector. 16 large companies were chosen and among them are the leaders in quality and green manufacturing. Of the 16 large companies, 10 belonged to automotive sector and 6 belonged to earthmoving sector.

The questionnaire was used as an instrument to collect data. The data was input into SPSS version 23 (Statistical package for Social sciences) for conducting statistical analysis. Reliability of questionnaire was measured through Cronbach's alpha post data collection and was found to be 0.923 which is considered a good value and signifies high reliability of scaled items in the questionnaire.

Chapter 4 Detailed Analysis of Data

This chapter deals with analysis of the collected data. After the data collection activity was completed both descriptive and inferential statistical analysis was carried using SPSS licensed software. Result are reported objective wise so that inferences can be collated later in the coming chapters.

Objective 1

To survey and assess the current status of cooperative / standalone framework for innovations in green manufacturing practices: Automotive and earthmovers in and around Bengaluru.

4.1.1. Standalone Framework: ISO/TS/ Any others

Standalone Frameworks as per this research is described as a quality framework being adopted in a company but not through a cooperative platform (by collaborating with peer group). They could be ISO certifications, TS and others. Table 4.1 along with fig 4.1 provides the data on distribution of companies who have standalone frameworks (either ISO/TS/ Any others). The relative proportion of Automotive components are more in number than Earthmoving components companies and this has been the trend considering the number of automobile manufacturers to Earthmoving equipment manufactures and their suppliers that have been surveyed in Bengaluru. Considering the Quality standards expected that are required in both the sectors, it was expected that most of the companies would be having a Quality Standard implemented in their manufacturing and Operations. The surveyed data also confirms the same I.e. out of 70 companies surveyed, 68 have ISO standards and 1 company has TS and one (1) company is not having an implemented standard. The data are provided in Table 4.1

Table 4-1: Data on Distribution of companies following Standalone frameworks

Companies	ISO	TS	Others	No	Total
Total (70)	68	1		1	70
Automobile (44)	43			1	44
Earth Moving (26)	25		1		26

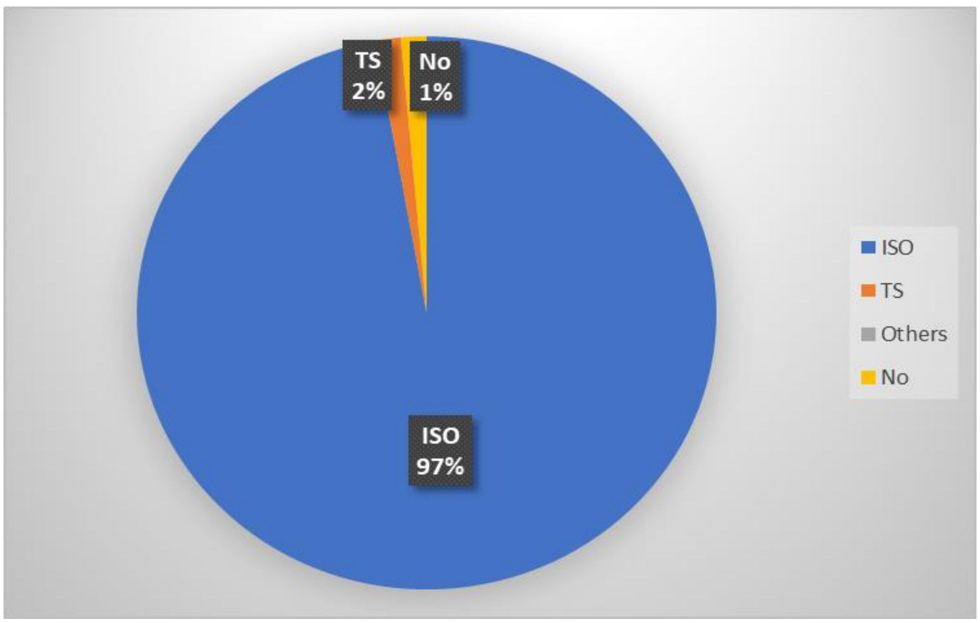

Figure 4.1 Distribution of companies following Standalone frameworks

4.1.2. Nature of Companies that exhibit Standalone Framework

It was expected that as companies progress in years, they become mature in terms of the manufacturing operations. In order to sustain their business over years, they have to remain competitive and in order to remain competitive; they are expected to follow quality standards to provide high quality parts to OEMs. Hence based on this premise, it can be argued that companies become mature in manufacturing operations over years.

It can be observed in table 4.2 and figure 4.2 that most of the companies that have standalone framework (quality standards) are more than 20 years old. 8 of them are between 16 and 20 years and 12 of them are between 11 and 15 years. Amongst the companies surveyed, the total number of companies that are more than 10 years and having standalone framework are 52 when compared to those that are less than 11 years which are 17 in number. Among the 70 companies, all the 16 large companies chosen have standalone frameworks. One company was not having any implemented standard. From Table 4-3 and Figure 4.3, it was observed that there are more number of partnership firms than single owner firms

Table 4.2: Age of companies that exhibit Standalone framework

SL No	**Age of Company (Years)**	**Number of Companies**
a	1-5	9
b	6-10	8
c	11-15	12
d	16-20	8
e	>20	32
Total		**69**

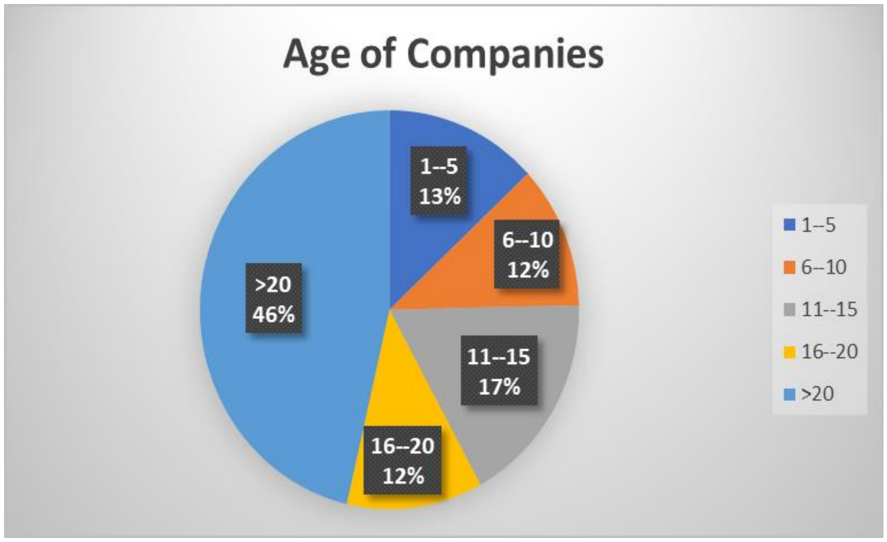

Figure 4.2 Age of companies that exhibit Standalone framework

Table 4.3-Ownership Description of Companies

SL No	Ownership pattern	Number of Companies
a	Single Owner	23
b	Partnership Firm	46

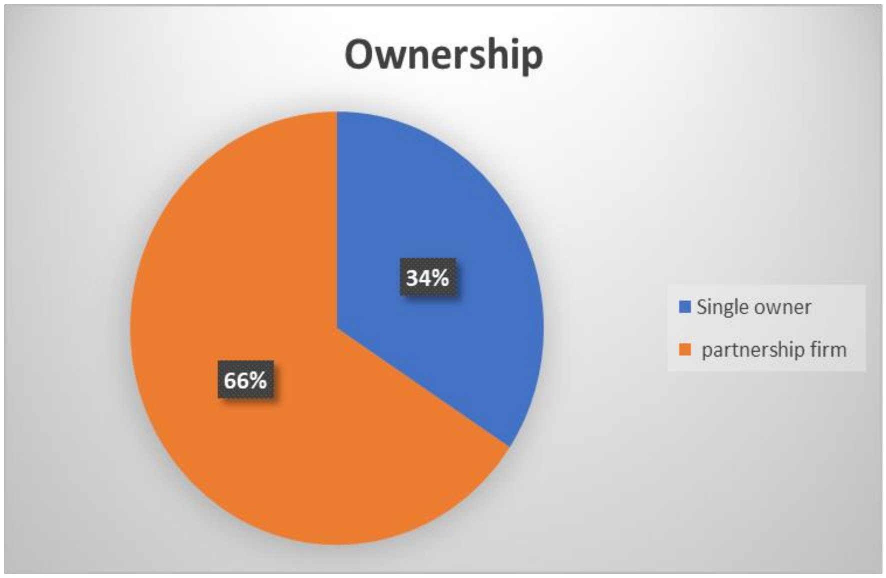

Figure 4.3 Ownership Description of Companies

Table 4.4: Employee Strength

SL No	Employee Strength	Number of companies
a	Less than 50	19
b	Between 50-100	10
c	Between 100 -150	8
d	Between 150 - 200	2
e	Above 200	30

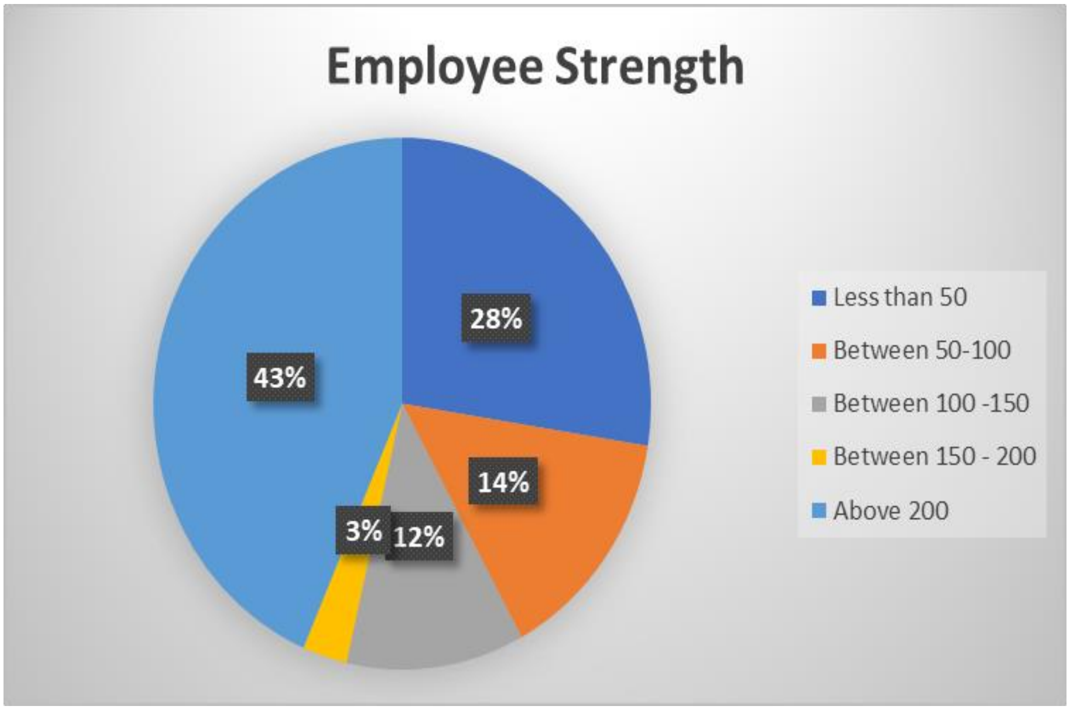

Figure 4.4 Employee Strength

Table 4.5: Turnover in Lakhs of Rupees

SL No	Turnover (Lakhs of Rupees)	Number of Companies
a	Up to 100 lakhs	16
b	100-300 lakhs	10
c	300-700 lakhs	8
d	700-1000 lakhs	4
e	More than 1000 lakhs	31

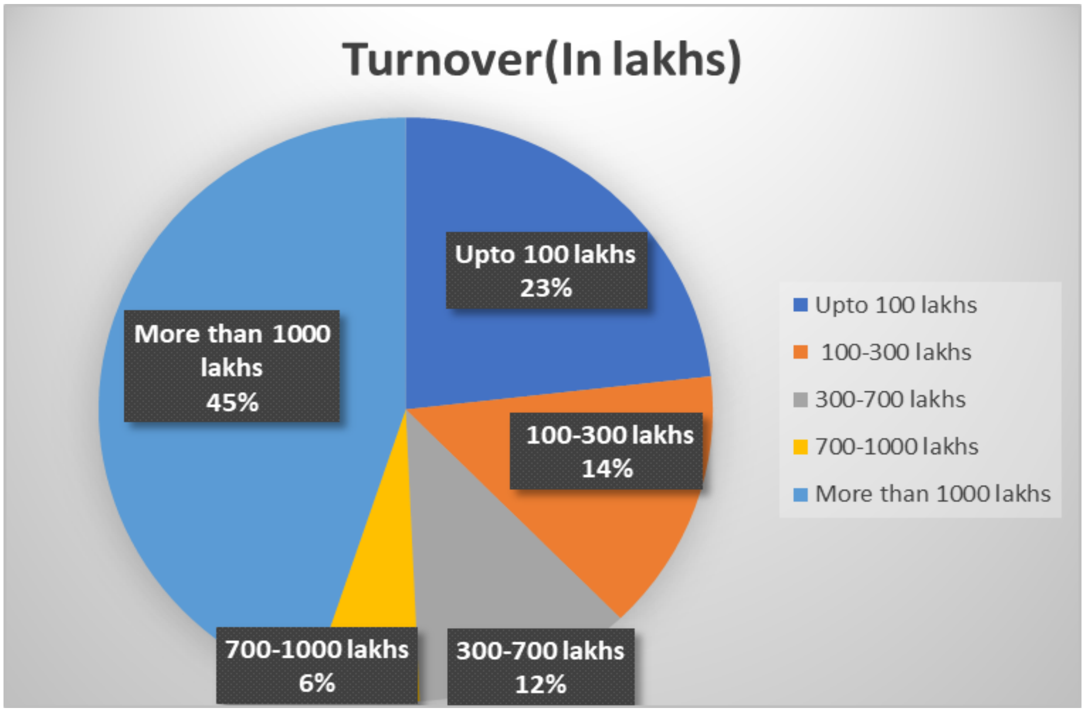

Figure 4.5 Turnover in Lakhs of Rupees

It was assumed that companies that have adopted quality standards also do well in terms of sales turnover and have higher employee strength. This could be due to the fact that better quality could translate into higher sales and higher sales sustainability could translate into greater human resources requirements to operate more products and production lines, an exclusive quality department to oversee implementation of quality standards and higher sales force to market more and different number of products. The data from table 4.4 and figure 4.4 pointed in the same lines as our assumption regarding employee strength.

It can be observed from table 4-5 and figure 4.5, most of the companies that have standalone frameworks are more than 20 years old, partnership companies, with an employee strength of more than 200 and turnover of more than 1000 Lakh Rupees. This is followed by companies that are between 11 and 15 years, partnership firms, employee strength of less than 50 and turnover of up to 100 lakh per annum.

Characteristics of the 16 large companies chosen: 13 companies were more than 20 years old, one company was between 16 and 20 years, one was between 11 and 15 years and one was between 6 to 10 years. All the 16 companies had an employee strength of above 200 employees. 13 companies had a turnover of more than INR 1000 lakh, one had a turnover between INR 700 and 1000 lakh, one had a turnover between INR 300 and 700 lakh, and one had a turnover between INR 100 and 300 lakh.

4.1.3. Cooperative Framework

Cooperative Framework was tested based on response to the following questions:

a) How often do you participate on a cooperative platform to exchange green manufacturing ideas with other manufacturing units?

b) The companies should share their green manufacturing knowledge with others?

It was perceived that participation on cooperative platforms was only restricted to their collaboration with their suppliers and not with their peer groups for sharing of ideas due to the spirit of competition. However, for gaining a better understanding in green manufacturing, companies preferred that they receive green knowledge on cooperative platforms and expected others to share their green manufacturing knowledge with one another. Table 4.6 provides distribution of companies that have responded to how often they participate on cooperative platforms to share their green manufacturing knowledge. Figure xxx provides the percentages of companies participating in cooperative platforms.

Table 4-6: Frequency distribution of companies based on how often they participate on Cooperative platforms

Response	Number of Companies
Never	3
Rarely	17
Sometimes	26
Often	17
Almost Always	7
Total	70

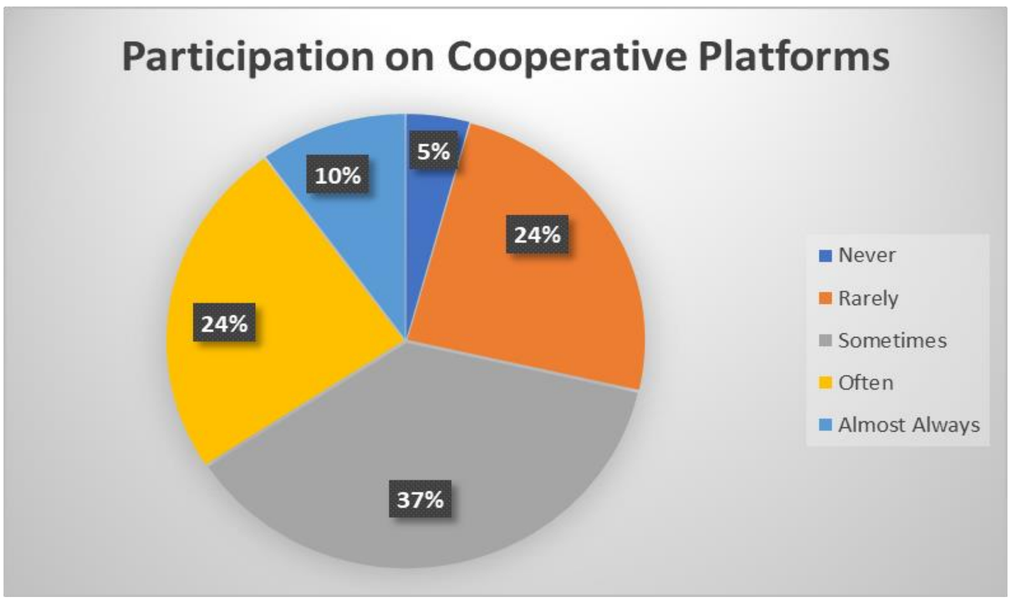

Figure 4.6 How often they participate on Cooperative platforms

It can be observed from Table 4.7 that 17 companies often participate on cooperative platform to share green manufacturing ideas and 7 companies almost always participate. In total, 24 companies out of 70 companies often participate on cooperative platforms. That works to 34.3 %.

Characteristics of three companies that never have participated in cooperative platforms:

Two companies are more than 20 years of age, one is between 11 and 15 years. One company has an employee strength of less than 50, one has an employee strength between 50 and 100 and one between 110 – 150. One company has a turnover between 300 – 700 Lakh, another has a turnover between 300- 700 lakh and two companies have a turnover of more than 1000 lakh each.

Table 4.7: Attitude towards sharing green manufacturing knowledge with others

Response	Number of Companies
Strongly Agree	34
Agree	29
Neither Agree Nor Disagree	5
Strongly disagree	2
Total	70

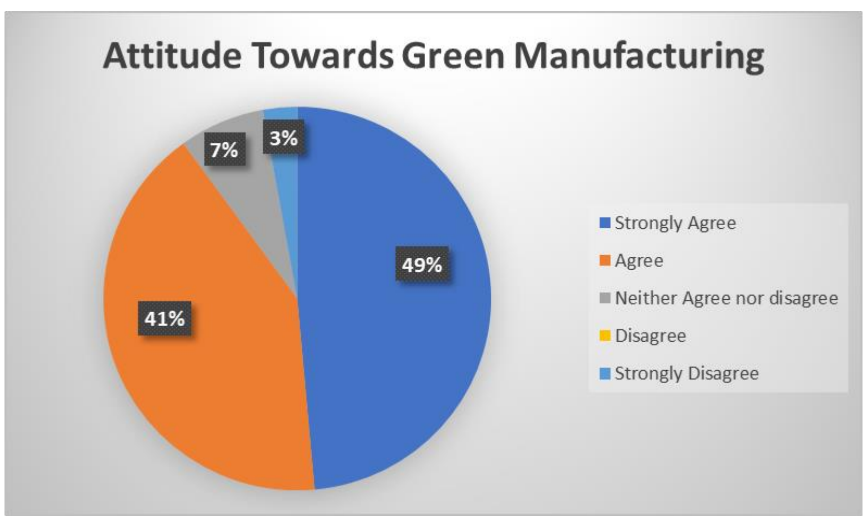

Figure 4.7 Attitude towards sharing green manufacturing knowledge with others

It can be observed from table 4.8 that most of the companies (90 %) believe that companies should share their green manufacturing knowledge with others.

The data from tables 4.7 and 4.8 point in the direction that many companies do not participate frequently on cooperative green platforms but would like green manufacturing knowledge to be shared. It is possible that they may want to share with others and they want other leaders to share the green manufacturing knowledge with them and this has not been tested here.

On cooperative framework, the data were further subdivided into Automotive and earthmoving companies and cross tab descriptive statistics of companies with respect to response to how often do you participate is provided in table 4.9

Table 4.8: Attitude towards sharing green manufacturing knowledge with others

Cross Tab Descriptive of Automotive and earthmoving Companies			
Response	**How frequently do companies participate on**		**Total**
	Earthmoving	**Automotive**	
Never	2	1	3
Rarely	11	6	17
	18	8	26
Sometimes	7	10	17
Often	5	2	7
Total	**43**	**27**	**70**

Table 4.9: Cross Tab Descriptive: Age of companies and responses to frequent participation on cooperative platforms

Response to frequent participation on cooperative platforms	Age of Companies					Total
	Up to 5 Years	2- 6 Years	11- 15 years	16- 20 years	> 20 years	
Never	0	0	1	0	2	3
Rarely	3	3	4	2	5	17
Sometimes	5	5	3	2	11	26
Often	1	0	3	3	10	17
	0	0	1	1	5	7
Total	**9**	**8**	**12**	**8**	**33**	**70**

It can be observed from the table 4.10 that there are 19 companies which exhibited positive response (responses recorded as ‘often’ and ‘almost always’) are more than 16 years in existence. Whereas there are 9 companies that are more than 16 years that have responded with negative response (responses recorded as ‘Never’ and ‘Rarely’). Companies that have exhibited positive response and are more than 16 years are 19 in number and the number of companies that have shown positive response but less than 16 years are 4 in number. Hence this points to certain important facts: 1). More companies that are greater than 16 years in existence exhibit positive response to participation in cooperative frameworks than companies that are less than 16 years. 2) There are more companies that exhibit a positive response (24 in number) than those that exhibit a negative response (20 in number).

Table 4.10: Cross tab Descriptive of Employee numbers and responses to frequent participation on cooperative platforms

Employee numbers and Responses to frequent participation on cooperative platforms	Employee Strength (numbers)					Total
	< 50	50-100	100-150	150-200	>200	
Never	1	1	1	0	0	3
	7	3	2	0	5	17
Rarely	10	5	1	0	10	26
Sometimes						
Often	2	1	3	1	10	17
	0	0	1	1	5	7
Total	20	10	8	2	30	70

We can observe that 17 companies who participate in cooperative platforms have an employee strength of more than 150. 5 companies who never or rarely participate in cooperative platforms have employee numbers of more than 150. 17 companies that exhibit positive response have an employee strength of more than 150 whereas 7 companies that show positive response have an employee strength of less than 150. It could mean that companies with more number of employees are more likely to participate on cooperative platforms see table 4.11

Table 4 .11: Cross tab descriptive of Company Turnover (lakhs INR) and responses to frequent participation on cooperative platforms

Company Turnover (lakhs INR) and responses to frequent participation on cooperative platforms	Turnover (Lakhs of Rupees)					Total
	Up to 100	100- 300	>300- 700	>700 – 1000	>1000	
Never	0	0	1	0	2	3
Rarely	4	3	3	0	7	17
	10	5	1	1	9	26
Sometimes	3	1	2	3	8	17
Often	0	1	1	0	5	7
Total	**17**	**10**	**8**	**4**	**31**	**70**

Of the companies that exhibit positive response (responses recorded as 'Often' and 'Almost always'), it can be observed that companies with turnover of more than 700 lakh I, e 700 – 1000 lakh and > 1000 lakh are 24 in number and those that exhibit negative response (Responses recorded as ' Never' and 'Rarely') are 20. Of the total companies that exhibit positive response, there are more companies (16 companies) who have a turnover of more than Rs 700 lakh (700- 1000 and > 1000 lakh) than the companies with turnover < 700 lakh (8 companies). These indicate that companies with a higher turnover exhibit a positive response to participation on cooperative platforms see fig 4.12

Table 4.12 Cross Tab Descriptive of companies that have ISO/ TS certification and their responses to 1.

(1- Yes, 2- No, 3-In Progress, 4 – Others)

Companies having ISO/TS/Others	Yes	No	Others	Total
Never	3	0	0	3
	17	0	0	17
Rarely	25	1	0	26
Sometimes	17	0	0	17
Often	6	0	1	7
Total	**68**	**1**	**1**	**70**

It can be observed from table 13 that 23 companies having ISO / TS /Others exhibited a positive response to participation on cooperative platforms whereas 20 companies show negative response to participation on cooperative platforms.

4.1.4. Summary of results of Objective 1 - Descriptive statistics

Standalone Frameworks:

1. Maximum number of companies have standalone framework for green manufacturing and this was expected as companies have to cater to minimum quality standards to be competitive suppliers.
2. Most number of companies surveyed (52 in number) exhibit standalone framework of quality standards.

3. Companies that have adopted quality standards also have higher sales turnover and have higher employee strength.

Cooperative Frameworks

Of the companies surveyed, there are more number of companies that participate on cooperative framework (24) than those that do not participate (20).

1. Most companies (63) believe that companies should share green manufacturing knowledge with others.
2. Companies that more than 16 years in existence exhibit a positive response to frequent participation in cooperative frameworks.
3. Companies that have employees more than 150 exhibit a positive response to frequent participation on cooperative platforms.
4. Companies that have a turnover of more than INR 700 Lakh exhibit a positive response to frequent participation on cooperative platforms.

From the above observations it can be summarised that as companies progress in years, those having a higher sales turnover and those having a higher number of employees exhibit a greater tendency to participate in standalone and cooperative frameworks of green manufacturing.

4.1.5. The Descriptive Statistics for automotive and earthmoving sector

The Descriptive Statistics has also been provided separately for automotive and earthmoving sectors.

4.1.6. Automotive Sector

Table 4.13: Data on Distribution of companies following Standalone frameworks

Companies	ISO	TS	Others	No	Total
Automobile (44)	43	1	-		44

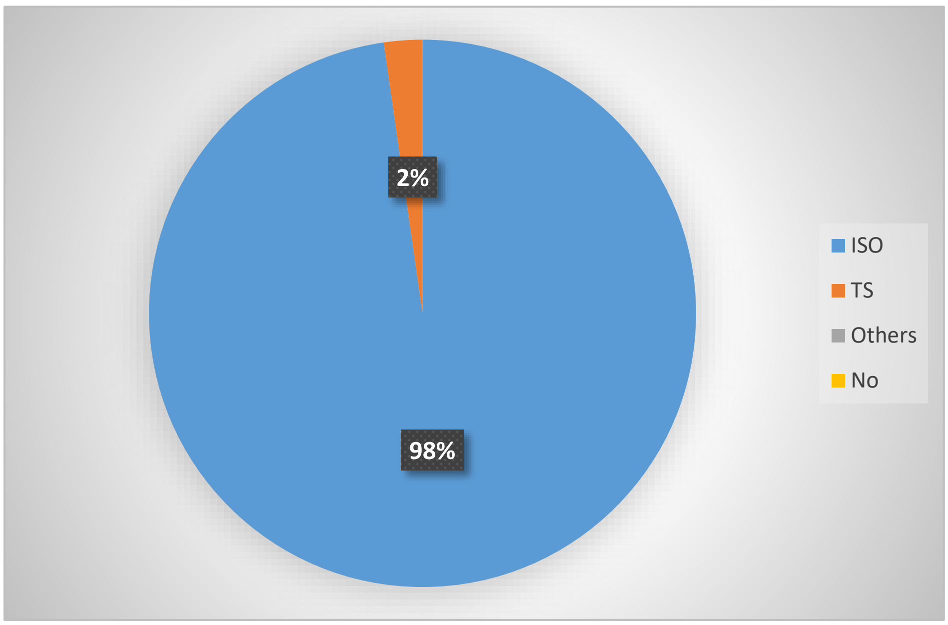

Figure 4.8 Distribution of companies following Standalone frameworks

Nature of Automotive Companies that Exhibit standalone framework

Table 4.14: Age of companies that exhibit Standalone framework

SL No	Age of Company (Years)	Number of Companies
a	0-5	7
b	6-10	5
c	11-15	8
d	16-20	4
e	>20	20

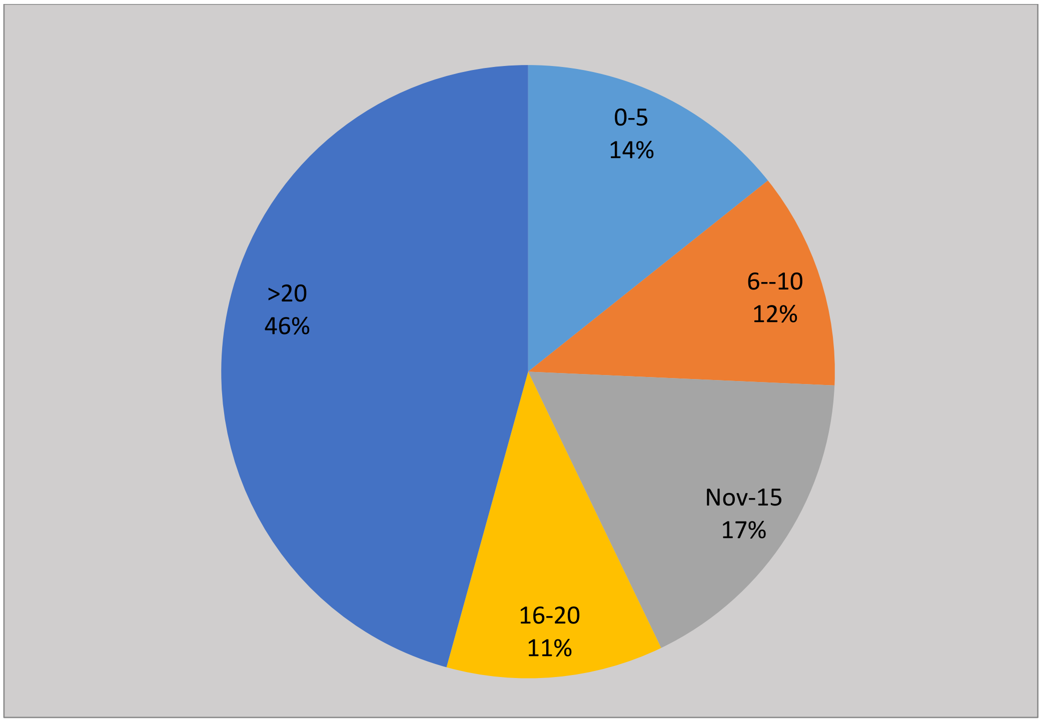

Figure 4.9 Age of companies that exhibit Standalone framework

Table 4.15: Ownership Pattern of Companies

SL No	Ownership Pattern	Number of companies
a	Single owner	18
b	partnership firm	26

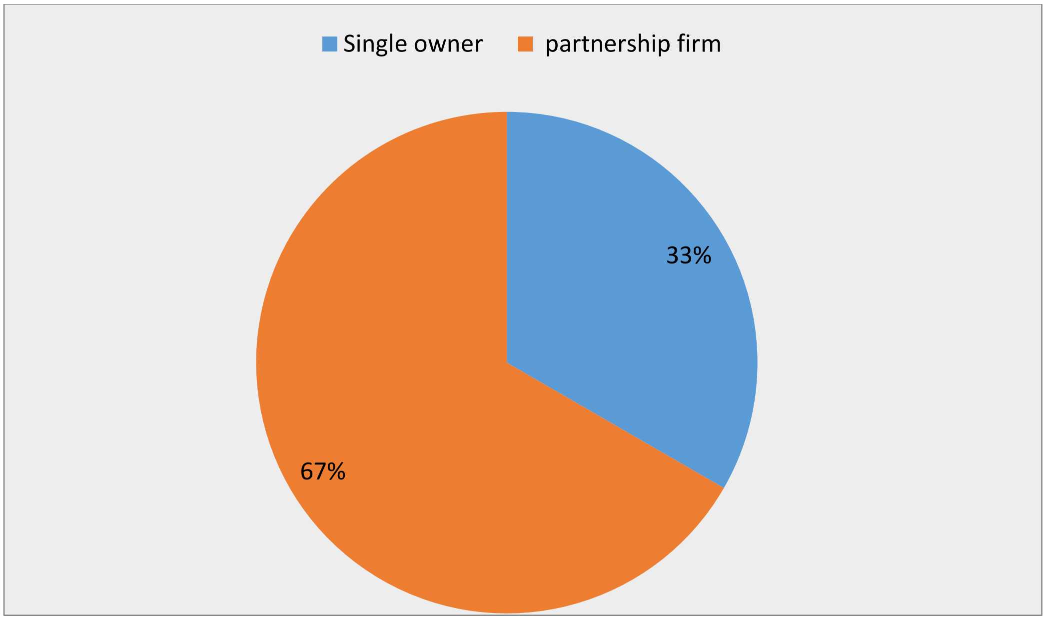

Figure 4.10 Ownership Pattern of Companies

Table 4.16: Employee Strength

SL No	Employee Strength	Number of companies
a	Less than 50	15
b	Between 50-100	6
c	Between 100 -150	5
d	Between 150 - 200	1
e	Above 200	17

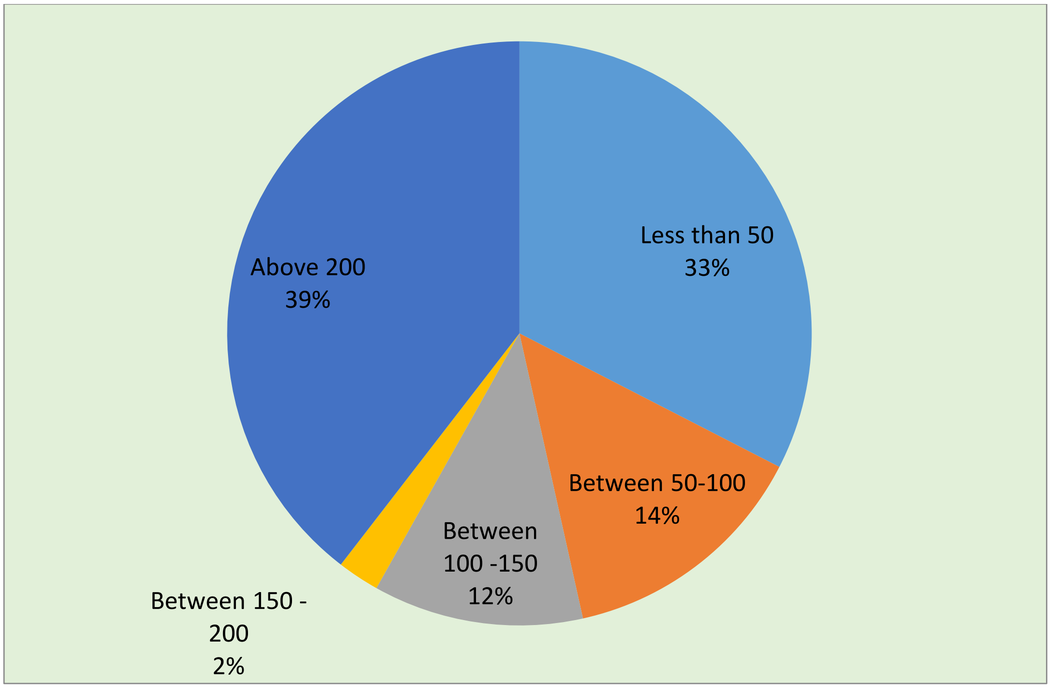

Figure 4.11 Employee Strength

Table 4.17: Turnover in Lakhs of Rupees

Sl No	Turnover (Lakhs of Rupees)	Number of Companies
A	Upto 100 lakhs	13
B	100-300 lakhs	7
C	300-700 lakhs	5
D	700-1000 lakhs	1
E	More than 1000 lakhs	18

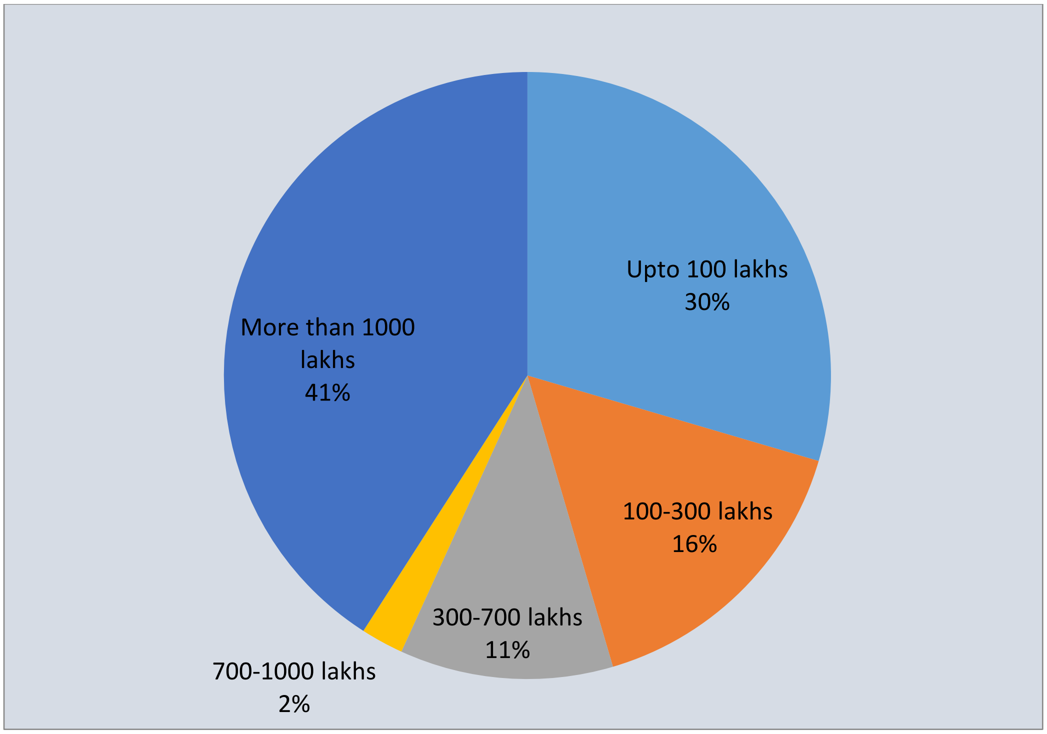

Figure 4.12 Turnover in Lakhs of Rupees

Table 4.18: Frequency distribution of companies based on how often they participate on cooperative platforms

Response	Number of Companies
Never	2
Rarely	12
Sometimes	18
Often	7
Almost Always	5
Total	44

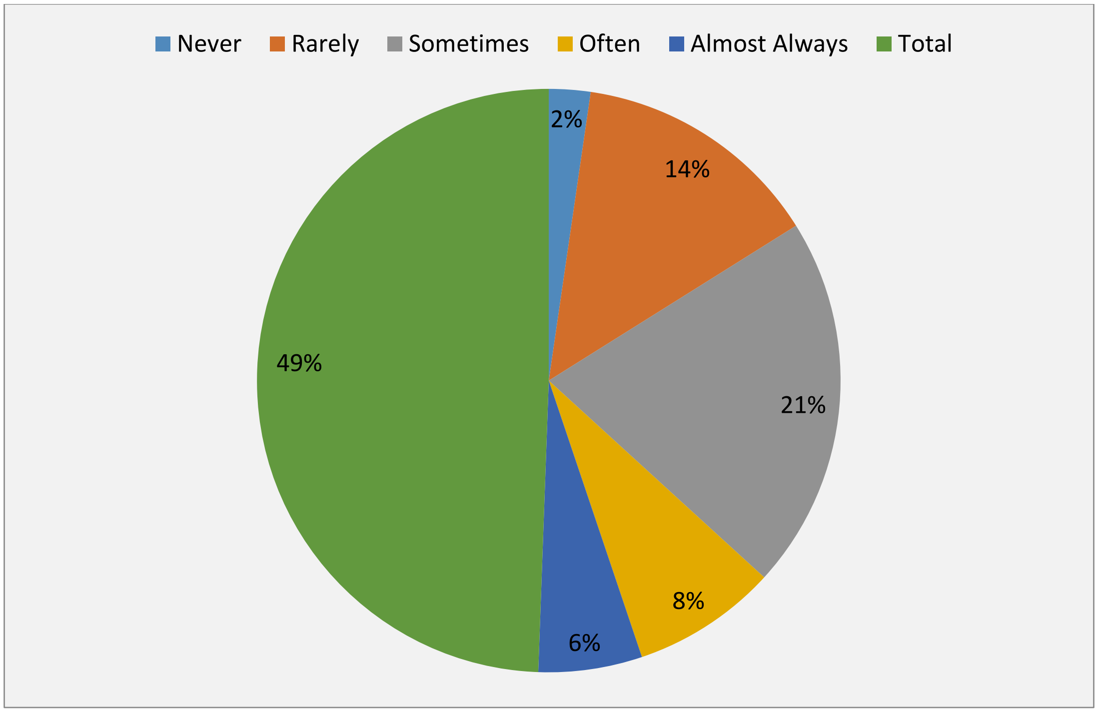

Figure 4.13 How often they participate on cooperative platforms

Table 4.19: Attitude towards sharing green manufacturing knowledge with others

Response	Number of Companies
Strongly Disagree	2
Disagree	0
Neither agree nor disagree	3
Agree	15
Strongly Agree	24

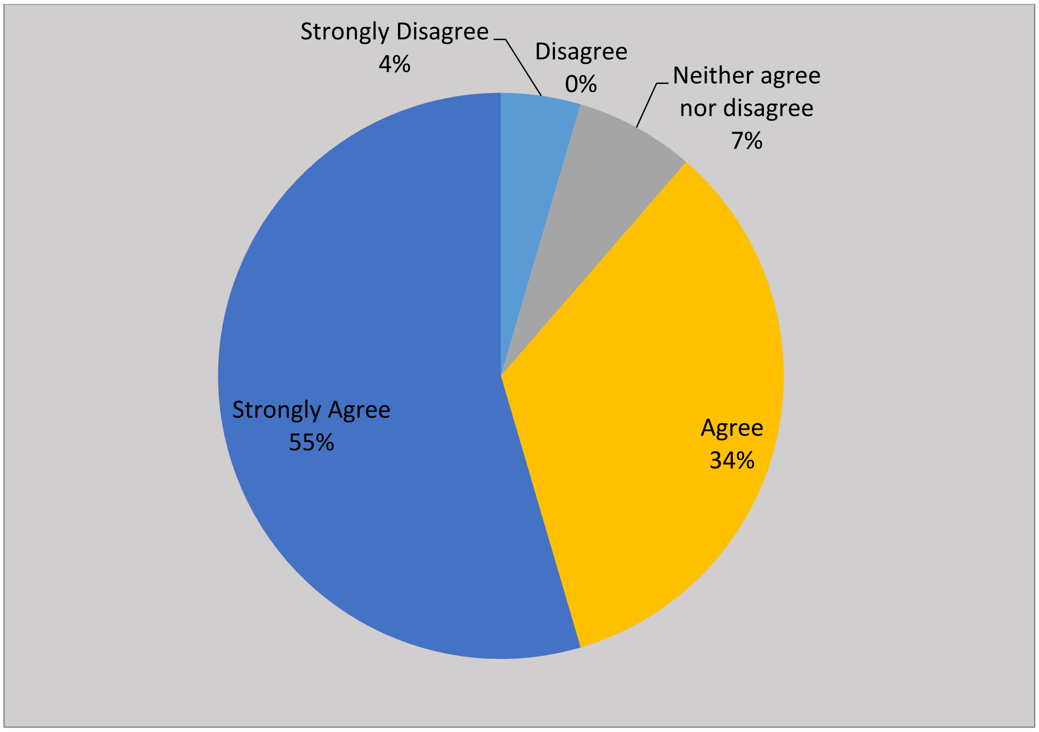

Figure 4.14 Attitude towards sharing green manufacturing knowledge with others

Summary of results

From the descriptive statistics of the automotive sector, it can be summarised that a large number of companies have progressed in years, are partnership firms, have more employee strength (> 200), have a higher turnover (> 1000 lakhs), participate in green manufacturing cooperative platforms and would want knowledge on green manufacturing to be shared. These observations reflect the overall observations.

4.1.7. Earthmoving Sector

Table 4.20: Data on Distribution of companies following Standalone frameworks

Companies	ISO	TS	Others	No	Total
Earth Moving(26)	25	--	--	1	26

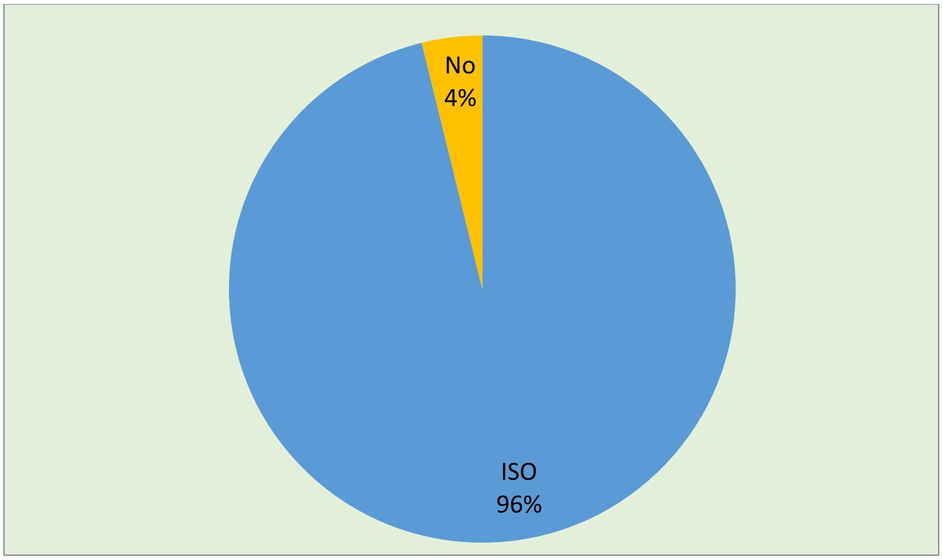

Figure 4.15 Distribution of companies following Standalone frameworks

Nature of Earth moving Companies that Exhibit standalone framework

Table 4.21: Age of companies that exhibit Standalone framework

SL No	Age of Company (Years)	Number of Companies
a	0-5	2
b	6-10	3
c	11-15	4
d	16-20	3
e	>20	13
Total		**25**

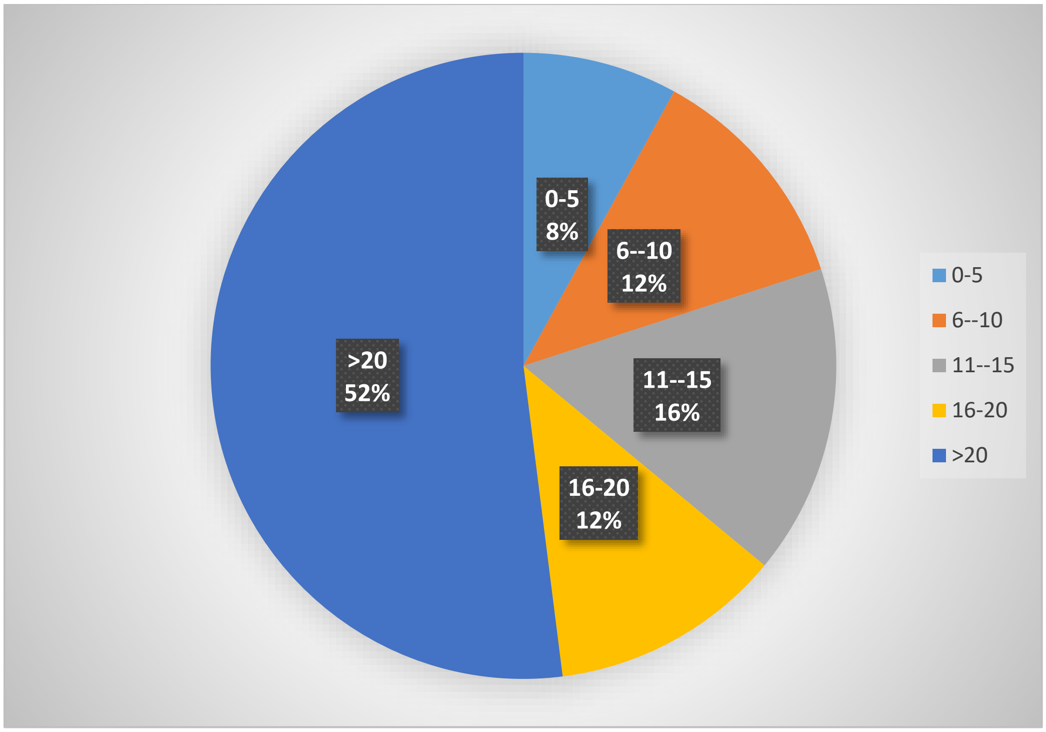

Figure 4.16 Age of companies that exhibit Standalone framework

Table 4.22: Ownership Pattern of Companies

SL No	Ownership Pattern	Number of companies
a	Single owner	6
b	Partnership firm	19

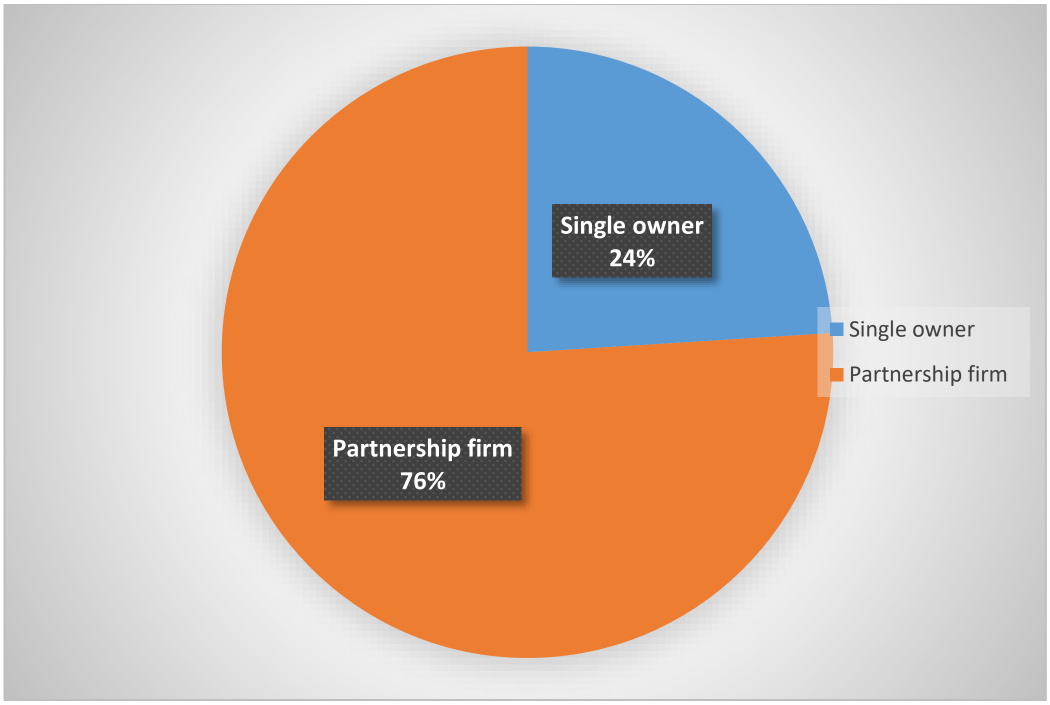

Figure 4.17 Ownership Pattern of Companies

Table 4.23: Employee Strength

SL No	Employee Strength	Number of companies
a	Less than 50	5
b	Between 50-100	4
c	Between 100 -150	3
d	Between 150 - 200	0
e	Above 200	13

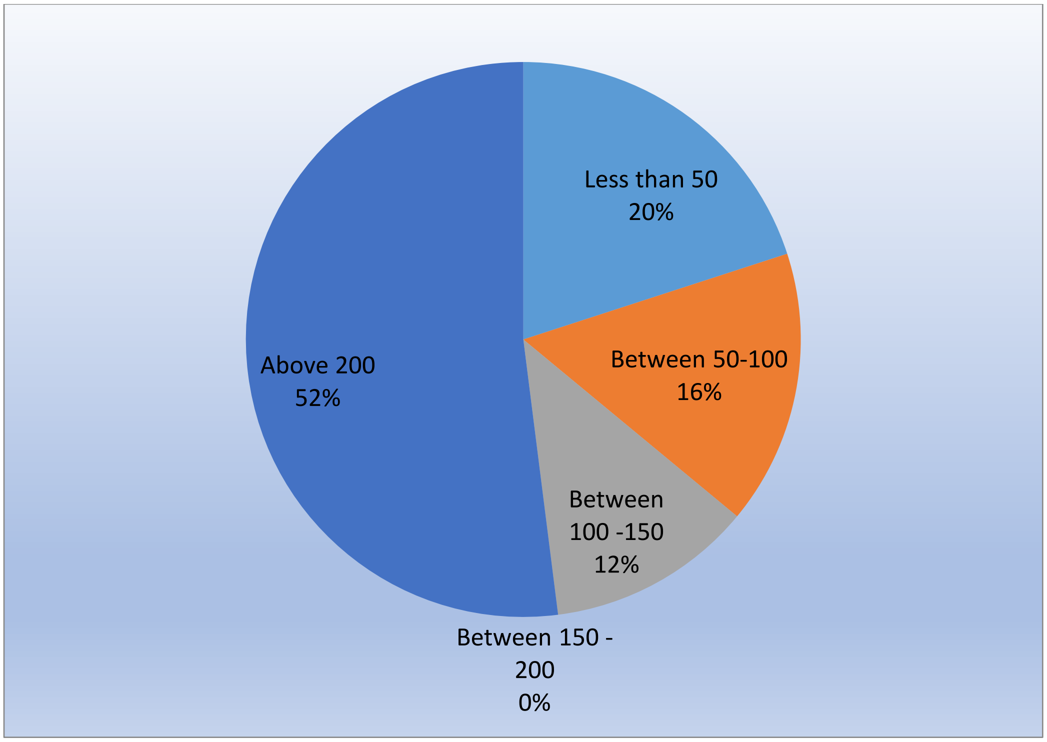

Figure 4.18 Employee Strength

Table 4.24 Turnover in Lakhs of Rupees

SL No	Turnover (Lakhs of Rupees)	Number of Companies
a	Up to 100 lakhs	4
b	100-300 lakhs	3
c	300-700 lakhs	3
d	700-1000 lakhs	3
e	More than 1000 lakhs	12

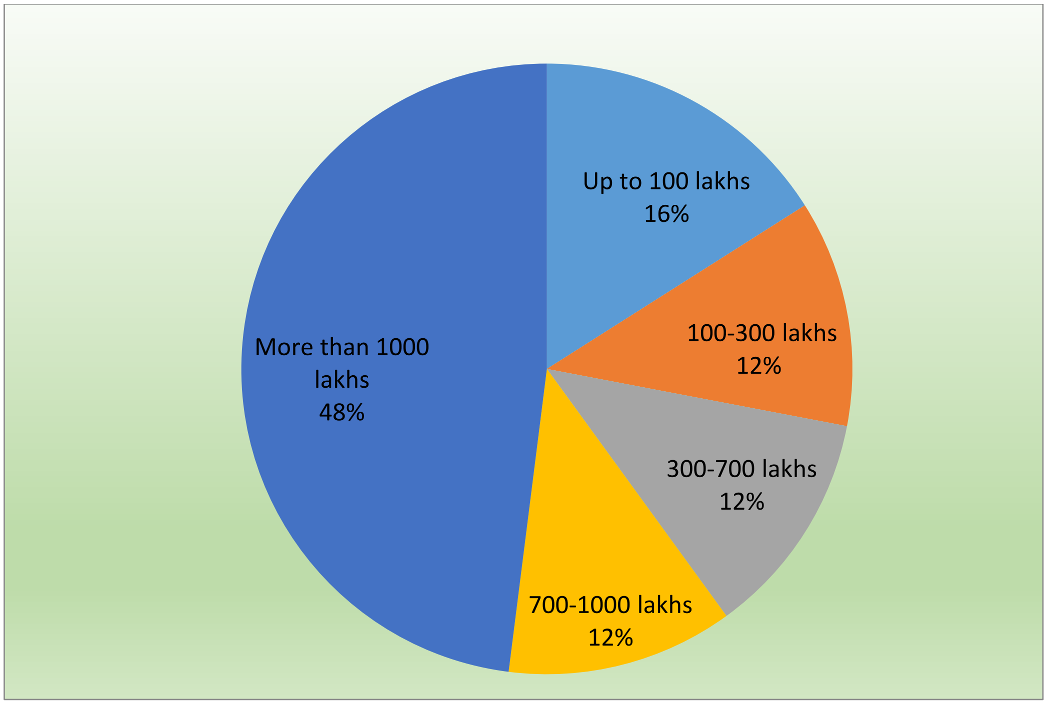

Figure 4.19 Turnover in Lakhs of Rupees

Table 4.25: Frequency distribution of companies based on how often they participate on cooperative platforms

Response	Number of Companies
Never	1
Rarely	5
Sometimes	8
Often	10
Almost Always	1
Total	25

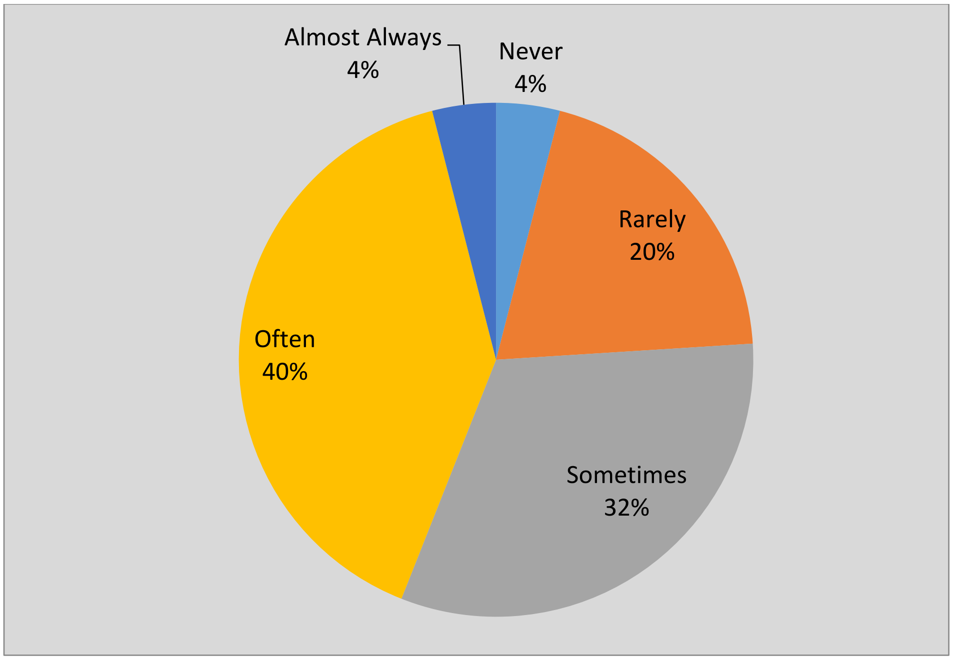

Figure 4.20 Companies based on how often they participate on cooperative platforms

Table 4.26: Attitude towards sharing green manufacturing knowledge with others

Response	Number of Companies
Strongly Disagree	0
Disagree	0
Neither agree nor disagree	2
Agree	14
Strongly Agree	9

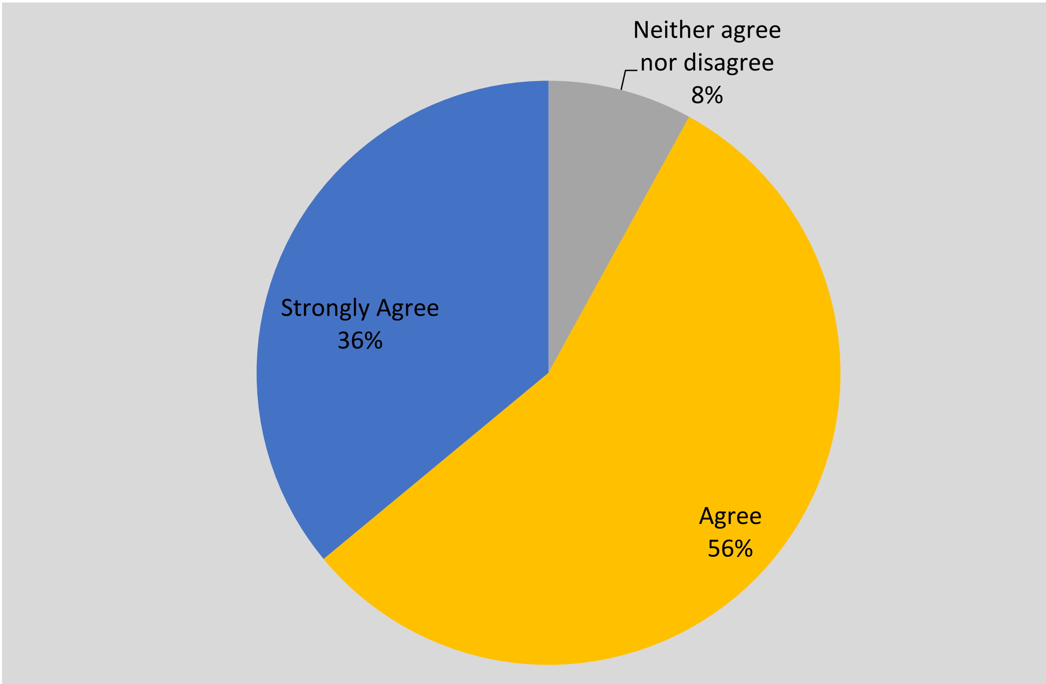

Figure 4.21: Attitude towards sharing green manufacturing knowledge with others

4.2 Categorisation of Companies based on Green Manufacturing Innovations

Objective 2:

To categorise companies based on innovations in green manufacturing practices and do a comparative study.

The process of categorization was achieved by adding all the scores obtained by respective samples across their scaled questions that measured their journey from green awareness towards Green Innovation.

The variables considered for categorization were selected based on feedbacks taken from industry experts and academic experts. These variables essentially measured the awareness about green innovations, budgets allocated existence of green manufacturing policy, extent of design towards green aspects, usage of renewable energy for manufacturing processes, extent of reuse, recycle, support to / from stakeholders for recycling, recovery management, proportion of green value chain (raw materials to shipping of finished goods), energy audits, budgets for green manufacturing, alignment of strategy for green manufacturing, participation on green platforms and knowledge sharing. The minimum score achieved by a company was 112 and maximum scored was 217. The median value was taken as the mid-point and this median value was 168. Hence Companies that scored more than 168 were categorized as those that were more innovative in green manufacturing and was grouped as '1' (also called 'Leaders' for the purpose of this research). Companies that scored equal to and less than 168 were grouped as '2' (called 'followers' for the purpose of this research). This assumption was done for the purpose of classification and finding key differences between two groups. The variables are provided in table 4.27 and the variables on which two groups differed based on their mean values are listed in table 1 in Appendix B.

Table 4.27: Variables indicating movement towards green innovation

SL No	Variables
1.	Awareness about Innovations in Green manufacturing practices
2.	Willingness to develop a policy on Green manufacturing
3.	Extent of 3R practice
4.	Design to reduce material consumption
5.	Design to reduce energy consumption
6.	Design to reduce use of hazardous material
7.	Extent of scrap generation
8.	Generation of hazardous byproducts
9.	Use of renewable energy sources
10.	Use of refurbished machines in operations

11.	Reuse tools, jigs and fixtures
12.	Salvage of in house rejected materials
13.	Existence of recycling policy
14.	Extent of recyclability
15.	Use recycled raw materials
16.	Finished product recyclable
17.	Encouragement to suppliers to use recycled materials
18.	Support from customers to use recycled materials
19.	Maturity level of recycling technology in industry
20.	Proportion of products designed for eco- friendliness
21.	Proportion of manufacturing processes for eco-friendliness
22.	Proportion of logistic processes designed for eco-friendliness
23.	Practice of active recovery management for products
24.	Practice of active recovery management for tools
25.	Practice of active recovery management for consumables
26.	Level of awareness about REACH
27.	Use of volatile organic compounds in company
28.	Suppliers following green manufacturing
29.	Support Suppliers in Green initiatives
30.	Participation in Green manufacturing competitions
31.	Follow environmentally friendly way in disposal of old parts/ machinery
32.	Importance of energy cost per unit manufactured

33.	Importance of resource per unit manufactured
34.	Budget for Green initiatives
35.	Strategies aligned towards green manufacturing
36.	Roadmap for green manufacturing
37.	Assess employee performance from green initiative perspective
38.	Extent of economic advantage through green initiatives
39.	Extent of participation on cooperative platforms
40.	Share green manufacturing knowledge with others.

Development of Hypotheses and Hypotheses testing:

Hypotheses Development

The leaders in green manufacturing are expected to be distinctly different in green manufacturing practices and systems, green manufacturing culture and green excellence than the followers. The leaders having understood the benefits of green manufacturing practices and with their resources and experience gathered over years of being in business are assumed to have forged ahead in terms of green practices. Based on comparison of means and observations, we propose the following hypotheses.

Hypothesis 1

There is no significant difference between leaders and followers about the extent to which design reduces consumption of material.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) $\neq$ μ (followers)

Hypothesis 2

There is no significant difference between leaders and followers about the extent to which design reduces consumption of energy.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) $\neq$ μ (followers)

Hypothesis 3

There is no significant difference between leaders and followers about the extent to which tools, jigs and fixtures are reused.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) $\neq$ μ (followers)

Hypothesis 4

There is no significant difference between leaders and followers about the extent to which materials in their company are recyclable.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) $\neq$ μ (followers)

Hypothesis 5

There is no significant difference between leaders and followers about the extent to which their finished products are recyclable.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) $\neq$ μ (followers)

Hypothesis 6

There is no significant difference between leaders and followers about proportion of their manufacturing processes designed for eco-friendly advantages.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) $\neq$ μ (followers)

Hypothesis 7

There is no significant difference between leaders and followers about their logistics processes designed for eco-friendly advantages.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) $\neq$ μ (followers)

Hypothesis 8

There is no significant difference between leaders and followers about extent of recovery management practices.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) ≠ μ (followers)

Hypothesis 9

There is no significant difference between leaders and followers about extent to which they are willing to support their suppliers in green initiatives.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) ≠ μ (followers)

Hypothesis 10

There is no significant difference between leaders and followers about importance to which they attach for computation of energy cost per unit produced.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) ≠ μ (followers)

Hypothesis 11

There is no significant difference between leaders and followers about importance to which they attach for computation of resource consumption per unit produced.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) ≠ μ (followers)

Hypothesis 12

There is no significant difference between leaders and followers about importance attached to budget for green initiatives.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) ≠ μ (followers)

Hypothesis 13

There is no significant difference between leaders and followers about the extent to which strategies are aligned with green manufacturing.

Ho: μ (leaders) = μ (followers)

H1: μ (leaders) ≠ μ (followers)

Hypothesis 14

There is a strong correlation between age of the companies and their Green manufacturing awareness levels.

To test this hypothesis, age of companies was ranked on a five point scale. The lowest rank of '1' was assigned "Upto 5 years", '2' – 6- 10 years, '3' to 11- 15 years, '4' to 16-20 years and the highest rank of '5' was assigned to > 20 years.

The age was correlated with a) Green manufacturing involves practise of Reduction, Reuse and Recycle. It was found that correlation between age of companies and Green manufacturing that involves Reduce, Reuse and Recycle was 0.354 (significant to 0.01 level). This implies that they are moderately correlated.

b) Correlation between age and Level of awareness about innovations in green manufacturing practices:

Correlation has a low value of 0.153 and not significant.

Hence taking into account both a) and b), null hypothesis was rejected. Please check.

4.2.1. Results of Hypothesis Testing

Independent sample't' tests were conducted for the variables whose means had to be tested for differences (Appendix B, Table – 2). A two tailed test with significance level of 0.05 was considered for testing purpose and the degrees of freedom are 68 (sum of sample size of first group and sample size of second group – 2). The critical't' value is 1.995 taking into consideration of significance levels of 0.95, a two tailed test and degrees of freedom at 68.

Table 4.28: Results of Hypothesis Testing based on‘t’ tests

Hypothesis	Critical ‘t’ value Two tailed with 5 % significance levels	Calculated ‘t’ value	Accepted/ rejected
1.	1.995	3.892	Rejected
2.	1.995	4.279	Rejected
3.	1.995	2.606	Rejected
4.	1.995	2.562	Rejected
5.	1.995	2.481	Rejected
6.	1.995	3.993	Rejected
7.	1.995	3.808	Rejected
8.	1.995	4.928	Rejected
9.	1.995	3.894	Rejected
10.	1.995	2.889	Rejected
11.	1.995	3.369	Rejected
12.	1.995	3.327	Rejected
13.	1.995	4.249	Rejected

4.2.4. Summarising the results

All the proposed hypotheses were rejected and null hypotheses were accepted and it proves that Leaders significantly differ from followers in terms of variables that point in the direction of innovation.

4.2.5. **'t'- Test for Automotive sector – to differentiate between Leaders and followers**

The same set of variables as indicated in table 4.27 was used to perform the't' test to understand the differences between Innovators and followers in the automotive sector. Table 3 in Appendix B provides the mean values of the two groups and table 4 in Appendix B provides the't' test values.

4.2.6. Summarising the results

A two-tailed test with significance level of 0.05 was considered for testing purpose and the degrees of freedom are 42 (sum of sample size of first group (20) and sample size of second group (24) – 2). **The critical't 'value corresponding to significance level of 0.05 and degrees of freedom = 42 is 2.018.**

Significant differences were found in mean values for all variables except : Awareness about 3R, extent of scrap generation, generate hazardous by products, efforts in usage of renewable sources of energy, buy refurbished machines and tools, use refurbished machines and tools for being green, support from customers for using recycled materials, easy for customers to recycle products purchased, proportion of products designed for green, use of volatile compounds, companies should share green manufacturing knowledge.

4.2.7. 't'- Test for Earthmoving sector – to differentiate between Leaders and followers

The same set of variables as indicated in table 4.27 was used to perform the't' test to understand the differences between Innovators and followers in the Earthmoving sector. Table 5 in Appendix B provides the mean values of the two groups and Table 6 in Appendix B provides the't' test values.

4.2.8. Summarising the results

A two-tailed test with significance level of 0.05 was considered for testing purpose and the degrees of freedom are 24 (sum of sample size of first group (16) and sample size of second group (11) – 2). **The critical‘t‘value corresponding to significance level of 0.05 and degrees of freedom = 24 is 2.064.**

Significant differences were found in mean values for all the variables except : Awareness about 3R, Extent of 3R practices, generate hazardous by products, reuse tools, jigs and fixtures, salvage in house materials, materials recyclable, use recycled raw materials, recyclable finished products, easy for customers to recycle products, manufacturing process for green, logistic process for green, volatile compounds, green competitions, green ways of disposing old parts and machinery, compute energy cost per unit manufactured, compute resource per unit manufactured, budget for green, strategies aligned with green manufacturing, assess employee performance for green, participate in cooperative platform for green.

4.3. Critical Factors impacting practices of Green Innovation

Objective 3 was **t**o evaluate critical factors that impacted practices of green innovation in automotive and earthmover sector.

4.3.1. Methodology

• Identify internal and external stakeholders and factors impacting green innovation and manufacturing practices. Exploratory Factor Analysis was used to discover the factors.

• To determine the importance of factors in the success of green manufacturing practice, a Multiple Linear regression was used for this purpose.

4.3.2. Exploratory factor Analysis

Exploratory factor Analysis was conducted to understand the important factors explaining the phenomenon being studied and it was found that 11 factors explained the phenomenon to 78 % which is indicated in the total variance explained in table (Appendix C). The factors were extracted based on method of VARIMAX rotation. All factors with an Eigen value of more than 1 were considered as important. 11 factors with an Eigen value of more than 1 were extracted. During the process of factor analysis, variables with a factor loading of less than 0.5 were dropped as they were considered to be less important in explanation of the phenomenon.

4.3.3. Factors and their constituent variables

Table 4.29: Factors, Constituent Variables and % Variance Explained

Factors	Constituent Variables	% Variance Explained	Factor Name
1	Importance of Green Supply Chain Importance of Green Marketing Importance of Green Consumables Importance of Green Production Importance of Green Services	11.43	Green Value Chain
2	Extent of usage of recycled raw materials Extent of recyclability of finished products Extent of encouragement to suppliers for using recycled raw materials Extent of support received from customers for using recycled raw materials Maturity level of recycling technology in industry sector	9.51	Recyclability

3	Design for reduced consumption Extent of product designed for eco-friendly advantage Extent of manufacturing process designed for eco – friendly advantage Extent of logistic process for eco-friendly advantage	8.35 %	Green design
4	Active Recovery Management for products Active Recovery Management for Tools Active Recovery Management for Consumables	7.68	Recovery Management
5	Importance of computation of energy cost per unit Importance of computation of resource consumption per unit Importance of budget for green initiatives Importance of assessment of employee performance through green initiatives	7.64	Cost and resource assessment
6	Support to suppliers Support to Neighbouring Industries Influence of Green Brand on Employee Morale	7.38 %	Green Stakeholder support
7	Level of awareness about green innovations Alignment of Strategies towards Green manufacturing	5.75%	Strategic Alignment towards Green manufacturing
8	Top management Commitment Shop floor level commitment Green Ideas initiated reactively	5.60	Green Commitment of Employees
9	Use of refurbished machines Easy for customers to recycle products purchased Frequency of participation in cooperative platforms	5.40	Refurbishment
10	Reuse tolls , jigs and fixtures Salvage of materials	4.81	Reuse
11	Awareness of 3 R's Setup difficulty of 3R's	4.34	3R Awareness

4.3.4. Methodology for naming the factors

The factors were named based on the closeness of the items/ variables in the underlying factors. The first factor had the variables which emphasised on importance of going green across all stages of value chain starting from raw materials – production to marketing and hence was named as ***"Green Value Chain"***. This factor indicates that importance given to value chain benefits that can occur due to adoption of green processes. The next important factor ***"Recyclability"*** has the variables that emphasises on recyclability of raw materials to recycling technology that is available in the industry. This also points in the direction that much of the parts produced are resource intensive and recycling offers huge benefits for the manufacturer and the suppliers. The third important factor has been ***"Green design"***. This factor has variables that emphasise on importance of design for green manufacturing. Recovery of materials, tools and products were grouped under the fourth factor "***Recovery Management"***. This factor emphasised on importance of recovery of materials and tools. ***"Design for Green Advantage"*** covered variables that emphasised on green design, design of green process and green supply chain. ***"Green Stakeholder support"*** had the variables that emphasised on green support to suppliers, neighbourhood industries and employees. The next important factor was ***"Strategic alignment for Green manufacturing"*** that had the variables ranging from awareness of green manufacturing to alignment of strategies for green manufacturing and having a green manufacturing road map. ***"Green Commitment of Employees"*** emphasised on involvement of employees in green manufacturing initiatives. This factor was followed by ***"Refurbishment"*** and Reuse of tools and materials loaded in the factor ***"Reuse Tools and materials"***. The last factor was ***the "3R awareness".***

The variables that were dropped were: Extent of practice of 3R's, extent of difficulty to setup effective 3R, Frequency of Training for 3R, Design to reduce consumption of raw materials, Design to reduce consumption of energy, Design to reduce usage of hazardous material, extent of scrap generation, extent of hazardous by products, efforts in renewable energy usage, usage of refurbished machines, cost advantage of refurbished machine, usage of refurbished machine, reach Awareness, use of volatile organic compounds, Suppliers following green practices, Top management commitment, Middle management commitment, Operating staff commitment, staff focus on resource conservation, proactive initiation of green ideas, Reactive initiation of green ideas, frequency of participation in green competitions, eco-friendly way of disposal of old parts/ machinery.

4.3.5. Summarising the results of Exploratory factor Analysis

Benefits in value chain have been given highest importance and it means the tangible benefits are valued the highest while taking up green initiatives. Recyclability offers cost benefits to manufacturers and hence given high importance. Importance of resource measurement and recovery management also offers scope for economic benefits to manufacturers and hence accorded high importance. Design for Green manufacturing, strategic alignment and green stakeholder support were more about aligning and supporting the resources and process of the organisation to achieve green objectives. This points in the direction about cost advantages being the primary explanation for green behaviour followed by strategic alignment of resources. Lesser important factors were Reuse of Tools and materials, Green awareness and Product Recycle.

4.3.6. Linear Regression

To investigate which factors are more important than others, a linear regression was conducted using all factor scores as independent variables. As the number of independent variables statistically did not match with required sample size (for each independent variable, minimum required sample is 5 and here in our case the maximum samples were 70 even though our required sample size as per project requirements was only 60 companies). This is an acceptable procedure to use factor scores (source: IBM.com) as independent variables. The earlier calculated green index value I.e. value obtained by adding up all the values of scaled variables of each sample (what were the variables used to calculate has to be specified earlier) was considered the dependent variable. As the factor scores for each factor were already orthogonal (In Principal component method, orthogonal factors are extracted), tests of multicollinearity was not essential.

Linear regression resulted in adjusted R Square value of 0.945 which is a good value and it means the factors taken explain up to 94.5 percent of the variance in the dependent variable. The F value for regression is very high at 109.798 and is significant. This means the regression model is statistically significant. The Standardised Beta (regression Co- efficient value) are provided in the table and listed in descending order. All the beta values are significant at 0.000 levels.

Table 4.30: The Standardised Beta Co- efficient values

Factor	Beta Co – efficient (standardised)	Factor Name
Factor 2	0.394	Recyclability
Factor 4	0.385	Recovery Management
Factor 6	0.359	Green Stakeholder support
Factor 8	0.328	Green Commitment of Employees
Factor 1	0.323	Green Value Chain
Factor 5	0.282	Cost and resource assessment
Factor 3	0.267	Green design
Factor 7	0.251	Strategic Alignment towards Green manufacturing
Factor 10	0.196	Reuse
Factor 11	0.187	3R awareness

The green innovation index value has been influenced by Recyclability, Recovery Management, Green Stakeholder support, Green Commitment of Employees, Green Value Chain, Cost and Resource measurement, Green Design, Strategic alignment towards green manufacturing, Reuse and 3R implementation in the order.

We can observe that Green Innovation index is more influenced by ability to recycle, recovery management, green stakeholder support, green commitment of employees and green value chain. All these point towards importance of reduction in costs by recycling, better recovery management with the help of stakeholder support and commitment of employees towards green manufacturing.

Chapter 5 Results and Discussions

Based on the results of data analysis conducted, this chapter discusses and describes the development of green innovations framework and the proposed roadmap for implementation of green innovations framework. This chapter also proposes the role of our University in creation of landing platform for the stakeholders to learn the best practices from one another. These are Objectives 4 and 5 as per the research proposal.

5.1. Development of Green Innovations Framework

The exploratory factor analysis conducted has been considered as the basis for the development of Green Innovations framework. All the factors that came up significant (with Eigen Values more than 1) have been considered the Key Drivers for the development of framework for Green manufacturing Innovations. The Key Drivers are provided in the table below.

Table 5-1: Key Drivers for development of framework

Factors	Factor name
1	Green Value Chain
2	Recyclability
3	Green design
4	Recovery Management
5	Cost and resource assessment (Green Assessment)
6	Green Stakeholder support
7	Strategic Alignment towards Green manufacturing
8	Green Commitment of Employees

9	Refurbishment
10	Reuse
11	3R Awareness

Furthermore, the questionnaire was developed based on different stages in Green manufacturing.

The stages in the questionnaire are:

1. **Green commitment:** Awareness of Importance of green manufacturing. Green manufacturing practices offer not only environmental advantages but makes the company operations more lean. Reduced energy consumption, raw material and resource are great promoters to implement a green manufacturing system. Policy , mechanism, feedback + rationale green commitment
2. **Green Systems and Practices: Practices,** tools and techniques for green manufacturing. A well-defined system that focuses on green manufacturing system will have measurement system (KPIs), tools and techniques, standards and reporting mechanism
3. **Green Culture and Excellence**: Behaviour towards green manufacturing and a journey towards becoming best in class. Green culture emphasizes on green practices that are followed without system level monitoring and appraisal in the company. Green excellence is a journey towards becoming best in class and guide others towards a sustainable business enterprise both economically and ecologically.

Mapping the Key Drivers (as obtained by Exploratory Factor Analysis), we have proposed the following framework for Green Manufacturing Innovations.

5.2. Green Innovations Framework

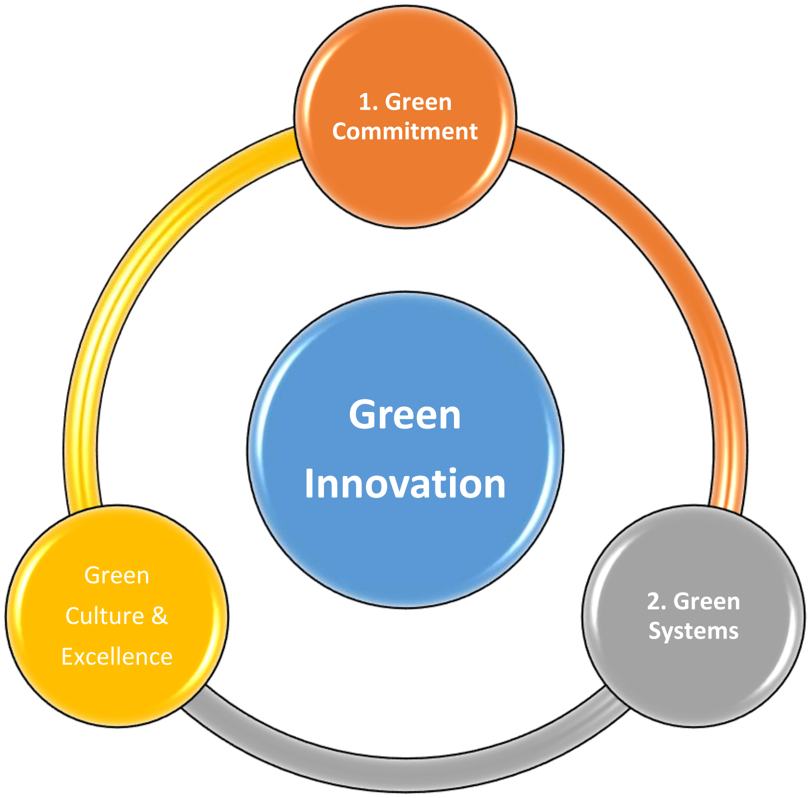

Figure 5.1 Green Innovations Framework

Stage 1: Green Commitment: The beginning of Green Innovations Journey starts with Green Awareness. Companies have to be aware of principles of 3 R's (Reduce, Recycle, Re Use), should be able to appreciate the benefits that can accrue in the entire value chain by adopting green manufacturing. It is also required to align the strategy towards green manufacturing as a detailed plan can only lead to goals and results. Hence the Key drivers (factors) ***– 3 R Awareness, Value Chain benefits and Strategic alignment*** mark the beginning of the Green Innovations Journey.

Stage 2: Green Systems

The next stage is about preparing the stage by a detailed planning. Detailed planning starts with measurement and this measurement is about energy and resources being consumed, how this can be reduced and to what extent this can be reduced. In the manufacturing context, it involves calculation of energy and other resources being consumed per unit manufactured and human resources being deployed per unit manufactured. This would involve Assessment and hence the key driver ***Green assessment*** is associated with this stage. ***Design*** of a product is the beginning of manufacturing journey followed by planning of raw materials, procuring the raw materials, processing the raw materials into finished goods, packing and shipping of finished goods. All these stages are a part of manufacturing operations and logistics operations. Green operations like Recycling, Recovery management, refurbishment and reuse can be embedded across this value chain to bring in better benefits to the manufacturing organisation. Hence ***Green Assessment, Green Design and Green Operations*** form this stage.

Stage 3: Green Culture and excellence

Supporting these stages are benchmarking with best practices, the orientation and support from stakeholders (Employees, Suppliers, etc.) to bring about continuous changes, and Green Network which involves active participation in dissemination of green knowledge through peer groups, competitions etc. This helps in upgrading the necessary knowledge continuously required for green innovations. ***Continuous journey across these stages can lead to green manufacturing innovations.***

5.3 **Proposed Road Map for Green Innovation in Manufacturing**

The journey towards green innovations needs a phase wise approach that can be planned by individual organization considering both internal and external factors like existing culture, leadership, regulations etc. To scale up the green innovations in manufacturing organizations, a standard roadmap helps to foresee the phases and plan and execute actions. This roadmap can be customised to the organization's needs and maturity level. It still can be used as it is, if the organizations are ready with standards like ISO/TS and other Good manufacturing practices/systems in place. The framework and proposed road map were discussed with leaders in green manufacturing during visits and with also many other small and medium industries during a workshop conducted.

The leaders in green manufacturing made the following observations and suggestions to strengthen the road map.

1. **M/s. TVS Motors Pvt. Ltd., Hosur**

- Under green culture and excellence, include biodiversity and corporate social investment as metrics has hallmark practices
- Include programs like external upkeep of the factories; gardening and planting fruit bearing trees
- Extend the scope of the framework to include the external stakeholders
- Extend the scope of the green innovations framework to get a sense of urgency
- Metering and disclosing the status of key resources and regulatory requirements (preferably online)

2. **M/s. India Nippon Electrical Ltd., Hosur**

- Green commitment from top management must be extended in all phases of Green Innovations Roadmap
- Elaborate on the roles of stakeholders to practice and sustain the Green Innovations Framework

3. **M/s. Bosch India Limited, Adugodi.**

- Elaborate on the roles of stakeholders to practice and sustain the Green Innovations
- Include the external award and reward systems
- Green innovations framework is industry relevant

- Green innovations framework and roadmap could be explained in much detail with examples and ideal behaviours that support green manufacturing

4. M/s. Stanzen Engineering Private Limited, Peenya

- Include measures to account invisible waste like electricity and water and clean air
- Encourage the use of biodegradable and recyclable products inside the factory
- Inspire from standard and well established systems implementation models

5. M/s. Volvo Earthmoving Equipments, Peenya

- Suppliers and vendors will be playing an important role; provide scope for including suppliers in the roadmap
- The research development teams must be sensitized on green innovations and green alternative technologies/materials/processes/systems and economic advantages
- Include cross functional team approach for green innovations

The industry participants in the final workshop conducted, agreed upon the framework and proposed roadmap and also suggested that they need handholding to implement the roadmap as they cannot provide for dedicated resources unlike the large industries. The proposed roadmap can be adopted by organizations to start, implement, practice, sustain and excel in green innovations. The roadmap has five phases:

1. Green Commitment
2. Green Practice
3. Green System
4. Green Culture
5. Green innovation

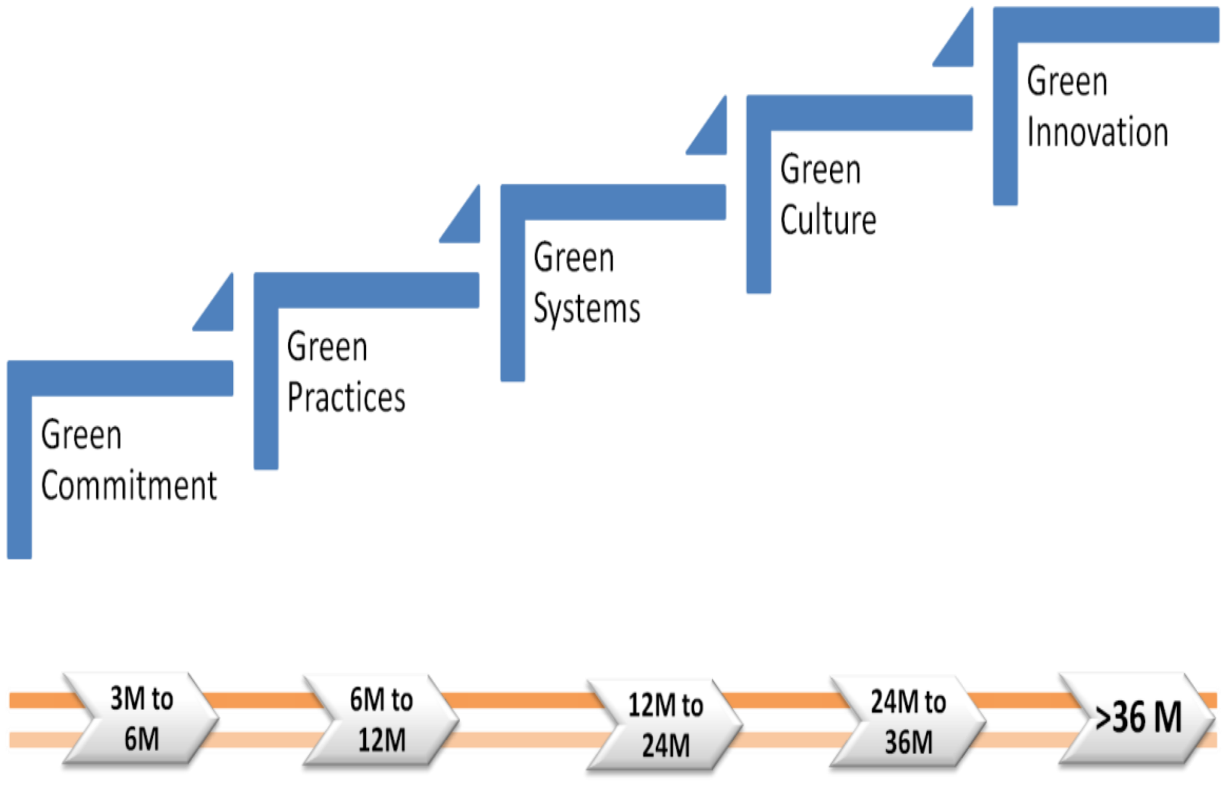

Figure 5.2 Green Innovations Roadmap

5.3.1 Phase I: Green commitment

Green commitment is the first phase in the green innovations roadmap. This phase prepares the organization for green innovations journey. The leadership of the organization with basic awareness about green manufacturing can start this phase. Green commitment phase can be completed within three to six months depending on the size of the organization. The expected deliverables from this phase are:

Top Management Commitment for Green Manufacturing

- Creation of Green vision and mission statements
- Strategic goals for green manufacturing

- Development of green manufacturing policy
- Allocation of Green budget

The following indicative KPIs can be used to monitor the progress:

- Existence of green policy/ plans to develop/review at green policy with time lines
- Budget allocated for Green Innovations in Manufacturing
- Number of awareness/ training Meeting with planned and achieved with stakeholders

5.3.2 Phase II: Green Practice

Green practice is the second phase of the green innovations roadmap. The objective of this phase is to first prove that green manufacturing indeed brings both economic and environmental benefits within the organization. It can start with simple improvements or Kaizens that has an environmental impact. Green Kaizens must be carried across the organizational hierarchy. Green practice phase can be completed within six months to twelve months of period depending on the size of the organization. The expected deliverables from green practices phase are:

- Access to body of knowledge
- Execute easy Green Kaizens across the organization
- Develop plan for system level green Kaizen
- Periodic Green walks in the organization
- Training on Green Manufacturing

The following indicative KPIs can be used to monitor the progress:

- Number of green Kaizens completed
- Number of green plans and time lines for the plant

- Number of green teams (including cross functional teams)
- Number of horizontal implementation of green projects

5.3.3 Phase III: Green System

Green system is the third phase of green innovations roadmap. The objective of this phase is to assure that green practices are followed in a standard way across the value stream in an organization. The basic standards must be set and has to be upgrade periodically. Establishing green standards in all functions of organization demands a thorough understanding of the concepts, tools, technology, financial implications, ease of implementation etc., in this phase systems level green program are planned and executed. Green alternative for materials, machines, methods (ICT and IOT technological interventions) and energy source has to be explored in this phase. Well defined monitoring and feedback mechanism has to be an important aspect of this phase. This phase can be completed within twelve months to twenty-four months. The expected deliverables of this phase are:

- Department/function/system level green assessments
- Green standardization of processes
- Adherence to green standards , Daily Management and Consistent monitoring
- Long term green projects (more than one year) executed
- Horizontal deployment of green projects across units/functions/processes
- Awards and Reward systems

The following indicative KPIs can be used to monitor the progress:

- Number of department/function/system level green projects
- Number of green standardized processes ex: selection of suppliers based on green manufacturing

- Number of long term green projects (more than one year) executed and horizontal deployment across units/functions/processes
- Number of external and internal rewards

5.3.4 Phase IV: Green Culture

Green culture phase is fourth phase in green innovations framework. Green culture emphasizes on the ideal behavior needed to practice green innovations. This phase aims to bring a culture of green manufacturing and practices across the value stream map. The concerns for environment, adherence to standards, involuntary programs/ projects /events will highlight the culture towards green manufacturing and innovations. This phase can be completed within twenty-four months to thirty six months. The expected deliverables of this phase are:

- Formal and semiformal groups contributing to Green Manufacturing / Green Innovations
- Cross functional teams with other organizations
- Orientation programs outside stakeholders
- Resource conservation programs: land, water, air, energy and raw material

The following indicative KPIs can be used to monitor the progress in this phase:

- Number of formal and semiformal groups contributing to Green Manufacturing / Green Innovations
- Percentage of employees who are a part of these groups
- Number of improvement suggestions implemented in year
- Number of rewards (for involuntary suggestions)

5.3.5 Phase V: Green Innovations

This is last and fifth phase of Green Innovation roadmap. The objective of this phase is to achieve benchmark milestones in green innovations by the organization. The organization must get involved in implementing, practicing and sustaining green innovations across the complete value chain. Initiation of Green leadership programs with national and international agencies/organizations/ can help organizations to achieve benchmark milestones. This phase can be achieved in thirty sixth month from the date of first phase. The expected deliverables of this phase are:

- Green programs across value chain
- Benchmark programs and results
- Cross industry collaborations
- National and International awards for green manufacturing
- Biodiversity programs across units and suppliers

The following indicative KPIs can be used to monitor the progress:

- Number of green programs across value chain
- Number of cross industry collaborations
- Number of benchmark programs and results
- Number of National and International awards for green manufacturing
- Number of Biodiversity programs across units and suppliers

During the workshop, experts suggested that the steps in roadmap need not be sequential as this also depended on the available expertise and resources.

5.4 Creation of a Landing platform through a shared approach

5.4.1 To Create a Landing platform through a shared approach (public-private partnership) which can benefit a larger number of stakeholders

Our University – M S Ramaiah University of Applied Sciences actively supports research and has established various research centres. Among them is Innovation and entrepreneurship research centre. Under this centre, we propose to establish a centre for excellence in Green Innovations.

The aim of the proposed Centre is to provide a strategic impetus to conduct and disseminate research in Green manufacturing and Green Business. It is expected that the proposed research centre will create a viable platform to showcase Ramaiah Group's research contribution towards its Mission of becoming an entity of International Stature and Global Relevance.

This centre will bring in all stakeholders across all categories of green innovation maturity to participate in knowledge sharing workshops and will involve in dissemination of research. It plans to bring in global experts from industry and academia, to share the platform with Indian experts and novices in Green manufacturing and services and foster green innovation and sharing of green manufacturing ideas in the process.

The vision, mission and goals would be as follows:

5.4.2 Vision Statement

Empower, create and synergize research groups across Ramaiah Institutions to address societal relevance of Green Manufacturing and Green services

5.4.3 Mission Statement

Propagate Ramaiah Group's sustainable research contribution towards becoming an entity of International Stature and Global Relevance

5.4.4 Goal

The main goal is to create a financially viable ecosystem using the inter-disciplinary expertise across Ramaiah Institutions.

5.4.5 Objectives

- Invite Large and leading firms and their value chain partners in green manufacturing to share green manufacturing knowledge with manufacturers belonging to Small and Medium Enterprise (SME)
- Initiate and lead research on a topic impacting the global relevance by attracting acclaimed Professors/Scholars/Experts/Fellows from other educational Institutions / Universities in India and abroad to enhance the research profile
- Perform independent research and demonstrate the effective research management skills through the formulation of research clusters/groups leading to the scholarly growth of Faculty Members, Post-Doctoral, Doctoral Scholars and PG students across Ramaiah Institutions
- Engage consistently, continuously and proactively in conducting high quality and transformational research by making available the results for peers to set the stage for solving practical/societal problems of national importance
- Encourage, promote and participate in the activities conforming to the Ramaiah Group's Vision by creating an eco-system for interdisciplinary research

The proposed Centre for excellence will have its own Steering Committee and Advisors who can meet bi-annually to review the progress of the Centre. The steering committee would be drawn from industry and academia.

The key deliverables from the proposed research centre will be to obtain Grants from funding agencies in India and abroad by collaborating on topics of National Importance, conduct regular workshops (bi annual) for exchange and dissemination of green manufacturing knowledge, provide consultancy services to Industries, research supervision and host PG, Doctoral and Post-Doctoral students through Scholarships; publications in highly reputed journals of international relevance. In order to leverage on the knowledge repository, this research centre will work on critical thrust areas of National Importance and generate revenue through grants and consultancy projects across India. By virtue of this Centre, inter-disciplinary research groups across Ramaiah Institutions focusing on sub-themes/verticals will be created to solve societal problems of national importance. Through these activities, the SME sector will get to benefit from green manufacturing knowledge shared by experts and large companies, new knowledge creation will happen through research and student community will get to study and research in the area of green manufacturing which will lead to capacity building of expertise.

Chapter 6 Summary and Recommendations

With an objective to survey and assess the current status standalone / Cooperative framework for innovations in automotive and earthmoving sectors, it was found that most of the companies surveyed had a standalone framework either in form of ISO/ TS/ Others. Among the companies that have adopted the standalone framework of quality standards, there are more number of older companies that a higher turnover and larger workforce.

The co-operative framework was studied through their willingness to participate on cooperative platforms and their perception towards others sharing green manufacturing knowledge. There are more number of companies that participate in cooperative framework than those who do not participate. There are more number of companies that believe about sharing green manufacturing knowledge than those who do not. Companies that are older, having a higher turnover and higher employee numbers participate more frequently in cooperative framework than those who are younger, have a lower turnover and lesser number of employees. This may point in direction of business growth and sustainability that is linked to their willingness to participate in cooperative framework for green manufacturing.

Companies were categorized based on summated score of the scaled variables used and this was taken as proxy indicator of their journey in green manufacturing. An attempt was made to differentiate between leaders from followers and understand the key differences between the two groups. It was found that variables - Recycling policy to take back products from customers, Encouragement to suppliers to use recycled materials, Support to Suppliers in Green Initiatives, Alignment of Strategies towards Green Initiatives, Extent of Economic advantage due to green manufacturing practices. This indicates that support to suppliers for green initiatives, alignment of strategies towards green initiatives and extent of economic advantages gained are key differentiators. This also points to the fact that if companies have to successfully move towards green manufacturing, they have to align their strategy towards green manufacturing and support their stakeholders like suppliers to a greater extent.

Trying to understand the important factors that explains the phenomenon of green manufacturing, it was found that factors - Green Value Chain, Recyclability, Green design, Recovery Management, Cost and resource assessment, Green Stakeholder support, Strategic Alignment towards Green manufacturing, Green Commitment of Employees, Refurbishment, Reuse and 3R implementation. The factors directly point towards gains to be acquired by adopting green manufacturing practices followed by factors that require alignment of systems, strategy and people with green manufacturing practice. Hence while propagating green manufacturing across the community of manufacturers, it is necessary that gains are made aware first and then how to align systems, strategy and people with green manufacturing.

The journey of 1000 miles starts with a single step and the green manufacturing journey starts with being aware of the need and benefits of 3 R's – reduce , recycle and Reuse. This stage also needs an appreciation of the value chain benefits that can accrue due to green manufacturing practices and without the alignment of strategic with green manufacturing, the journey cannot begin well.

The next stage starts with detailed planning and setting up of systems to assist in green manufacturing followed by setting up a culture of continued excellence in green manufacturing.

The roadmap that can be set for the companies has the following stages of journey: Green Commitment, Green Practices, Green systems, Green culture and Green Innovation

6.1 Policy Recommendations

First and foremost, it can be observed from the analysis that most of the companies are having a standalone framework and many of them want green manufacturing knowledge to be shared among the community.

There are leaders in Green manufacturing who would want to share the green manufacturing knowledge with others in their community. One of the important steps is to identify such leaders.

The research analysis revealed the following factors that are important for green manufacturing and they are “Green Value Chain”, “Recyclability”, “Green design”, “Recovery Management”, “Design for Green Advantage”, “Green Stakeholder support”, “Strategic alignment for Green manufacturing”, “Green Commitment of Employees”, “Refurbishment”, “Reuse Tools and materials” and “3R implementation”. Taking these factors into account, the policy makers can develop the roadmap as prescribed in this research and with the help of leaders in green manufacturing; the followers can be supported in their green manufacturing journey following the road map. In return for supporting those followers, the leaders can be rewarded with appropriate incentives. The road map journey can also be organised by industry bodies like Peenya Industrial association, Hosur industrial association etc. A mandate can be made for the industry associations to provide training to companies on their green journeys until they reach a certain maturity stage.

6.2 Limitations and scope for Future work:

1. From the data available from the sources from Peenya Industrial Association, Hosur Industrial Association, information sources from ACMA, and other industry bodies, it was very difficult to arrive at exact number of component manufacturers for Automotive and Earthmoving Industry in and around Bengaluru to calculate the population size. This research had to predominantly depend on the convenient sampling but yet has achieved the sample size as per the research requirements and attempted to maintain a good representation.
2. The 54 companies that belonged to small and medium sector are not further segmented into small and medium as this data is hard to obtain and most of the companies claim that they belong to SME sector as a whole and do not elaborate on whether their belong to small sector or medium sector. There are other detailed data descriptors of the companies like sales turnover, number of employees

3. Multiple frameworks could not be arrived separately for automotive and earthmoving sector for one good reason. Framework was developed based on factors discovered by conducting Exploratory Factor analysis. Exploratory factor analysis requires that for each variable, a minimum sample of 5 companies were needed. Our sample size consisted of a total 70 companies of which 44 were in automotive segment and 26 were in Earthmoving segment. A total of 40 scaled variables were considered for the study and if we had to have a separate framework for each sector, then for automotive sector our sample size should have been 40* 5 = 200 and for Earthmoving sector also, the sample size should have been 200. As this was beyond the scope of sample size requirements of the project (n = 60), a single framework was arrived at for both the sectors put together. It was also assumed that manufacturing operations were similar as both catered to closely related sectors – Automotive and earthmoving.

Research Summary

Development of a Green Innovations Framework for Manufacturing Sector: A study on Green Innovations in Earth Moving and Automotive manufacturing sectors by Dr H.S. Srivatsa, M S Ramaiah University of Applied Sciences, Bengaluru, and Karnataka 2020.

This work aimed to develop a framework and roadmap for manufacturing companies to practice and sustain green manufacturing innovations. Literature review and expert consultations were used to develop a survey manual for data collection. Qualitative and Quantitative analysis pointed towards lack of systematic approach to initiate, implement and sustain green manufacturing innovations. Green innovations index was derived and was used to assess the current green innovations level of participant companies. The key factors that influenced the green innovations index are Green Value Chain, Recyclability, Green design, Recovery Management, Cost and resource assessment, Green Stakeholder support, Strategic Alignment towards Green manufacturing, Green Commitment of Employees, Refurbishment, and Reuse and 3R implementation. Further, based on the findings, Green Manufacturing Innovations framework and a Roadmap was developed for earth moving and automotive companies. The developed framework and roadmap will help the SME sectors to adopt green manufacturing practices and carry out green innovations.

References

Arindam Bhattacharya, (2001) Green manufacturing available [online]: www.cii.in/webcms/Upload/BCG-CII%20Green%20Mfg%20Report.pdf [25 April 2015]

Chen, Y, Chang, C and Wu, F. S. (2012) Origins of green innovations: The differences between proactive and reactive green innovations, Emerald Insight, Journal of Management Decisions, Vol. 50.

Deif, A. M. (2011) A system model for green manufacturing, Science Direct, Journal of Cleaner Production, Vol.19, pp.1553-1559.

Govindan, K, Diabat, A and Shankar, M. K. (2015) Analyzing the drivers of green manufacturing with a fuzzy approach, Journal of Cleaner Production, Vol. 96, pp.182-193.

Karnataka Government Industrial policy 2014-19, (2014) Adopt a sustainable green industrial growth strategy to safeguard and protect the natural resources of Karnataka state.

Kesting, P and Gu¨nzel-Jensen, F. (2015) SMEs and new ventures need business model sophistication, Elsevier Inc.

Kiran, R and Jain, V. (2012) Enhancing innovation and intellectual property culture in manufacturing small and medium enterprises, African Journal of Business Management, Vol. 6(4), pp. 1234-1243.

Mittal, V. K and Sangwan, K. S. (2014) Prioritizing barriers to green manufacturing: Environmental, social and economic perspectives, Science Direct, Procedia of 47th CIRP Conference on Manufacturing Systems, pp.559-564.

Nulkar, G. (2014) SMEs and environmental performance – A framework for green business strategies, Science Direct, Procedia of Social and Behavioral Sciences, Elseiver Ltd. pp.130-140.

Pampanelli, A.B, Found. P and Bernardes, A.M. (2014) A lean and green model for a production cell, Journal of Cleaner Production, Vol. 85, pp.19-30.

Paul, I.D, Bhole, G.P and Chaudari, J. R. (2014) A review on green manufacturing: Its important, methodology, and its application, Science Direct, 3rd International Conference on Materials Processing and Characterization (ICMPC 2014), Elsevier Ltd. pp.1644-1649.

Singh, N, Jain, S, Sharma, P. (2013) Determinants of proactive environmental management practices in Indian firms: an empirical study, Journal of Cleaner Production, Vol. 66, pp.469-478.

Tsai, W, Chen, H, Leu, J, Chang, Y and Lin, T. W. (2013) A product-mix decision model using green manufacturing technologies under activity-based costing, Journal of Cleaner Production, Elsevier Ltd.

Appendix A

Local Project Advisory Committee for Project Entitled" Development of a Green Innovations framework for Manufacturing Sector"

Sl No	NAME, DESIGNATION& PHONE NUMBER	AFFILIATION	CHAIRMAN/ MEMBER/ CONVENER
1	Prof. Dr. Anantha Raman Visiting Professor Mobile: 9845796497.	Harvard Business School, Professor of Innovation, Strategy, General Management (based in Bangalore).	Chairman
2	Dr. A. N. Rai Director, NSTMIS Division Mobile: 9868162728.	Department of Science and Technology Government of India	Member
3	Dr Praveen Arora Head CHORD Division, DST. Phone: 011-26590331.	Department of Science and Technology, Government of India.	Member
4	Dr. M. H. Balasubramanya Professor.	Department of Management Studies, Indian Institute of Science, Bengaluru.	Member
5	Dr. Balachandra Patil Principal Research Scientist.	Department of Management Studies, Indian Institute of Science, Bengaluru.	Member
6	Dr. H.S. Srivatsa Professor and Head of Management studies Principal Investigator of project. Mobile: 9901752702	Ramaiah University of Applied Sciences, Bengaluru.	Convener
7	Mr. Ajit Kumar, Independent Director Mobile : 9448018578	Menon pistons Ltd , Kolapur Menon Bearings Ltd , Kolapur	Member
8	Mr. Seenivasan. K Manager Quality Assurance, Mobile : 9972060622	Bosch Ltd , Bengaluru.	Member
9	Mr. Vasu R TQM , Manager Mobile : 9538895171	Tractors and Farm Equipment Ltd , Bengaluru	Member

10	Mr. Sankarpadmanaban Senior Manager , Mobile : 09994343497	Engineering ,TVS Motor Company Ltd,Hosur	Member
11	Mr. Sandeep. N Assistant Professor – Mechanical and Manufacturing Engineering Department Co - Principal Investigator, Mobile: 9980497179	Ramaiah University of Applied Sciences, Bengaluru.	Co- Convener
12	Mr. S. Vijaya Kumar Assistant Professor – Mechanical and Manufacturing Engineering Department Co - Principal Investigator Mobile: 9480414678.	Ramaiah University of Applied Sciences, Bengaluru	Co- Convener
14	Mr. R Arun Assistant Professor – Mechanical and Manufacturing Engineering Department Co - Principal Investigator Mobile: 9742289232	Ramaiah University of Applied Sciences, Bengaluru	Co- Convener

List of Automotive Companies Surveyed

1.	M/s Hi-tech industries	2.	M/s Rajsriya Automotive
3.	M/s Feathers auto tech	4.	M/s Motherson Sumi Systems Ltd.
5.	M/s Sri Jai Ganesh enterprises	6.	M/s Auto CNC Machining Ltd.
7.	M/s G.R.S Gears &tool Tech	8.	M/s Micro plastics pvt ltd
9.	M/s Sasi enterprises	10.	Searock precision products Pvt ltd
11.	M/s Dhiyan industries	12.	M/s Stanzen Engineering Pvt. Ltd.
13.	M/s Spark engineers	14.	M/s India Nippo Electricals
15.	M/s Agathiyan Industries	16.	Surin Automotive Pvt Ltd
17.	M/s Mahathi industres	18.	SAN Electromec
19.	M/s Nidhin Engineering Works	20.	M/s J L Engineering Industries
21.	M/s Karnataka Automats Pvt. Ltd.	22.	M/s Sansera engineering pvt ltd
23.	M/s Shree sai industries	24.	M/s Surface treatment system
25.	M/s Sandhar Automotive	26.	M/s Hema Engineering ltd
27.	M/s HUXO precision tools	28.	Bangalore Metallurgicals Pvt. Ltd.
29.	M/s S.I industries	30.	M/s BOSCH Ltd.
31.	Precision Press Products	32.	M/s TVS Motor Company Ltd.
33.	M/s Jaraa cnc products	34.	AMAC
35.	M/s J.E.R Tools	36.	M/s Sunikh components pvt ltd
37.	M/s Yes vee press components	38.	M/s Praveen engineering
39.	M/s WENDT (INDIA) Ltd.	40.	M/s Aditya Auto Products and Engg. Pvt. Ltd.
41.	SAAB	42.	Sriudyog Sangha
43.	M/s Almek Enginerring	44.	AMAC
45.	M/s Tenneco Automotive india pvt ltd	46.	M/s Sunikh components pvt ltd

List of Earthmoving Equipment Companies surveyed

1.	Hycom Engineering pvt ltd	2.	Triveni industries
3.	Arun Machine Components	4.	M/s Uniflex precision products pvt ltd
5.	Rishi Laser ltd	6.	Vipra Machine Tools
7.	Pragathi Transmission Pvt Ltd	8.	M/s KLN Engineering Products Pvt. Ltd.
9.	ICE Steel	10.	Vaishista Manufacturing Industries
11.	Apex Auto ltd	12.	L&T Construction Equipment Limited
13.	Taram Engineering Pvt Ltd	14.	M/s VST Tillers tractors ltd
15.	Galvano Track Solution pvt ltd	16.	M/s Canara Hydraulics Pvt. Ltd.
17.	Ferrum Extreem Engineering Pvt ltd	18.	Hydrolines India
19.	Accutech Enterprises	20.	Alpha Systems
21.	Focus Rubber Industries	22.	Balambiga Metal Finishers
23.	Wipro Infrastructure Engineering	24.	Volvo Group India pvt ltd
25.	Mag Engineering pvt ltd	26.	Fab Tool Industries

Appendix B

Table 1: Mean values of variables for the two groups – Leaders ('1') and Followers ('2) (Combined Samples of Automotive and Earthmoving sector)

Group Statistics					
Variable	Innovation rank	N	Mean	Std. Deviation	Std. Error Mean
1.	1.0	35	3.400	.6039	.1021
	2.0	35	2.714	.7101	.1200
2.	1.0	35	1.429	1.5771	.2666
	2.0	35	2.857	1.4581	.2465
3.	1.0	35	3.400	.8812	.1489
	2.0	35	2.543	.8521	.1440
4.	1.0	35	3.486	.7811	.1320
	2.0	35	2.686	.9322	.1576
5.	1.0	35	3.486	.7425	.1255
	2.0	35	2.657	.8726	.1475
6.	1.0	35	3.629	1.1398	.1927

	2.0	35	2.486	1.1973	.2024
7.	1.0	35	2.486	.8179	.1382
	2.0	35	2.600	.7746	.1309
8.	1.0	35	1.600	.6945	.1174
	2.0	35	1.829	.8907	.1505
9.	1.0	35	3.029	1.1754	.1987
	2.0	35	2.343	.8382	.1417
10.	1.0	35	2.743	.9805	.1657
	2.0	35	2.343	.9056	.1531
11.	1.0	35	3.457	.9185	.1553
	2.0	35	2.857	1.0042	.1697
12.	1.0	35	3.114	1.2071	.2040
	2.0	35	2.200	1.1061	.1870
13.	1.0	35	1.571	.5021	.0849
	2.0	35	1.886	.3228	.0546

14.	1.0	35	3.200	.9641	.1630
	2.0	35	2.543	1.1718	.1981
15.	1.0	35	2.914	1.0675	.1804
	2.0	35	2.171	1.0428	.1763
16.	1.0	35	2.914	1.2217	.2065
	2.0	35	2.143	1.3750	.2324
17.	1.0	35	3.029	.8570	.1449
	2.0	35	2.229	1.0314	.1743
18.	1.0	35	3.114	1.1054	.1868
	2.0	35	2.514	.9194	.1554
19.	1.0	35	3.143	.8793	.1486
	2.0	35	2.200	.9331	.1577
20.	1.0	35	2.771	1.0314	.1743
	2.0	35	2.914	1.0396	.1757
21.	1.0	35	3.371	1.3738	.2322

	2.0	35	2.457	1.3138	.2221
22.	1.0	35	3.514	1.0947	.1850
	2.0	35	2.457	1.1205	.1894
23.	1.0	35	3.686	1.1054	.1868
	2.0	35	2.629	1.2148	.2053
24.	1.0	35	3.314	1.1825	.1999
	2.0	35	2.057	.9375	.1585
25.	1.0	35	3.914	.9509	.1607
	2.0	35	2.371	1.0314	.1743
26.	1.0	35	3.714	1.0730	.1814
	2.0	35	2.429	1.0651	.1800
27.	1.0	35	2.371	1.1903	.2012
	2.0	35	1.743	.9500	.1606
28.	1.0	35	3.000	.9701	.1640
	2.0	35	2.143	.9121	.1542

29.	1.0	35	4.000	.5941	.1004
	2.0	35	3.343	.8023	.1356
30.	1.0	35	3.057	1.1617	.1964
	2.0	35	2.257	.8859	.1497
31.	1.0	35	4.486	.6585	.1113
	2.0	35	3.886	.8321	.1407
32.	1.0	35	4.629	.6897	.1166
	2.0	35	4.114	.7960	.1345
33.	1.0	35	4.686	.7183	.1214
	2.0	35	4.057	.8382	.1417
34.	1.0	35	4.286	1.0452	.1767
	2.0	35	3.457	1.0387	.1756
35.	1.0	35	4.114	.6761	.1143
	2.0	35	3.229	1.0314	.1743
36.	1.0	35	3.486	1.1212	.1895

	2.0	35	2.543	1.0939	.1849
37.	1.0	35	3.971	.8220	.1389
	2.0	35	3.429	.8501	.1437
38.	1.0	35	3.971	.6177	.1044
	2.0	35	3.257	.7800	.1318
39.	1.0	35	3.514	1.0109	.1709
	2.0	35	2.714	.8935	.1510
40.	1.0	35	4.514	.7811	.1320
	2.0	35	4.143	.8793	.1486

Table 2: 't' values of variables

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
1	Equal variances assumed	.097	.756	4.352	68	.000	.6857	.1576	.3713	1.0001
	Equal variances not assumed			4.352	66.291	.000	.6857	.1576	.3712	1.0003
2	Equal variances assumed	1.522	.222	-3.935	68	.000	-1.4286	.3631	-2.1530	-.7041

	Equal variances not assumed			-3.935	67.585	.000	-1.4286	.3631	-2.1531	-.7040
3	Equal variances assumed	.085	.772	4.137	68	.000	.8571	.2072	.4437	1.2706
	Equal variances not assumed			4.137	67.924	.000	.8571	.2072	.4437	1.2706
4	Equal variances assumed	.590	.445	3.892	68	.000	.8000	.2056	.3898	1.2102
	Equal variances not assumed			3.892	65.979	.000	.8000	.2056	.3896	1.2104
5	Equal variances assumed	.110	.742	4.279	68	.000	.8286	.1937	.4421	1.2150
	Equal variances not assumed			4.279	66.302	.000	.8286	.1937	.4420	1.2152

6	Equal variances assumed	.448	.506	4.090	68	.000	1.1429	.2794	.5853	1.7004
	Equal variances not assumed			4.090	67.836	.000	1.1429	.2794	.5852	1.7005
7	Equal variances assumed	.158	.692	-.600	68	.550	-.1143	.1904	-.4942	.2657
	Equal variances not assumed			-.600	67.800	.550	-.1143	.1904	-.4943	.2657
8	Equal variances assumed	2.357	.129	-1.197	68	.235	-.2286	.1909	-.6095	.1524
	Equal variances not assumed			-1.197	64.187	.236	-.2286	.1909	-.6099	.1528
9	Equal variances assumed	.667	.417	2.810	68	.006	.6857	.2440	.1988	1.1726

	Equal variances not assumed			2.810	61.474	.007	.6857	.2440	.1979	1.1736
10	Equal variances assumed	.004	.948	1.773	68	.081	.4000	.2256	-.0502	.8502
	Equal variances not assumed			1.773	67.576	.081	.4000	.2256	-.0503	.8503
11	Equal variances assumed	.021	.886	2.608	68	.011	.6000	.2300	.1410	1.0590
	Equal variances not assumed			2.608	67.466	.011	.6000	.2300	.1409	1.0591
12	Equal variances assumed	.461	.499	3.304	68	.002	.9143	.2768	.3620	1.4665
	Equal variances not assumed			3.304	67.487	.002	.9143	.2768	.3620	1.4666

13	Equal variances assumed	43.033	.000	-3.115	68	.003	-.3143	.1009	-.5156	-.1130
	Equal variances not assumed			-3.115	58.005	.003	-.3143	.1009	-.5163	-.1123
14	Equal variances assumed	3.175	.079	2.562	68	.013	.6571	.2565	.1453	1.1690
	Equal variances not assumed			2.562	65.565	.013	.6571	.2565	.1450	1.1693
15	Equal variances assumed	.000	.984	2.945	68	.004	.7429	.2522	.2395	1.2462
	Equal variances not assumed			2.945	67.963	.004	.7429	.2522	.2395	1.2462
16	Equal variances assumed	2.246	.139	2.481	68	.016	.7714	.3109	.1510	1.3918

	Equal variances not assumed			2.481	67.070	.016	.7714	.3109	.1509	1.3920
17	Equal variances assumed	6.218	.015	3.529	68	.001	.8000	.2267	.3477	1.2523
	Equal variances not assumed			3.529	65.792	.001	.8000	.2267	.3474	1.2526
18	Equal variances assumed	.420	.519	2.469	68	.016	.6000	.2430	.1150	1.0850
	Equal variances not assumed			2.469	65.817	.016	.6000	.2430	.1147	1.0853
19	Equal variances assumed	.835	.364	4.351	68	.000	.9429	.2167	.5104	1.3753
	Equal variances not assumed			4.351	67.762	.000	.9429	.2167	.5104	1.3753

20	Equal variances assumed	.053	.818	-.577	68	.566	-.1429	.2475	-.6368	.3511
	Equal variances not assumed			-.577	67.996	.566	-.1429	.2475	-.6368	.3511
21	Equal variances assumed	.093	.762	2.845	68	.006	.9143	.3213	.2731	1.5555
	Equal variances not assumed			2.845	67.865	.006	.9143	.3213	.2731	1.5555
22	Equal variances assumed	.001	.972	3.993	68	.000	1.0571	.2648	.5288	1.5855
	Equal variances not assumed			3.993	67.963	.000	1.0571	.2648	.5288	1.5855
23	Equal variances assumed	.451	.504	3.808	68	.000	1.0571	.2776	.5032	1.6111

	Equal variances not assumed			3.808	67.403	.000	1.0571	.2776	.5031	1.6112
24	Equal variances assumed	2.944	.091	4.928	68	.000	1.2571	.2551	.7481	1.7661
	Equal variances not assumed			4.928	64.639	.000	1.2571	.2551	.7477	1.7666
25	Equal variances assumed	.369	.546	6.506	68	.000	1.5429	.2371	1.0697	2.0160
	Equal variances not assumed			6.506	67.555	.000	1.5429	.2371	1.0696	2.0161
26	Equal variances assumed	.070	.792	5.031	68	.000	1.2857	.2556	.7758	1.7957
	Equal variances not assumed			5.031	67.996	.000	1.2857	.2556	.7758	1.7957

27	Equal variances assumed	3.455	.067	2.442	68	.017	.6286	.2574	.1149	1.1423
	Equal variances not assumed			2.442	64.813	.017	.6286	.2574	.1144	1.1427
28	Equal variances assumed	.254	.616	3.808	68	.000	.8571	.2251	.4080	1.3063
	Equal variances not assumed			3.808	67.743	.000	.8571	.2251	.4080	1.3063
29	Equal variances assumed	9.728	.003	3.894	68	.000	.6571	.1687	.3204	.9939
	Equal variances not assumed			3.894	62.666	.000	.6571	.1687	.3199	.9944
30	Equal variances assumed	1.050	.309	3.240	68	.002	.8000	.2470	.3072	1.2928

	Equal variances not assumed			3.240	63.552	.002	.8000	.2470	.3066	1.2934
31	Equal variances assumed	.652	.422	3.345	68	.001	.6000	.1794	.2421	.9579
	Equal variances not assumed			3.345	64.588	.001	.6000	.1794	.2417	.9583
32	Equal variances assumed	1.126	.292	2.889	68	.005	.5143	.1780	.1590	.8695
	Equal variances not assumed			2.889	66.648	.005	.5143	.1780	.1589	.8697
33	Equal variances assumed	3.014	.087	3.369	68	.001	.6286	.1866	.2562	1.0009
	Equal variances not assumed			3.369	66.443	.001	.6286	.1866	.2561	1.0011

34	Equal variances assumed	.704	.404	3.327	68	.001	.8286	.2491	.3315	1.3256
	Equal variances not assumed			3.327	67.997	.001	.8286	.2491	.3315	1.3256
35	Equal variances assumed	6.078	.016	4.249	68	.000	.8857	.2085	.4697	1.3017
	Equal variances not assumed			4.249	58.665	.000	.8857	.2085	.4685	1.3029
36	Equal variances assumed	.129	.721	3.561	68	.001	.9429	.2648	.4145	1.4712
	Equal variances not assumed			3.561	67.959	.001	.9429	.2648	.4145	1.4712
37	Equal variances assumed	.819	.369	2.716	68	.008	.5429	.1999	.1440	.9417

	Equal variances not assumed			2.716	67.923	.008	.5429	.1999	.1440	.9417
38	Equal variances assumed	6.983	.010	4.247	68	.000	.7143	.1682	.3787	1.0499
	Equal variances not assumed			4.247	64.606	.000	.7143	.1682	.3784	1.0502
39	Equal variances assumed	1.384	.244	3.508	68	.001	.8000	.2280	.3449	1.2551
	Equal variances not assumed			3.508	66.990	.001	.8000	.2280	.3448	1.2552
40	Equal variances assumed	.165	.686	1.868	68	.066	.3714	.1988	-.0253	.7681
	Equal variances not assumed			1.868	67.068	.066	.3714	.1988	-.0254	.7682

Table 3: Mean values of variables between 'Innovators' and 'Followers' in Automotive sector

Group Statistics					
	Innovation rank	N	Mean	Std. Deviation	Std. Error Mean
B4	1.0	20	3.500	.6882	.1539
	2.0	24	2.625	.7109	.1451
B5	1.0	20	1.200	1.6416	.3671
	2.0	24	2.500	1.3513	.2758
C1	1.0	20	3.400	.8208	.1835
	2.0	24	2.500	.8847	.1806
C4	1.0	20	3.500	.8885	.1987
	2.0	24	2.625	1.0555	.2155
C5	1.0	20	3.450	.8870	.1983
	2.0	24	2.667	.7614	.1554
C6	1.0	20	3.600	1.2312	.2753
	2.0	24	2.583	1.3486	.2753
C7	1.0	20	2.700	.8645	.1933
	2.0	24	2.458	.7790	.1590
C8	1.0	20	1.600	.6806	.1522
	2.0	24	1.792	.9315	.1901
C9	1.0	20	2.800	1.2397	.2772
	2.0	24	2.208	.8330	.1700
C10	1.0	20	2.700	1.0809	.2417
	2.0	24	2.542	.8836	.1804
C11	1.0	20	3.550	.9987	.2233
	2.0	24	2.750	1.0321	.2107
C12	1.0	20	3.050	1.3945	.3118
	2.0	24	1.958	1.0826	.2210
C15	1.0	20	1.650	.4894	.1094
	2.0	24	1.875	.3378	.0690
C16	1.0	20	3.100	1.0712	.2395
	2.0	24	2.208	1.1025	.2251
C17	1.0	20	2.750	1.2513	.2798
	2.0	24	1.958	.9079	.1853
C18	1.0	20	2.800	1.1965	.2675
	2.0	24	1.792	1.2151	.2480
C19	1.0	20	2.950	.8870	.1983
	2.0	24	2.125	1.1156	.2277

C20	1.0	20	2.850	1.0400	.2325
	2.0	24	2.583	.8805	.1797
C21	1.0	20	3.000	.9733	.2176
	2.0	24	2.208	.9315	.1901
C22	1.0	20	2.950	1.0501	.2348
	2.0	24	2.792	1.0206	.2083
C23	1.0	20	3.300	1.5594	.3487
	2.0	24	2.500	1.3188	.2692
C24	1.0	20	3.650	1.2258	.2741
	2.0	24	2.250	1.1132	.2272
C25	1.0	20	3.800	1.1517	.2575
	2.0	24	2.375	1.2091	.2468
C26	1.0	20	3.200	1.2397	.2772
	2.0	24	2.042	.9546	.1949
C27	1.0	20	4.000	1.0260	.2294
	2.0	24	2.417	1.1389	.2325
C28	1.0	20	3.800	1.1965	.2675
	2.0	24	2.583	1.1001	.2246
C30	1.0	20	2.000	.9733	.2176
	2.0	24	1.583	.7755	.1583
C31	1.0	20	3.250	1.0699	.2392
	2.0	24	2.250	.9891	.2019
D6	1.0	20	3.900	.6407	.1433
	2.0	24	3.417	.7755	.1583
D11	1.0	20	3.250	1.2513	.2798
	2.0	24	2.333	.8681	.1772
E1	1.0	20	4.900	.3078	.0688
	2.0	24	4.167	.7614	.1554
E2	1.0	20	4.900	.3078	.0688
	2.0	24	4.083	.7755	.1583
E3	1.0	20	4.600	.5982	.1338
	2.0	24	3.542	1.1025	.2251
E4	1.0	20	4.250	.7164	.1602
	2.0	24	3.167	1.0901	.2225
E5	1.0	20	3.500	1.2773	.2856
	2.0	24	2.625	1.2091	.2468
E7	1.0	20	4.250	.8507	.1902
	2.0	24	3.500	.9325	.1903

E8	1.0	20	4.000	.6489	.1451
	2.0	24	3.208	.8330	.1700
E9	1.0	20	3.500	1.1471	.2565
	2.0	24	2.625	.7697	.1571
E10	1.0	20	4.500	.9459	.2115
	2.0	24	4.208	.9771	.1994

Table 4: 't' test for Automotive sector

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
B4	Equal variances assumed	.024	.877	4.124	42	.000	.8750	.2122	.4468	1.3032
	Equal variances not assumed			4.137	41.020	.000	.8750	.2115	.4478	1.3022
B5	Equal variances assumed	1.251	.270	-2.882	42	.006	-1.3000	.4510	-2.2102	-.3898
	Equal variances not assumed			-2.831	36.819	.007	-1.3000	.4592	-2.2305	-.3695
C1	Equal variances assumed	.609	.440	3.471	42	.001	.9000	.2593	.3768	1.4232
	Equal variances not assumed			3.495	41.480	.001	.9000	.2575	.3802	1.4198

C4	Equal variances assumed	1.157	.288	2.939	42	.005	.8750	.2978	.2741	1.4759
	Equal variances not assumed			2.986	41.991	.005	.8750	.2931	.2835	1.4665
C5	Equal variances assumed	1.095	.301	3.153	42	.003	.7833	.2485	.2819	1.2847
	Equal variances not assumed			3.109	37.740	.004	.7833	.2520	.2731	1.2936
C6	Equal variances assumed	1.189	.282	2.589	42	.013	1.0167	.3926	.2243	1.8090
	Equal variances not assumed			2.611	41.619	.012	1.0167	.3893	.2308	1.8026
C7	Equal variances assumed	.041	.841	.975	42	.335	.2417	.2479	-.2586	.7420
	Equal variances not assumed			.965	38.755	.340	.2417	.2503	-.2647	.7481
C8	Equal variances assumed	2.583	.116	-.765	42	.449	-.1917	.2505	-.6973	.3139
	Equal variances not assumed			-.787	41.359	.436	-.1917	.2435	-.6834	.3001
C9	Equal variances assumed	1.921	.173	1.885	42	.066	.5917	.3139	-.0419	1.2252
	Equal variances not assumed			1.819	32.219	.078	.5917	.3252	-.0706	1.2539
C10	Equal variances assumed	.492	.487	.535	42	.596	.1583	.2961	-.4391	.7558

	Equal variances not assumed			.525	36.661	.603	.1583	.3016	-.4529	.7696
C11	Equal variances assumed	.048	.828	2.598	42	.013	.8000	.3079	.1785	1.4215
	Equal variances not assumed			2.606	41.025	.013	.8000	.3070	.1800	1.4200
C12	Equal variances assumed	1.873	.178	2.923	42	.006	1.0917	.3735	.3380	1.8454
	Equal variances not assumed			2.856	35.484	.007	1.0917	.3822	.3161	1.8672
C15	Equal variances assumed	13.559	.001	-1.798	42	.079	-.2250	.1251	-.4775	.0275
	Equal variances not assumed			-1.740	32.813	.091	-.2250	.1293	-.4882	.0382
C16	Equal variances assumed	.882	.353	2.706	42	.010	.8917	.3295	.2266	1.5567
	Equal variances not assumed			2.713	40.975	.010	.8917	.3287	.2279	1.5554
C17	Equal variances assumed	3.159	.083	2.428	42	.020	.7917	.3260	.1337	1.4497
	Equal variances not assumed			2.359	33.932	.024	.7917	.3356	.1096	1.4738
C18	Equal variances assumed	.056	.813	2.760	42	.009	1.0083	.3653	.2710	1.7456
	Equal variances not assumed			2.764	40.799	.009	1.0083	.3648	.2714	1.7452

C19	Equal variances assumed	5.276	.027	2.675	42	.011	.8250	.3084	.2026	1.4474
	Equal variances not assumed			2.732	41.925	.009	.8250	.3020	.2155	1.4345
C20	Equal variances assumed	.140	.710	.921	42	.362	.2667	.2894	-.3174	.8508
	Equal variances not assumed			.907	37.443	.370	.2667	.2939	-.3286	.8620
C21	Equal variances assumed	.117	.734	2.750	42	.009	.7917	.2878	.2108	1.3725
	Equal variances not assumed			2.739	39.881	.009	.7917	.2890	.2075	1.3758
C22	Equal variances assumed	.004	.950	.506	42	.616	.1583	.3131	-.4735	.7901
	Equal variances not assumed			.504	40.140	.617	.1583	.3139	-.4760	.7927
C23	Equal variances assumed	1.231	.274	1.844	42	.072	.8000	.4337	-.0753	1.6753
	Equal variances not assumed			1.816	37.418	.077	.8000	.4405	-.0922	1.6922
C24	Equal variances assumed	.416	.522	3.968	42	.000	1.4000	.3529	.6879	2.1121
	Equal variances not assumed			3.932	38.908	.000	1.4000	.3560	.6798	2.1202
C25	Equal variances assumed	.173	.679	3.977	42	.000	1.4250	.3583	.7019	2.1481

	Equal variances not assumed			3.995	41.212	.000	1.4250	.3567	.7048	2.1452
C26	Equal variances assumed	2.082	.156	3.501	42	.001	1.1583	.3309	.4906	1.8260
	Equal variances not assumed			3.419	35.296	.002	1.1583	.3388	.4707	1.8460
C27	Equal variances assumed	.423	.519	4.801	42	.000	1.5833	.3298	.9178	2.2489
	Equal variances not assumed			4.848	41.717	.000	1.5833	.3266	.9241	2.2426
C28	Equal variances assumed	.623	.434	3.511	42	.001	1.2167	.3466	.5173	1.9161
	Equal variances not assumed			3.483	39.149	.001	1.2167	.3493	.5103	1.9231
C30	Equal variances assumed	1.370	.248	1.581	42	.121	.4167	.2636	-.1153	.9486
	Equal variances not assumed			1.548	36.080	.130	.4167	.2691	-.1291	.9624
C31	Equal variances assumed	.554	.461	3.218	42	.002	1.0000	.3108	.3728	1.6272
	Equal variances not assumed			3.194	39.252	.003	1.0000	.3130	.3669	1.6331
D6	Equal variances assumed	3.110	.085	2.224	42	.032	.4833	.2173	.0448	.9218
	Equal variances not assumed			2.264	41.999	.029	.4833	.2135	.0525	.9142

D11	Equal variances assumed	2.427	.127	2.860	42	.007	.9167	.3206	.2697	1.5636
	Equal variances not assumed			2.768	32.923	.009	.9167	.3312	.2428	1.5905
E1	Equal variances assumed	17.755	.000	4.035	42	.000	.7333	.1817	.3666	1.1001
	Equal variances not assumed			4.314	31.442	.000	.7333	.1700	.3869	1.0798
E2	Equal variances assumed	14.140	.001	4.421	42	.000	.8167	.1847	.4439	1.1894
	Equal variances not assumed			4.731	31.169	.000	.8167	.1726	.4647	1.1686
E3	Equal variances assumed	12.045	.001	3.842	42	.000	1.0583	.2754	.5025	1.6142
	Equal variances not assumed			4.042	36.594	.000	1.0583	.2618	.5277	1.5890
E4	Equal variances assumed	2.213	.144	3.808	42	.000	1.0833	.2845	.5092	1.6575
	Equal variances not assumed			3.951	40.008	.000	1.0833	.2742	.5292	1.6375
E5	Equal variances assumed	.145	.705	2.330	42	.025	.8750	.3756	.1171	1.6329
	Equal variances not assumed			2.318	39.688	.026	.8750	.3775	.1119	1.6381
E7	Equal variances assumed	.650	.425	2.763	42	.008	.7500	.2714	.2023	1.2977

	Equal variances not assumed			2.787	41.624	.008	.7500	.2691	.2068	1.2932
E8	Equal variances assumed	5.062	.030	3.462	42	.001	.7917	.2287	.3302	1.2531
	Equal variances not assumed			3.542	41.838	.001	.7917	.2235	.3405	1.2428
E9	Equal variances assumed	4.638	.037	3.014	42	.004	.8750	.2903	.2891	1.4609
	Equal variances not assumed			2.909	32.188	.007	.8750	.3008	.2625	1.4875
E10	Equal variances assumed	.147	.703	1.000	42	.323	.2917	.2916	-.2968	.8801
	Equal variances not assumed			1.003	41.020	.322	.2917	.2907	-.2954	.8788

Table 5: Mean values of variables (Earthmoving Sector)

Group Statistics					
	Innovation rank	N	Mean	Std. Deviation	Std. Error Mean
B4	1.0	15	3.267	.4577	.1182
	2.0	11	2.909	.7006	.2113
B5	1.0	15	1.733	1.4864	.3838
	2.0	11	3.636	1.4334	.4322
C1	1.0	15	3.400	.9856	.2545
	2.0	11	2.636	.8090	.2439
C4	1.0	15	3.467	.6399	.1652
	2.0	11	2.818	.6030	.1818
C5	1.0	15	3.533	.5164	.1333
	2.0	11	2.636	1.1201	.3377
C6	1.0	15	3.667	1.0465	.2702
	2.0	11	2.273	.7862	.2371

C7	1.0	15	2.200	.6761	.1746
	2.0	11	2.909	.7006	.2113
C8	1.0	15	1.600	.7368	.1902
	2.0	11	1.909	.8312	.2506
C9	1.0	15	3.333	1.0465	.2702
	2.0	11	2.636	.8090	.2439
C10	1.0	15	2.800	.8619	.2225
	2.0	11	1.909	.8312	.2506
C11	1.0	15	3.333	.8165	.2108
	2.0	11	3.091	.9439	.2846
C12	1.0	15	3.200	.9411	.2430
	2.0	11	2.727	1.0090	.3042
C15	1.0	15	1.467	.5164	.1333
	2.0	11	1.909	.3015	.0909
C16	1.0	15	3.333	.8165	.2108
	2.0	11	3.273	1.0090	.3042
C17	1.0	15	3.133	.7432	.1919
	2.0	11	2.636	1.2060	.3636
C18	1.0	15	3.067	1.2799	.3305
	2.0	11	2.909	1.4460	.4360
C19	1.0	15	3.133	.8338	.2153
	2.0	11	2.455	.8202	.2473
C20	1.0	15	3.467	1.1255	.2906
	2.0	11	2.364	1.0269	.3096
C21	1.0	15	3.333	.7237	.1869
	2.0	11	2.182	.9816	.2960
C22	1.0	15	2.533	.9904	.2557
	2.0	11	3.182	1.0787	.3252
C23	1.0	15	3.467	1.1255	.2906
	2.0	11	2.364	1.3618	.4106
C24	1.0	15	3.333	.8997	.2323
	2.0	11	2.909	1.0445	.3149
C25	1.0	15	3.533	1.0601	.2737
	2.0	11	3.182	1.0787	.3252
C26	1.0	15	3.467	1.1255	.2906
	2.0	11	2.091	.9439	.2846
C27	1.0	15	3.800	.8619	.2225
	2.0	11	2.273	.7862	.2371

C28	1.0	15	3.600	.9103	.2350
	2.0	11	2.091	.9439	.2846
C30	1.0	15	2.867	1.3020	.3362
	2.0	11	2.091	1.2210	.3682
C31	1.0	15	2.667	.7237	.1869
	2.0	11	1.909	.7006	.2113
D6	1.0	15	4.133	.5164	.1333
	2.0	11	3.182	.8739	.2635
D11	1.0	15	2.800	1.0142	.2619
	2.0	11	2.091	.9439	.2846
E1	1.0	15	4.267	.8837	.2282
	2.0	11	4.000	.8944	.2697
E2	1.0	15	4.400	.9856	.2545
	2.0	11	4.000	1.0000	.3015
E3	1.0	15	3.867	1.3558	.3501
	2.0	11	3.273	.9045	.2727
E4	1.0	15	3.933	.5936	.1533
	2.0	11	3.364	.9244	.2787
E5	1.0	15	3.467	.9155	.2364
	2.0	11	2.364	.8090	.2439
E7	1.0	15	3.600	.6325	.1633
	2.0	11	3.273	.6467	.1950
E8	1.0	15	3.933	.5936	.1533
	2.0	11	3.364	.6742	.2033
E9	1.0	15	3.533	.8338	.2153
	2.0	11	2.909	1.1362	.3426
E10	1.0	15	4.533	.5164	.1333
	2.0	11	4.000	.6325	.1907

Table 6:'t' values of variable (Earthmoving Sector)

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
B4	Equal variances assumed	.588	.451	1.576	24	.128	.3576	.2269	-.1108	.8259
	Equal variances not assumed			1.477	16.112	.159	.3576	.2421	-.1553	.8704
B5	Equal variances assumed	.271	.608	-3.273	24	.003	-1.9030	.5814	-3.1029	-.7031
	Equal variances not assumed			-3.292	22.152	.003	-1.9030	.5780	-3.1012	-.7048
C1	Equal variances assumed	.220	.643	2.100	24	.046	.7636	.3637	.0130	1.5142
	Equal variances not assumed			2.166	23.624	.041	.7636	.3525	.0355	1.4918

C4	Equal variances assumed	2.611	.119	2.615	24	.015	.6485	.2480	.1366	1.1604
	Equal variances not assumed			2.640	22.417	.015	.6485	.2457	.1395	1.1574
C5	Equal variances assumed	3.259	.084	2.744	24	.011	.8970	.3269	.2222	1.5717
	Equal variances not assumed			2.470	13.133	.028	.8970	.3631	.1134	1.6806
C6	Equal variances assumed	.851	.365	3.709	24	.001	1.3939	.3758	.6182	2.1696
	Equal variances not assumed			3.878	23.967	.001	1.3939	.3595	.6520	2.1359
C7	Equal variances assumed	.049	.826	-2.602	24	.016	-.7091	.2725	-1.2715	-.1467
	Equal variances not assumed			-2.587	21.245	.017	-.7091	.2741	-1.2786	-.1396
C8	Equal variances assumed	.019	.891	-1.001	24	.327	-.3091	.3086	-.9461	.3279

	Equal variances not assumed			-.982	20.082	.338	-.3091	.3146	-.9653	.3471
C9	Equal variances assumed	.477	.496	1.839	24	.078	.6970	.3790	-.0853	1.4792
	Equal variances not assumed			1.915	23.897	.068	.6970	.3640	-.0545	1.4485
C10	Equal variances assumed	.001	.978	2.643	24	.014	.8909	.3371	.1951	1.5867
	Equal variances not assumed			2.658	22.150	.014	.8909	.3352	.1961	1.5857
C11	Equal variances assumed	.001	.979	.700	24	.490	.2424	.3461	-.4719	.9567
	Equal variances not assumed			.684	19.740	.502	.2424	.3542	-.4970	.9818
C12	Equal variances assumed	.004	.949	1.228	24	.231	.4727	.3851	-.3220	1.2674
	Equal variances not assumed			1.214	20.786	.238	.4727	.3894	-.3375	1.2830

C15	Equal variances assumed	26.933	.000	-2.534	24	.018	-.4424	.1746	-.8028	-.0821
	Equal variances not assumed			-2.742	23.064	.012	-.4424	.1614	-.7762	-.1086
C16	Equal variances assumed	.206	.654	.169	24	.867	.0606	.3580	-.6782	.7994
	Equal variances not assumed			.164	18.811	.872	.0606	.3701	-.7146	.8359
C17	Equal variances assumed	2.694	.114	1.299	24	.206	.4970	.3825	-.2924	1.2863
	Equal variances not assumed			1.209	15.487	.245	.4970	.4112	-.3770	1.3710
C18	Equal variances assumed	.458	.505	.294	24	.772	.1576	.5365	-.9497	1.2649
	Equal variances not assumed			.288	20.061	.776	.1576	.5471	-.9834	1.2985
C19	Equal variances assumed	.000	.996	2.065	24	.050	.6788	.3287	.0003	1.3573

	Equal variances not assumed			2.070	21.912	.050	.6788	.3279	-.0014	1.3589
C20	Equal variances assumed	.019	.891	2.560	24	.017	1.1030	.4309	.2137	1.9923
	Equal variances not assumed			2.598	22.761	.016	1.1030	.4246	.2241	1.9820
C21	Equal variances assumed	1.134	.298	3.450	24	.002	1.1515	.3338	.4626	1.8404
	Equal variances not assumed			3.290	17.568	.004	1.1515	.3500	.4148	1.8882
C22	Equal variances assumed	.226	.639	-1.589	24	.125	-.6485	.4081	-1.4908	.1939
	Equal variances not assumed			-1.567	20.570	.132	-.6485	.4137	-1.5100	.2130
C23	Equal variances assumed	.757	.393	2.260	24	.033	1.1030	.4881	.0957	2.1103
	Equal variances not assumed			2.193	19.103	.041	1.1030	.5030	.0506	2.1555

C24	Equal variances assumed	.124	.728	1.110	24	.278	.4242	.3821	-.3645	1.2130
	Equal variances not assumed			1.084	19.682	.291	.4242	.3913	-.3929	1.2414
C25	Equal variances assumed	.258	.616	.829	24	.415	.3515	.4239	-.5234	1.2264
	Equal variances not assumed			.827	21.483	.417	.3515	.4251	-.5313	1.2343
C26	Equal variances assumed	.512	.481	3.289	24	.003	1.3758	.4182	.5126	2.2390
	Equal variances not assumed			3.382	23.486	.003	1.3758	.4067	.5353	2.2162
C27	Equal variances assumed	.001	.976	4.629	24	.000	1.5273	.3300	.8463	2.2083
	Equal variances not assumed			4.697	22.764	.000	1.5273	.3251	.8543	2.2003
C28	Equal variances assumed	.107	.747	4.112	24	.000	1.5091	.3670	.7517	2.2664

	Equal variances not assumed			4.089	21.236	.001	1.5091	.3691	.7420	2.2761
C30	Equal variances assumed	.540	.470	1.540	24	.137	.7758	.5037	-.2638	1.8153
	Equal variances not assumed			1.556	22.470	.134	.7758	.4986	-.2569	1.8084
C31	Equal variances assumed	.652	.427	2.672	24	.013	.7576	.2835	.1724	1.3427
	Equal variances not assumed			2.686	22.105	.013	.7576	.2820	.1728	1.3423
D6	Equal variances assumed	2.308	.142	3.483	24	.002	.9515	.2732	.3876	1.5154
	Equal variances not assumed			3.222	15.072	.006	.9515	.2953	.3224	1.5807
D11	Equal variances assumed	.150	.702	1.813	24	.082	.7091	.3912	-.0983	1.5165
	Equal variances not assumed			1.834	22.553	.080	.7091	.3867	-.0918	1.5100

E1	Equal variances assumed	.117	.735	.756	24	.457	.2667	.3526	-.4610	.9943
	Equal variances not assumed			.755	21.553	.458	.2667	.3533	-.4668	1.0002
E2	Equal variances assumed	.369	.549	1.016	24	.320	.4000	.3936	-.4124	1.2124
	Equal variances not assumed			1.014	21.521	.322	.4000	.3946	-.4193	1.2193
E3	Equal variances assumed	.775	.387	1.259	24	.220	.5939	.4719	-.3800	1.5679
	Equal variances not assumed			1.338	23.851	.193	.5939	.4438	-.3222	1.5101
E4	Equal variances assumed	4.536	.044	1.915	24	.067	.5697	.2975	-.0443	1.1837
	Equal variances not assumed			1.791	15.922	.092	.5697	.3181	-.1049	1.2443
E5	Equal variances assumed	.533	.473	3.184	24	.004	1.1030	.3464	.3880	1.8180

	Equal variances not assumed			3.247	23.068	.004	1.1030	.3397	.4005	1.8056
E7	Equal variances assumed	.682	.417	1.291	24	.209	.3273	.2534	-.1958	.8503
	Equal variances not assumed			1.287	21.421	.212	.3273	.2543	-.2010	.8555
E8	Equal variances assumed	1.730	.201	2.284	24	.032	.5697	.2495	.0548	1.0846
	Equal variances not assumed			2.238	19.988	.037	.5697	.2546	.0386	1.1008
E9	Equal variances assumed	.448	.510	1.619	24	.119	.6242	.3856	-.1715	1.4200
	Equal variances not assumed			1.543	17.508	.141	.6242	.4046	-.2275	1.4760
E10	Equal variances assumed	1.070	.311	2.367	24	.026	.5333	.2253	.0683	.9984
	Equal variances not assumed			2.292	18.935	.034	.5333	.2327	.0462	1.0205

Appendix C

Questionnaire - Reliability test for Scaled Items in Questionnaire – Cronbach's alpha

Case Processing Summary

		N	%
Cases	Valid	70	100.0
	Excluded[a]	0	.0
	Total	70	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.923	58

Objective – 1: 't' test results for Innovators and Followers

Mean values for the two groups – for the variables considered for 't' test

Group Statistics

	Innovation rank	N	Mean	Std. Deviation	Std. Error Mean
B4	1.0	35	3.400	.6039	.1021
	2.0	35	2.714	.7101	.1200
B5	1.0	35	1.429	1.5771	.2666
	2.0	35	2.857	1.4581	.2465
C1	1.0	35	3.400	.8812	.1489
	2.0	35	2.543	.8521	.1440
C4	1.0	35	3.486	.7811	.1320
	2.0	35	2.686	.9322	.1576
C5	1.0	35	3.486	.7425	.1255
	2.0	35	2.657	.8726	.1475
C6	1.0	35	3.629	1.1398	.1927
	2.0	35	2.486	1.1973	.2024

C7	1.0	35	2.486	.8179	.1382
	2.0	35	2.600	.7746	.1309
C8	1.0	35	1.600	.6945	.1174
	2.0	35	1.829	.8907	.1505
C9	1.0	35	3.029	1.1754	.1987
	2.0	35	2.343	.8382	.1417
C10	1.0	35	2.743	.9805	.1657
	2.0	35	2.343	.9056	.1531
C11	1.0	35	3.457	.9185	.1553
	2.0	35	2.857	1.0042	.1697
C12	1.0	35	3.114	1.2071	.2040
	2.0	35	2.200	1.1061	.1870
C15	1.0	35	1.571	.5021	.0849
	2.0	35	1.886	.3228	.0546
C16	1.0	35	3.200	.9641	.1630
	2.0	35	2.543	1.1718	.1981
C17	1.0	35	2.914	1.0675	.1804
	2.0	35	2.171	1.0428	.1763
C18	1.0	35	2.914	1.2217	.2065
	2.0	35	2.143	1.3750	.2324
C19	1.0	35	3.029	.8570	.1449
	2.0	35	2.229	1.0314	.1743
C20	1.0	35	3.114	1.1054	.1868
	2.0	35	2.514	.9194	.1554
C21	1.0	35	3.143	.8793	.1486
	2.0	35	2.200	.9331	.1577
C22	1.0	35	2.771	1.0314	.1743
	2.0	35	2.914	1.0396	.1757
C23	1.0	35	3.371	1.3738	.2322
	2.0	35	2.457	1.3138	.2221
C24	1.0	35	3.514	1.0947	.1850
	2.0	35	2.457	1.1205	.1894
C25	1.0	35	3.686	1.1054	.1868
	2.0	35	2.629	1.2148	.2053
C26	1.0	35	3.314	1.1825	.1999
	2.0	35	2.057	.9375	.1585
C27	1.0	35	3.914	.9509	.1607

	2.0	35	2.371	1.0314	.1743
C28	1.0	35	3.714	1.0730	.1814
	2.0	35	2.429	1.0651	.1800
C30	1.0	35	2.371	1.1903	.2012
	2.0	35	1.743	.9500	.1606
C31	1.0	35	3.000	.9701	.1640
	2.0	35	2.143	.9121	.1542
D6	1.0	35	4.000	.5941	.1004
	2.0	35	3.343	.8023	.1356
D11	1.0	35	3.057	1.1617	.1964
	2.0	35	2.257	.8859	.1497
D12	1.0	35	4.486	.6585	.1113
	2.0	35	3.886	.8321	.1407
E1	1.0	35	4.629	.6897	.1166
	2.0	35	4.114	.7960	.1345
E2	1.0	35	4.686	.7183	.1214
	2.0	35	4.057	.8382	.1417
E3	1.0	35	4.286	1.0452	.1767
	2.0	35	3.457	1.0387	.1756
E4	1.0	35	4.114	.6761	.1143
	2.0	35	3.229	1.0314	.1743
E5	1.0	35	3.486	1.1212	.1895
	2.0	35	2.543	1.0939	.1849
E7	1.0	35	3.971	.8220	.1389
	2.0	35	3.429	.8501	.1437
E8	1.0	35	3.971	.6177	.1044
	2.0	35	3.257	.7800	.1318
E9	1.0	35	3.514	1.0109	.1709
	2.0	35	2.714	.8935	.1510
E10	1.0	35	4.514	.7811	.1320
	2.0	35	4.143	.8793	.1486

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
B4	Equal variances assumed	.097	.756	4.352	68	.000	.6857	.1576	.3713	1.0001
	Equal variances not assumed			4.352	66.291	.000	.6857	.1576	.3712	1.0003
B5	Equal variances assumed	1.522	.222	-3.935	68	.000	-1.4286	.3631	-2.1530	-.7041
	Equal variances not assumed			-3.935	67.585	.000	-1.4286	.3631	-2.1531	-.7040
C1	Equal variances assumed	.085	.772	4.137	68	.000	.8571	.2072	.4437	1.2706
	Equal variances not assumed			4.137	67.924	.000	.8571	.2072	.4437	1.2706

C4	Equal variances assumed	.590	.445	3.892	68	.000	.8000	.2056	.3898	1.2102
	Equal variances not assumed			3.892	65.979	.000	.8000	.2056	.3896	1.2104
C5	Equal variances assumed	.110	.742	4.279	68	.000	.8286	.1937	.4421	1.2150
	Equal variances not assumed			4.279	66.302	.000	.8286	.1937	.4420	1.2152
C6	Equal variances assumed	.448	.506	4.090	68	.000	1.1429	.2794	.5853	1.7004
	Equal variances not assumed			4.090	67.836	.000	1.1429	.2794	.5852	1.7005
C7	Equal variances assumed	.158	.692	-.600	68	.550	-.1143	.1904	-.4942	.2657

	Equal variances not assumed			-.600	67.800	.550	-.1143	.1904	-.4943	.2657
C8	Equal variances assumed	2.357	.129	-1.197	68	.235	-.2286	.1909	-.6095	.1524
	Equal variances not assumed			-1.197	64.187	.236	-.2286	.1909	-.6099	.1528
C9	Equal variances assumed	.667	.417	2.810	68	.006	.6857	.2440	.1988	1.1726
	Equal variances not assumed			2.810	61.474	.007	.6857	.2440	.1979	1.1736
C10	Equal variances assumed	.004	.948	1.773	68	.081	.4000	.2256	-.0502	.8502
	Equal variances not assumed			1.773	67.576	.081	.4000	.2256	-.0503	.8503

C11	Equal variances assumed	.021	.886	2.608	68	.011	.6000	.2300	.1410	1.0590
	Equal variances not assumed			2.608	67.466	.011	.6000	.2300	.1409	1.0591
C12	Equal variances assumed	.461	.499	3.304	68	.002	.9143	.2768	.3620	1.4665
	Equal variances not assumed			3.304	67.487	.002	.9143	.2768	.3620	1.4666
C15	Equal variances assumed	43.033	.000	-3.115	68	.003	-.3143	.1009	-.5156	-.1130
	Equal variances not assumed			-3.115	58.005	.003	-.3143	.1009	-.5163	-.1123
C16	Equal variances assumed	3.175	.079	2.562	68	.013	.6571	.2565	.1453	1.1690

	Equal variances not assumed			2.562	65.565	.013	.6571	.2565	.1450	1.1693
C17	Equal variances assumed	.000	.984	2.945	68	.004	.7429	.2522	.2395	1.2462
	Equal variances not assumed			2.945	67.963	.004	.7429	.2522	.2395	1.2462
C18	Equal variances assumed	2.246	.139	2.481	68	.016	.7714	.3109	.1510	1.3918
	Equal variances not assumed			2.481	67.070	.016	.7714	.3109	.1509	1.3920
C19	Equal variances assumed	6.218	.015	3.529	68	.001	.8000	.2267	.3477	1.2523
	Equal variances not assumed			3.529	65.792	.001	.8000	.2267	.3474	1.2526

C20	Equal variances assumed	.420	.519	2.469	68	.016	.6000	.2430	.1150	1.0850
	Equal variances not assumed			2.469	65.817	.016	.6000	.2430	.1147	1.0853
C21	Equal variances assumed	.835	.364	4.351	68	.000	.9429	.2167	.5104	1.3753
	Equal variances not assumed			4.351	67.762	.000	.9429	.2167	.5104	1.3753
C22	Equal variances assumed	.053	.818	-.577	68	.566	-.1429	.2475	-.6368	.3511
	Equal variances not assumed			-.577	67.996	.566	-.1429	.2475	-.6368	.3511
C23	Equal variances assumed	.093	.762	2.845	68	.006	.9143	.3213	.2731	1.5555

	Equal variances not assumed			2.845	67.865	.006	.9143	.3213	.2731	1.5555
C24	Equal variances assumed	.001	.972	3.993	68	.000	1.0571	.2648	.5288	1.5855
	Equal variances not assumed			3.993	67.963	.000	1.0571	.2648	.5288	1.5855
C25	Equal variances assumed	.451	.504	3.808	68	.000	1.0571	.2776	.5032	1.6111
	Equal variances not assumed			3.808	67.403	.000	1.0571	.2776	.5031	1.6112
C26	Equal variances assumed	2.944	.091	4.928	68	.000	1.2571	.2551	.7481	1.7661
	Equal variances not assumed			4.928	64.639	.000	1.2571	.2551	.7477	1.7666

C27	Equal variances assumed	.369	.546	6.506	68	.000	1.5429	.2371	1.0697	2.0160
	Equal variances not assumed			6.506	67.555	.000	1.5429	.2371	1.0696	2.0161
C28	Equal variances assumed	.070	.792	5.031	68	.000	1.2857	.2556	.7758	1.7957
	Equal variances not assumed			5.031	67.996	.000	1.2857	.2556	.7758	1.7957
C30	Equal variances assumed	3.455	.067	2.442	68	.017	.6286	.2574	.1149	1.1423
	Equal variances not assumed			2.442	64.813	.017	.6286	.2574	.1144	1.1427
C31	Equal variances assumed	.254	.616	3.808	68	.000	.8571	.2251	.4080	1.3063

	Equal variances not assumed			3.808	67.743	.000	.8571	.2251	.4080	1.3063
D6	Equal variances assumed	9.728	.003	3.894	68	.000	.6571	.1687	.3204	.9939
	Equal variances not assumed			3.894	62.666	.000	.6571	.1687	.3199	.9944
D11	Equal variances assumed	1.050	.309	3.240	68	.002	.8000	.2470	.3072	1.2928
	Equal variances not assumed			3.240	63.552	.002	.8000	.2470	.3066	1.2934
D12	Equal variances assumed	.652	.422	3.345	68	.001	.6000	.1794	.2421	.9579
	Equal variances not assumed			3.345	64.588	.001	.6000	.1794	.2417	.9583

E1	Equal variances assumed	1.126	.292	2.889	68	.005	.5143	.1780	.1590	.8695
	Equal variances not assumed			2.889	66.648	.005	.5143	.1780	.1589	.8697
E2	Equal variances assumed	3.014	.087	3.369	68	.001	.6286	.1866	.2562	1.0009
	Equal variances not assumed			3.369	66.443	.001	.6286	.1866	.2561	1.0011
E3	Equal variances assumed	.704	.404	3.327	68	.001	.8286	.2491	.3315	1.3256
	Equal variances not assumed			3.327	67.997	.001	.8286	.2491	.3315	1.3256
E4	Equal variances assumed	6.078	.016	4.249	68	.000	.8857	.2085	.4697	1.3017

	Equal variances not assumed			4.249	58.665	.000	.8857	.2085	.4685	1.3029
E5	Equal variances assumed	.129	.721	3.561	68	.001	.9429	.2648	.4145	1.4712
	Equal variances not assumed			3.561	67.959	.001	.9429	.2648	.4145	1.4712
E7	Equal variances assumed	.819	.369	2.716	68	.008	.5429	.1999	.1440	.9417
	Equal variances not assumed			2.716	67.923	.008	.5429	.1999	.1440	.9417
E8	Equal variances assumed	6.983	.010	4.247	68	.000	.7143	.1682	.3787	1.0499
	Equal variances not assumed			4.247	64.606	.000	.7143	.1682	.3784	1.0502

E9	Equal variances assumed	1.384	.244	3.508	68	.001	.8000	.2280	.3449	1.2551
	Equal variances not assumed			3.508	66.990	.001	.8000	.2280	.3448	1.2552
E10	Equal variances assumed	.165	.686	1.868	68	.066	.3714	.1988	-.0253	.7681
	Equal variances not assumed			1.868	67.068	.066	.3714	.1988	-.0254	.7682

‘t’ test results of Automotive (1) and earthmovers (2)

Group Statistics

	A1	N	Mean	Std. Deviation	Std. Error Mean
B4	1.0	44	3.023	.8209	.1238
	2.0	26	3.115	.5883	.1154
B5	1.0	44	1.909	1.6113	.2429
	2.0	26	2.538	1.7258	.3385
C1	1.0	44	2.909	.9601	.1447
	2.0	26	3.077	.9767	.1915
C4	1.0	44	3.023	1.0672	.1609
	2.0	26	3.192	.6939	.1361
C5	1.0	44	3.023	.9019	.1360
	2.0	26	3.154	.9249	.1814
C6	1.0	44	3.045	1.3802	.2081
	2.0	26	3.077	1.1635	.2282
C7	1.0	44	2.568	.8183	.1234

	2.0	26	2.500	.7616	.1494
C8	1.0	44	1.705	.8235	.1241
	2.0	26	1.731	.7776	.1525
C9	1.0	44	2.477	1.0672	.1609
	2.0	26	3.038	.9992	.1960
C10	1.0	44	2.614	.9697	.1462
	2.0	26	2.423	.9454	.1854
C11	1.0	44	3.114	1.0830	.1633
	2.0	26	3.231	.8629	.1692
C12	1.0	44	2.455	1.3374	.2016
	2.0	26	3.000	.9798	.1922
C15	1.0	44	1.773	.4239	.0639
	2.0	26	1.654	.4852	.0951
C16	1.0	44	2.614	1.1657	.1757
	2.0	26	3.308	.8840	.1734
C17	1.0	44	2.318	1.1366	.1713
	2.0	26	2.923	.9767	.1915
C18	1.0	44	2.250	1.2962	.1954
	2.0	26	3.000	1.3266	.2602
C19	1.0	44	2.500	1.0891	.1642
	2.0	26	2.846	.8806	.1727
C20	1.0	44	2.705	.9543	.1439
	2.0	26	3.000	1.2000	.2353
C21	1.0	44	2.568	1.0207	.1539
	2.0	26	2.846	1.0077	.1976
C22	1.0	44	2.864	1.0251	.1545
	2.0	26	2.808	1.0590	.2077
C23	1.0	44	2.864	1.4721	.2219
	2.0	26	3.000	1.3266	.2602
C24	1.0	44	2.886	1.3506	.2036
	2.0	26	3.154	.9672	.1897
C25	1.0	44	3.023	1.3723	.2069
	2.0	26	3.385	1.0612	.2081
C26	1.0	44	2.568	1.2275	.1851
	2.0	26	2.885	1.2434	.2439
C27	1.0	44	3.136	1.3397	.2020
	2.0	26	3.154	1.1204	.2197

C28	1.0	44	3.136	1.2866	.1940
	2.0	26	2.962	1.1826	.2319
C30	1.0	44	1.773	.8856	.1335
	2.0	26	2.538	1.3033	.2556
C31	1.0	44	2.705	1.1326	.1707
	2.0	26	2.346	.7971	.1563
D6	1.0	44	3.636	.7499	.1131
	2.0	26	3.731	.8274	.1623
D11	1.0	44	2.750	1.1437	.1724
	2.0	26	2.500	1.0296	.2019
D12	1.0	44	4.091	.8577	.1293
	2.0	26	4.346	.6895	.1352
E1	1.0	44	4.500	.6988	.1054
	2.0	26	4.154	.8806	.1727
E2	1.0	44	4.455	.7299	.1100
	2.0	26	4.231	.9923	.1946
E3	1.0	44	4.023	1.0452	.1576
	2.0	26	3.615	1.2026	.2358
E4	1.0	44	3.659	1.0771	.1624
	2.0	26	3.692	.7884	.1546
E5	1.0	44	3.023	1.3027	.1964
	2.0	26	3.000	1.0198	.2000
E7	1.0	44	3.841	.9631	.1452
	2.0	26	3.462	.6469	.1269
E8	1.0	44	3.568	.8463	.1276
	2.0	26	3.692	.6794	.1332
E9	1.0	44	3.023	1.0452	.1576
	2.0	26	3.269	1.0023	.1966
E10	1.0	44	4.341	.9631	.1452
	2.0	26	4.308	.6177	.1211

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
B4	Equal variances assumed	.848	.360	-.504	68	.616	-.0927	.1840	-.4599	.2745
	Equal variances not assumed			-.548	65.335	.586	-.0927	.1692	-.4305	.2452
B5	Equal variances assumed	.029	.864	-1.538	68	.129	-.6294	.4092	-1.4459	.1872
	Equal variances not assumed			-1.511	49.717	.137	-.6294	.4166	-1.4663	.2075
C1	Equal variances assumed	.033	.856	-.702	68	.485	-.1678	.2390	-.6448	.3091
	Equal variances not assumed			-.699	51.870	.488	-.1678	.2401	-.6496	.3139
C4	Equal variances assumed	3.956	.051	-.724	68	.472	-.1696	.2343	-.6372	.2980
	Equal variances not assumed			-.805	67.293	.424	-.1696	.2107	-.5902	.2510
C5	Equal variances assumed	.060	.807	-.582	68	.562	-.1311	.2252	-.5805	.3183
	Equal variances not assumed			-.578	51.530	.566	-.1311	.2267	-.5861	.3239
C6	Equal variances assumed	3.445	.068	-.098	68	.923	-.0315	.3227	-.6755	.6125
	Equal variances not assumed			-.102	59.813	.919	-.0315	.3088	-.6492	.5863
C7	Equal variances assumed	.205	.652	.345	68	.731	.0682	.1974	-.3257	.4620
	Equal variances not assumed			.352	55.681	.726	.0682	.1937	-.3199	.4563
C8	Equal variances assumed	.094	.760	-.131	68	.896	-.0262	.1996	-.4245	.3721

	Equal variances not assumed			-.133	55.058	.894	-.0262	.1966	-.4203	.3678
C9	Equal variances assumed	1.376	.245	-2.176	68	.033	-.5612	.2579	-1.0759	-.0465
	Equal variances not assumed			-2.213	55.423	.031	-.5612	.2536	-1.0692	-.0531
C10	Equal variances assumed	.002	.968	.802	68	.425	.1906	.2377	-.2837	.6648
	Equal variances not assumed			.807	53.681	.423	.1906	.2361	-.2829	.6640
C11	Equal variances assumed	.933	.337	-.470	68	.640	-.1171	.2493	-.6145	.3803
	Equal variances not assumed			-.498	61.978	.620	-.1171	.2351	-.5872	.3529
C12	Equal variances assumed	5.743	.019	-1.810	68	.075	-.5455	.3013	-1.1468	.0558
	Equal variances not assumed			-1.958	64.732	.054	-.5455	.2785	-1.1017	.0108
C15	Equal variances assumed	4.002	.049	1.074	68	.287	.1189	.1107	-.1020	.3397
	Equal variances not assumed			1.037	47.074	.305	.1189	.1146	-.1117	.3495
C16	Equal variances assumed	3.768	.056	-2.620	68	.011	-.6941	.2649	-1.2226	-.1655
	Equal variances not assumed			-2.811	63.680	.007	-.6941	.2469	-1.1873	-.2008
C17	Equal variances assumed	1.865	.177	-2.263	68	.027	-.6049	.2673	-1.1382	-.0715
	Equal variances not assumed			-2.354	59.040	.022	-.6049	.2570	-1.1191	-.0907
C18	Equal variances assumed	.048	.828	-2.319	68	.023	-.7500	.3234	-1.3954	-.1046
	Equal variances not assumed			-2.305	51.613	.025	-.7500	.3254	-1.4031	-.0969
C19	Equal variances assumed	4.719	.033	-1.375	68	.174	-.3462	.2517	-.8483	.1560
	Equal variances not assumed			-1.453	61.436	.151	-.3462	.2383	-.8226	.1303

C20	Equal variances assumed	.644	.425	-1.136	68	.260	-.2955	.2601	-.8144	.2235
	Equal variances not assumed			-1.071	43.634	.290	-.2955	.2758	-.8515	.2606
C21	Equal variances assumed	.860	.357	-1.106	68	.273	-.2780	.2513	-.7794	.2235
	Equal variances not assumed			-1.110	53.145	.272	-.2780	.2505	-.7803	.2244
C22	Equal variances assumed	.707	.403	.218	68	.828	.0559	.2567	-.4563	.5681
	Equal variances not assumed			.216	51.216	.830	.0559	.2589	-.4637	.5756
C23	Equal variances assumed	1.465	.230	-.388	68	.699	-.1364	.3513	-.8375	.5647
	Equal variances not assumed			-.399	57.053	.692	-.1364	.3420	-.8211	.5484
C24	Equal variances assumed	4.049	.048	-.884	68	.380	-.2675	.3027	-.8715	.3365
	Equal variances not assumed			-.961	65.356	.340	-.2675	.2783	-.8232	.2882
C25	Equal variances assumed	3.097	.083	-1.155	68	.252	-.3619	.3134	-.9872	.2634
	Equal variances not assumed			-1.233	63.034	.222	-.3619	.2935	-.9483	.2245
C26	Equal variances assumed	.206	.651	-1.037	68	.303	-.3164	.3051	-.9253	.2924
	Equal variances not assumed			-1.034	52.050	.306	-.3164	.3061	-.9307	.2978
C27	Equal variances assumed	4.240	.043	-.056	68	.956	-.0175	.3126	-.6412	.6062
	Equal variances not assumed			-.059	60.133	.953	-.0175	.2985	-.6145	.5795
C28	Equal variances assumed	1.213	.275	.566	68	.573	.1748	.3090	-.4419	.7915
	Equal variances not assumed			.578	56.215	.565	.1748	.3023	-.4308	.7804
C30	Equal variances assumed	6.086	.016	-2.924	68	.005	-.7657	.2618	-1.2882	-.2433

	Equal variances not assumed			-2.655	38.825	.011	-.7657	.2884	-1.3491	-.1824
C31	Equal variances assumed	5.528	.022	1.417	68	.161	.3584	.2528	-.1461	.8629
	Equal variances not assumed			1.548	65.791	.126	.3584	.2315	-.1038	.8206
D6	Equal variances assumed	.088	.767	-.490	68	.626	-.0944	.1928	-.4791	.2903
	Equal variances not assumed			-.477	48.514	.635	-.0944	.1978	-.4919	.3031
D11	Equal variances assumed	.228	.634	.916	68	.363	.2500	.2729	-.2945	.7945
	Equal variances not assumed			.942	57.102	.350	.2500	.2655	-.2817	.7817
D12	Equal variances assumed	.882	.351	-1.290	68	.201	-.2552	.1979	-.6501	.1396
	Equal variances not assumed			-1.364	61.655	.177	-.2552	.1871	-.6293	.1188
E1	Equal variances assumed	3.916	.052	1.816	68	.074	.3462	.1906	-.0342	.7265
	Equal variances not assumed			1.711	43.564	.094	.3462	.2023	-.0617	.7540
E2	Equal variances assumed	7.489	.008	1.082	68	.283	.2238	.2068	-.1889	.6364
	Equal variances not assumed			1.001	41.100	.323	.2238	.2236	-.2277	.6752
E3	Equal variances assumed	.465	.497	1.489	68	.141	.4073	.2735	-.1384	.9531
	Equal variances not assumed			1.436	46.872	.158	.4073	.2836	-.1633	.9780
E4	Equal variances assumed	2.062	.156	-.137	68	.892	-.0332	.2426	-.5174	.4510
	Equal variances not assumed			-.148	64.759	.883	-.0332	.2242	-.4810	.4146
E5	Equal variances assumed	5.303	.024	.076	68	.940	.0227	.2984	-.5728	.6182
	Equal variances not assumed			.081	62.612	.936	.0227	.2803	-.5375	.5829

E7	Equal variances assumed	2.562	.114	1.782	68	.079	.3794	.2128	-.0454	.8041
	Equal variances not assumed			1.968	66.776	.053	.3794	.1928	-.0055	.7642
E8	Equal variances assumed	1.377	.245	-.636	68	.527	-.1241	.1952	-.5136	.2653
	Equal variances not assumed			-.673	61.704	.504	-.1241	.1845	-.4929	.2447
E9	Equal variances assumed	.179	.674	-.968	68	.337	-.2465	.2547	-.7547	.2617
	Equal variances not assumed			-.978	54.394	.332	-.2465	.2519	-.7515	.2585
E10	Equal variances assumed	2.002	.162	.158	68	.875	.0332	.2109	-.3876	.4540
	Equal variances not assumed			.176	67.469	.861	.0332	.1891	-.3442	.4106

Results of exploratory factor Analysis

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.686
Bartlett's Test of Sphericity	Approx. Chi-Square	1481.047
	df	465
	Sig.	.000

Communalities

	Initial	Extraction
B3	1.000	.859
B4	1.000	.718
C11	1.000	.791
C12	1.000	.646
C16	1.000	.809
C17	1.000	.710

C18	1.000	.583
C19	1.000	.868
C20	1.000	.785
C21	1.000	.782
C22	1.000	.895
C23	1.000	.874
C24	1.000	.903
C25	1.000	.922
C26	1.000	.760
C27	1.000	.859
C28	1.000	.736
D6	1.000	.768
D7	1.000	.756
D8	1.000	.811
E1	1.000	.897
E2	1.000	.894
E3	1.000	.762
E4	1.000	.801
E5	1.000	.674
E6a	1.000	.829
E6b	1.000	.739
E6c	1.000	.892
E6d	1.000	.861
E6e	1.000	.850
E7	1.000	.704

Extraction Method: Principal
Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.472	24.103	24.103	7.472	24.103	24.103	4.063	13.108	13.108
2	4.419	14.256	38.359	4.419	14.256	38.359	3.747	12.088	25.195
3	2.886	9.310	47.669	2.886	9.310	47.669	2.663	8.589	33.785
4	2.201	7.101	54.770	2.201	7.101	54.770	2.637	8.507	42.292
5	1.745	5.631	60.400	1.745	5.631	60.400	2.586	8.342	50.634
6	1.458	4.704	65.104	1.458	4.704	65.104	2.385	7.694	58.327
7	1.303	4.204	69.308	1.303	4.204	69.308	2.383	7.686	66.014
8	1.151	3.711	73.019	1.151	3.711	73.019	1.799	5.803	71.817
9	1.096	3.536	76.555	1.096	3.536	76.555	1.286	4.147	75.964
10	1.006	3.244	79.800	1.006	3.244	79.800	1.189	3.836	79.800
11	.798	2.574	82.374						
12	.687	2.216	84.590						
13	.657	2.120	86.710						
14	.506	1.631	88.341						
15	.473	1.527	89.869						
16	.413	1.334	91.202						
17	.384	1.240	92.442						
18	.345	1.112	93.554						
19	.313	1.009	94.563						
20	.288	.929	95.492						
21	.265	.856	96.348						
22	.220	.710	97.057						
23	.196	.631	97.688						
24	.170	.550	98.237						
25	.127	.409	98.646						
26	.105	.338	98.984						
27	.089	.286	99.271						
28	.076	.246	99.516						
29	.066	.212	99.728						
30	.047	.151	99.879						

31	.038	.121	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix

	Component									
	1	2	3	4	5	6	7	8	9	10
B3	.005	.174	.035	-.130	.077	.017	.022	.090	.891	.036
B4	.104	.203	.127	.058	.009	.779	.184	.041	-.026	.060
C11	.064	.042	.091	.150	.122	-.023	.268	.816	-.018	.023
C12	-.027	.230	.141	.241	.207	.117	.009	.585	.241	-.239
C16	.070	.680	.041	-.310	.159	.165	-.161	.376	-.076	-.132
C17	.009	.677	.022	-.036	.020	-.008	-.013	.480	.107	-.090
C18	-.119	.657	-.163	-.056	.252	.055	.164	-.021	-.068	-.095
C19	-.106	.834	-.008	.230	.123	-.030	.278	-.029	.120	.033
C20	-.062	.831	.005	.156	.054	.022	.208	-.111	.056	-.075
C21	-.086	.756	.209	.248	.021	.218	.100	.139	.131	.060
C22	.013	-.127	.102	-.105	-.038	-.006	-.060	-.104	.056	.915
C23	.171	.210	.038	.163	.844	-.016	.085	-.067	.169	-.142
C24	.081	.109	.135	.226	.839	.174	.192	.190	.057	.070
C25	.043	.144	.160	.211	.854	.098	.191	.213	-.098	.006
C26	.082	.132	-.040	.798	.167	.055	-.045	.250	-.013	-.028
C27	.137	.168	.086	.822	.214	.198	.164	.017	-.110	-.070
C28	.046	-.002	.091	.777	.173	.204	.214	.007	-.017	-.072
D6	.028	.199	.175	.159	.153	.203	.744	.073	-.102	-.193
D7	.044	.172	.006	.158	.201	.136	.800	.011	-.040	-.010
D8	-.010	.178	.155	.000	.080	.159	.794	.208	.209	.078
E1	.066	-.003	.912	-.014	.100	.125	.053	.148	.022	.096
E2	-.052	.042	.880	-.019	.116	.166	.076	.200	-.100	.133
E3	.083	-.128	.540	.213	.047	.458	.097	-.014	.406	.121
E4	.087	-.074	.170	.211	.056	.830	.129	.077	-.018	.003
E5	.224	.174	.143	.129	.180	.690	.120	-.073	.088	-.141
E6a	.868	-.036	.003	-.003	.056	.148	-.058	-.027	-.207	-.033
E6b	.794	-.022	.116	.245	.092	.030	-.042	-.096	.073	-.093
E6c	.924	-.064	.077	-.026	-.013	.068	.111	.015	.101	-.009
E6d	.909	-.053	-.039	.012	.003	.109	.077	.081	.027	.075
E6e	.896	-.084	-.080	.051	.133	.042	-.031	.085	.012	.057
E7	.017	.050	.664	.163	.065	.132	.192	-.267	.142	-.290

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 7 iterations.

Ramaiah University of Applied Sciences

Sponsored Research Project
Development of Green Innovation Framework for Manufacturing Sector

Survey Manual

Sponsor Agency

National Science and Technology Management Information System Division (NSTMIS) , a division of Department of Science and Technology (DST), Government of India , New Delhi

Research Team

Dr. H S Srivatsa, Mr. Sandeep N, Mr. Vijaya Kumar S, Mr. Arun R

Ramaiah University of Applied Sciences University House, New BEL Road, MSR Nagar, Bengaluru – 560 054 www.msruas.ac.in

Introduction

Green manufacturing practices (GMP) is one of the new trends gaining prominence in the manufacturing sector. GMP helps companies to function in an ecofriendly and sustainable way. The energy and material cost will reduce if GMPs are implemented in true spirit. GMP demands an innovative approach towards all the functions of the company like design, manufacturing, supplies, facilities etc. Many companies have tried out approaches and systems for going green with varying degrees of success. However, based on observations and existing body of research, a standard and common framework for carrying out innovations with focus on green manufacturing is required. For this purpose, there is a need for developing a robust framework that acts as guidelines for implementing, practicing and sustaining GMP in manufacturing companies.

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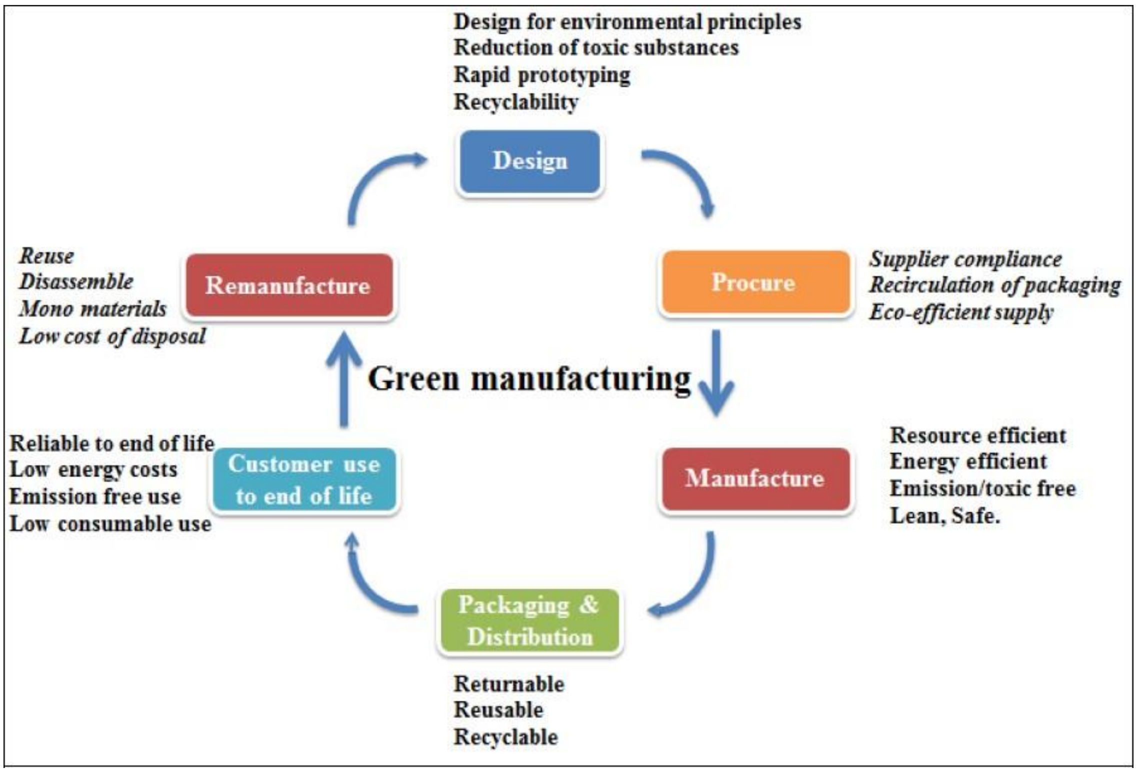
Green Manufacturing

Green manufacturing is a philosophy to optimize natural resources usage and minimize wastes and pollution in operating process. It is a business strategy that focuses on profitability through saving manufacturing cost by adopting eco-efficient and eco- friendly operating processes (see figure 1).



Source: Frost & Sullivan, 2009

Figure .1 Model of Green manufacturing

Green Manufacturing (GM) is a term used to describe manufacturing practices that do not harm the environment during any stage of manufacturing process. Green manufacturing addresses a number of key manufacturing issues covered under 7R's - Reduce, Reuse, and Recycle, Remanufacturing, Redesign, Recover, and Refuse .

Green manufacturing involves transformation of industrial operations in three ways: (1) using Green energy, (2) developing and selling Green products and (3) employing Green processes in business operations.

1.1 Green Innovations

Defining green innovation is not an easy task although several attempts have been made in the literature (Carrillo-Hermosilla et al., 2010). Klemmer et al. (1999) determined the environmental innovations as a subset of innovations that lead to an improvement of ecological equality. Green innovation is defined as software or hardware innovation that is related to green products and processes including the innovation in technologies that are involved in energy-saving, pollution-prevention, waste recycling, green product designs(Chen et al. 2006, p. 332). According to Halila and Rundquist (2011), the term, eco-innovation (environmental innovation, green innovation or sustainable innovation), is often used to identify those innovations that contribute to a sustainable environment through ecological improvements.

Green manufacturing innovations can be described as process of making changes, large or small, radical or incremental to products, processes and services that results in the introduction of something new for the organization that adds value to customers and contributes to the knowledge store of the organization. Value for the customer is being created by providing the customer with environmentally friendly products and services. Value for the company is being created by improvement in processes, design, energy consumption etc. which can result in costs savings, regulatory compliance and sustainability. This new knowledge that is being created acts a platform for further innovations.

1.2 Introduction to Research Project

Pleasure to introduce ourselves as a faculty team of Ramaiah University of Applied Sciences, Bengaluru. With a goal of contributing to the **Green Mother Earth**, we are researching the green manufacturing practices/innovations in your esteemed organization. We have been granted this research by Department of Science and technology – Government of India.

We seek to understand green manufacturing practices in your esteemed organization, with the help of a questionnaire. **The data being collected will be used for research purpose.**

1.3 Development of Questionnaire

Green manufacturing is an endless pursuit towards sustainable manufacturing along with business results. Green manufacturing starts with green awareness, green systems and practices, green culture and green excellence. The green manufacturing reference model is developed as seen in figure 2

Figure. 2 Green manufacturing model

This questionnaire is framed to understand green manufacturing practices that can be grouped under four important sections:

1. **Green Awareness:** Importance of green manufacturing
2. **Green Systems:** Practices, tools and techniques for green manufacturing
3. **Green Culture:** Behaviour towards green manufacturing
4. **Green Excellence :** Benefits and levers for green manufacturing

1. Green Awareness: Green manufacturing practices offer not only environmental advantages but makes the company operations more lean. Reduced energy consumption, raw material and resource are great promoters to implement a green manufacturing system. This section of the questionnaire tries to understand the level of awareness about benefits of green manufacturing.

2. Green Systems and Practices: A well define system that focuses on green manufacturing system will have measurement system (KPIs), tools and techniques, standards and reporting mechanism. This section of the questionnaire tries to capture the system level needs for practicing green manufacturing

3. Green Culture: Green culture emphasizes on green practices that are followed without system level monitoring and appraisal in the company. This section of the questionnaire tries to understand the cultural aspects required for green manufacturing.

4. Green Excellence: Green excellence is a journey towards becoming best in class and guide others towards a sustainable business enterprise both economically and ecologically. This section of questionnaire tries to capture the best in class advantages and achievements by adopting green manufacturing practices.

Section A: Company Profile

Company Name :
Address :
Name of Respondent :
Designation :

1. Nature of your business? a) Automotive b) Earth moving c) others………………………
2. Age of your company (in Years)? a) 0-5 b) 6-10 c) 11- 15 d) 16- 20 e) > 20
3. Describe your company? a) Single owner b) partnership firm c) Private Limited d) Public Limited e) Indian company f) Multinational company g) Foreign collaboration h) No Foreign collaboration
4. Current employee strength? a) Less than 50 b) Between 50-100 c) Between 100 -150 d) Between 150 - 200 e) Above 200
5. Company's annual turnover (in Lakhs of Rupees)? a) 0-100 lakhs b) 100-300 lakhs c) 300-700 lakhs d) 700-1000 lakhs e) More than 1000 lakhs
6. Does your company has ISO certificate/ TS or any other standard? a) Yes b) No c) In progress d) others…………………

Any Green Initiatives/Systems/Practices/Tools/ Techniques in your company

Section B : Awareness on Green Manufacturing Innovations

1. **How can green manufacturing help your business?**
   a) Increases profitability b) Reduces cost C) Improves branding
   d) Increases market share e) All of the above

2. **What are the factors that influence practices of green manufacturing innovation in an organization?**
   a) Customer requirements b) To stay Ahead of competition
   c) Government regulation d) Healthy work environment e) Reduce cost
   f) Any others …….

3. **Do you agree that green manufacturing involves practice of 3Rs – Reduce, Reuse, Recycle?**
   a) Strongly Disagree b) Disagree c) Undecided d) Agree e) Strongly Agree

4. **Indicate your level of awareness about innovations in green manufacturing practices?**
   a) Very Low b) Low C) Moderate d) High e) Very High

5. **If you don't have a green manufacturing policy, how soon are you willing to develop a policy (skip this question if the company is already having a policy)?**
   a) Yes within three months b) Yes within six months
   b) Yes Within next one year d) Yes Within two years e) Not Sure

6. **If you already have a green manufacturing policy in your company, for what reasons did you adopt**
   a) Customer requirements b) To stay Ahead of competition
   c) Government regulation d) Healthy work environment e) Reduce cost
   f) Any others …….

Any Green Initiatives/Systems/Practices/Tools/ Techniques in your company

Section C : Green Manufacturing Practices and Systems

6R's: Reduce, Reuse, Recycle, Redesign, Recover, and Refuse

1. To what extent are you practicing '3R' (Reduce, Reuse, Recycle) in your organization? a) Very Low b) Low c) Average d) High e) Very High
2. How difficult is it to setup an effective '3R' (Reduce, Reuse, Recycle) practice in your organization? a) Very Low b) Low c) Average d) High e) Very High
3. What is the frequency of training programs being conducted in your organization with respect to the '3R'? a) Never b) Rare c) Yearly d) Half-Yearly e) Quarterly
Reduce
1. To what extent does the design of your products focus on reduced consumption of material? a) Very Low b) Low c) Average d) High e) Very High
2. To what extent does the design of your products focus on reduced consumption of energy? a) Very Low b) Low c) Average d) High e) Very High
3. To what extent does the design of your products focus on reduced usage of hazardous material? a) Very Low b) Low c) Average d) High e) Very High
4. To what extent does your manufacturing processes generate scrap? a) Very Low b) Low c) Average d) High e) Very High
5. To what extent does your manufacturing processes generate hazardous byproducts? a) Very Low b) Low c) Average d) High e) Very High
6. How do you rate your efforts in usage of renewable sources of energy in the last two years? a) Very Low b) Low c) Average d) High e) Very High

Reuse
1. **To what extent do you buy refurbished machines and tools for your regular operations?** a) Very Low b) Low c) Average d) High e) Very High
2. **To what extent do you reuse tools, jigs and fixtures?** a) Very Low b) Low c) Average d) High e) Very High
3. **What proportion of in-house rejected materials are salvaged to be used for other operational purposes?** a) Very Low b) Low c) Average d) High e) Very High
4. **The overall costs of using refurbished machine is more than overall costs of using a new machine** b) Strongly Agree b) Agree c) Neither Agree nor Disagree d) Disagree c) e) Strongly Disagree
5. **Our organization uses refurbished machines with the underlying objective of being environment friendly (by reducing the manufacturing processes and materials involved in making a new machine)** a) Strongly Agree b) Agree c) Neither Agree nor Disagree d) Disagree e) Strongly Disagree
Recycle
1. **Do you have a recycling policy where you take back the products manufactured by you from your customers** a) Yes b) No
2. **To what extent are the materials in your company recyclable?** a) Very Low b) Low c) Average d) High e) Very High
3. **To what extent are you using recycled raw materials in your company?** a) Very Low b) Low c) Average d) High e) Very High

4. To what extent are your finished products recyclable? a) Very Low b) Low c) Average d) High e) Very High
5. What is the extent of encouragement you provide to your suppliers for using recycled materials? a) Very Low b) Low c) Average d) High e) Very High
6. What is the level of support you receive from your customers for using recycled materials? a) Very Low b) Low c) Average d) High e) Very High
7. What is the maturity level of recycling technology in your industry sector? a) Very Low b) Low c) Average d) High e) Very High
8. Have you made it easy for your customers to recycle products purchased from you a) Very easy b) Easy c) Neither easy nor difficult d) Difficult e) Very difficult
Redesign
1. What proportion of your products are designed for eco-friendly advantages? a) None b) 25% of products C) 50% of products d) 75% of Products e) All Products
2. What proportion of your manufacturing processes are designed for eco-friendly advantages? a) None b) 25% of processes C) 50% of processes d) 75% of processes e) All Processes
3. What proportion of your logistic processes are designed for eco-friendly advantages? a) None b) 25% of processes C) 50% of processes d) 75% of processes e) All Processes

Recover
1. How often do you practice active recovery management system for your products? a) Never b) Rarely c) Sometimes d) Often e) Almost always
2. How often do you practice active recovery management system for your tools? a) Never b) Rarely c) Sometimes d) Often e) Almost always
3. How often do you practice active recovery management system for your consumables? a) Never b) Rarely c) Sometimes d) Often e) Almost always
Refuse
1. What is the level of your awareness about REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) compliancy? a) Very Low b) Low c) Average d) High e) Very High
2. How extensively do you use volatile Organic compounds in your company? a) Never b) Rarely c) Sometimes d) Often e) Almost always
3. What proportion of your suppliers follow green manufacturing practices? a) None b) 25% of suppliers C) 50% of suppliers d) 75% of suppliers e) All suppliers

Any Green Initiatives/Systems/Practices/Tools/ Techniques in your company

Section D : Green Manufacturing Culture

1. **Who leads the green manufacturing practices in your company?**

   ……………………………………….

2. **What is the level of commitment towards green manufacturing from your top management?**

   a) Very Low b) Low c) Average d) High e) Very High

3. **What is the level of commitment towards green manufacturing from your mid-management?**

   a) Very Low b) Low c) Average d) High e) Very High

4. **What is the level of commitment towards green manufacturing from your operating staff?**

   a) Very Low b) Low c) Average d) High e) Very High

5. **To what extent are the staff in the organization focused on resource conservation?**

   a) Very Low b) Low c) Average d) High e) Very High

6. **To what extent are you willing to support your suppliers in green initiatives?**

   a) Very Low b) Low c) Average d) High e) Very High

7. **To what extent are you willing to support your neighbouring industries in green initiatives?**

   a) Very Low b) Low c) Average d) High e) Very High

8. **To what extent does creating a green enterprise brand improve the morale of your employees?**

   a) Very Low b) Low c) Average d) High e) Very High

9. **To what extent are green ideas in your company initiated proactively?**

   a) Very Low b) Low c) Average d) High e) Very High

10. **To what extent are green ideas in your company initiated reactively?**

    a) Very Low b) Low c) Average d) High e) Very High

11. **How often do you participate in green manufacturing competitions?**

    a) Never b) Rarely c) Sometimes d) Often e) Almost always

12. **Your company follows environmentally friendly ways of disposing off old parts/machinery etc**

a) Strongly Agree b) Agree c) Neither Agree nor Disagree d) Disagree

e) Strongly Disagree

Any Green Initiatives/Systems/Practices/Tools/ Techniques in your company

Section E : GREEN EXCELLENCE

1. **As per you how important is it to compute energy cost per unit produced?**

   a) Not important b) Slightly important c) Fairly important d) Important

   e) Very important

2. **As per you how important is it to compute resource consumption per unit produced?**

   a) Not important b) Slightly important c) Fairly important d) Important

   e) Very important

3. **As per you how important is it to budget for green initiatives?**

   a) Not important b) Slightly important c) Fairly important d) Important

   e) Very important

4. **To what extent are your strategies aligned towards green manufacturing?**

   a) Very Low b) Low c) Average d) High e) Very High

5. **Do you plan to develop a roadmap for green manufacturing excellence?**

   a) No b) Planning sometime in Future c) Started Planning d) Plan in progress

   e) We already have a roadmap

6. **Rate the following function in which green manufacturing can benefit your company in the order of high benefit to low benefit (1 - high benefit and 5- low benefit)**

a) Green supply chain	1	2	3	4	5
b) Green marketing	1	2	3	4	5
c) Green consumables	1	2	3	4	5
d) Green Production	1	2	3	4	5
e) Green services	1	2	3	4	5

7. **As per you, how important is it to assess employee performance from the perspective of green initiatives?**

   a) Not important b) Slightly important c) Fairly important d) Important e) Very important

8. **What is the extent of economic advantage which you think might be obtained by adopting green manufacturing practices?**

   a) Very Low b) Low c) Average d) High e) Very High

9. **How often do you participate on a cooperative platform to exchange green manufacturing ideas with other manufacturing units?**

   a) Never b) Rarely c) Sometimes d) Often e) Almost always

10. **The companies should share their green manufacturing knowledge with others?**

    a) Strongly agree b) agree c) neither agree nor disagree d) disagree e) strongly disagree

11. **On a scale of 0- 100, how much marks will you assign for green manufacturing practice in your company?**

    Marks =

Any Green Initiatives/Systems/Practices/Tools/ Techniques in your company

What are the key challenges your company has faced in going green?

We thank you sincerely, for the time spent in answering these questions and we will revert back to you regarding the any other clarifications we need

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NSTMIS Division Department of Science & Technology Ministry of Science & Technology
Technology Bhawan, New Mehrauli Road, NewDelhi-110016 Phone:91-011-26567373

Website:www.nstmis-dst.org/

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