Study of select issues in the implementation of green manufacturing practices in Indian SMEs

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By

MANOJ KUMAR SINGH

(2K16/PhD/ME/10)

Under the Supervision of

Dr Pravin Kumar
Associate Professor
(Department of Mechanical Engineering, DTU)

Dr Saurabh Agrawal
Associate Professor
(Delhi School of Management, DTU)

Department of Mechanical Engineering

Delhi Technological University

Main Bawana Road, Shahabad Daulatpur, Delhi-110042, India

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Dedicated to

my beloved

father

Late Sahdeo Singh

&

mother Smt Sumitra Devi

CERTIFICATE

This is to certify that the thesis entitled "Study of select issues in the implementation of green manufacturing practices in Indian SMEs" is being submitted by Manoj Kumar Singh to the Delhi Technological University (Formerly known as Delhi College of Engineering), Delhi, for the award of the degree of Doctor of Philosophy is a bonafide record of original research work carried out by him. He has worked under our supervision and has fulfilled the requirements for submitting the thesis, which has reached the requisite standard.

The results of this thesis have not been submitted, in part or whole, to any other University or Institute for the award of any degree or diploma.

Dr. Pravin Kumar
Associate Professor
Department of Mechanical Engineering
Delhi Technological University
New Delhi - 110042
INDIA

Dr. Saurabh Agrawal
Associate Professor
Delhi School of Management
Delhi Technological University
New Delhi - 110042
INDIA

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ABSTRACT

The manufacturing sector is growing very fast to meet the needs of the increasing population. The high growth of the manufacturing industry has an adverse effect on the environment, a major cause of anxiety for researchers and industrialists. India's small and medium enterprises (SMEs) sector is the backbone of the Indian economy. The contribution of small and medium enterprises (SMEs) is an integral part of a nation's economic development. However, SMEs haphazardly use energy and natural resources, causing environmental pollution. Some SMEs are aware of environmental issues and follow environmental regulations. The increasing ecological pollution compels the organization to adopt green manufacturing practices (GMP). The manufacturing practices which do not harm the environment during the manufacturing process are known as GMP. Many organizations/MNCs (multinational companies) are trying to follow green practices and manufacture green products. Still, SMEs are reluctant to implement green practices due to poor awareness and inadequate resources.

Green manufacturing aims to reduce the consumption of natural resources needed to produce finished goods through efficient manufacturing processes that lower the negative externalities of waste and pollution. Green manufacturing is about using green energy, developing green products, and employing green techniques to optimize the use of resources and wastage. However, the Indian SMEs are not interested in green manufacturing and thus lag far behind the target.

Depending on the consumption pattern, the manufacturers can be motivated to adopt green manufacturing practices by the increasing demand for green products. In the present research, attempts have been made to find the factors influencing consumer behaviour and the production of green products. A literature survey explores consumer behaviour and purchasing intentions toward green products. Further, an attempt has also been made to

determine the reasons for the reluctance to implement green manufacturing practices by Indian SMEs.

The Partial Least Square-Path Modeling (PLS-PM) approach is used to know the causal relationship among the various factors of consumer behaviour, their impact on the production of green products, and find out the effect of the adoption of green manufacturing practices on the organizational performances. The result shows that the perceived quality and cost of the product influence the consumers' purchase intentions for green consumption. Along with these two factors, green initiatives, advertising and promotion, and social welfare also significantly influence consumers toward using green products. The research results show that the fear of financial loss amongst Indian SMEs is hypothetical; instead, there is an increase in profit and market share if the company goes for green manufacturing practices.

Many obstacles to green manufacturing practices (GMP) are identified through the literature survey and discussion with researchers and industry experts. The identified obstacles are classified into six groups: financial, managerial, operational, technological, regulatory, and environmental obstacles by factor analysis (FA) methods. The best-worst method (BWM) technique has been utilized to rank these obstacles according to their impact on GMP. Indian SMEs can quickly adopt GMP by addressing these sceptical obstacles.

Factors influencing green practices in SMEs have been identified from past literature, and an index to assess and benchmark green practices has been produced. From the literature survey total of 27 factors are recognized and bunched into seven major groups: top management commitment, effective government legislation and implementation, economic interest, consensus on green management, firm's competitiveness, green product design and development, and strong supplier relationship management. Based on these

factors, an index has been developed using Graph Theory and Matrix Approach (GTMA) to evaluate the green practices of the firm under consideration.

This study may attract consumers toward the green product and thus motivate management to produce green products. The framework developed may help managers assess their respective organizations' green performance as values taken from different green sub-factors are based on the inputs given by the manager of SMEs. A firm can also compare the green index of its organization with other organizations or with the best in the industry for benchmarking purposes. Benchmarking green practices may help organizations develop strategies to improve the green approach of manufacturing the products and resource conservation. Moreover, further studies may be conducted with different case studies to validate the proposed framework. Organizations can find strong and weak areas for implementing green practices based on the green index.

Keywords: Green manufacturing practices (GMP), Small and medium-sized enterprises (SMEs), Consumer behaviour, obstacles to green manufacturing, organizational performance, Partial Least Square-Path Modeling (PLS-PM), factor analysis (FA), best-worst method (BWM), Graph theory and matrix approach (GTMA).

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LIST OF ABBREVIATIONS USED

SMEs	Small and Medium-Sized Enterprises
GHG	Greenhouse Gases
CII-BCG	Confederation of Indian Industry and Boston Consulting Group
CSE	Centre for Science and Environment
GM	Green Manufacturing
GMP	Green Manufacturing Practices
CSR	Corporate Social Responsibility
BWM	Best-Worst Method
PLS-PM	Partial Least Square- Path Modelling
SEM	Structural Equation Modelling
GTMA	Graph Theory and Matrix Approach
GSCM	Green Supply Chain Management
ESC	Extended Supply Chain
IT	Information Technology
SSCM	Sustainable Supply Chain Management
TQM	Total Quality Management
GSCP	Green Supply Chain Practices
CB SEM	Covariance Based Structural Equation Modelling
HTMT	Heterotrait -Monotrait Ratio
VIF	Variance Inflation Factor
MCDM	Multi-Criteria Decision Making
GDP	Gross Domestic Product
AVE	Average Variance Extracted

PI	Purchase Intention
CB	Consumer Behaviour
GP	Green Products
PQ	Perceived Quality
BL	Brand Loyalty
SIAM	Society of Indian Automobile Manufacturers
PSUs	Public Sector Units
FP	Financial Performance
SP	Social Performance
EP	Environmental Performance
CPCB	Central Pollution Control Board
SPCB	State Pollution Control Board
BO	Best to Others
OW	Others to Worst
OEMs	Original Equipment Manufacturers
EMS	Environmental Management System
GPI	Green Performance Index

CHAPTER -I

INTRODUCTION

1.1 BACKGROUND

Environment, resources, and growing population are some critical issues in the global world. Any environmental change leads to an imbalance of life on the earth. The manufacturing sector is growing very fast to meet the needs of a large number of customers. Speedy industrialization increases the exploitation of natural resources causing environmental threats to society. High industrial growth also causes an increase in greenhouse gas (GHG) emissions. India is one of the fastest-growing, fourth-largest economies and the fifth-largest GHG emitter globally (CCAFS report, 2022). CII-BCG report (2011) states that from 1990 to 2008, India's CO_2 emissions increased by more than 150%, placing it just behind China. India generates approximately 4 million tons of industrial and biomedical hazardous waste, which causes water and land pollution. Apart from this, e-waste is also becoming a significant concern for India. According to the Centre for Science and Environment (CSE), India's CO_2 emissions in 2021 were 2.88 GT, and projections based on the median annual rate of change in the past decade, 2010-2019, India's CO_2 generation may be 4.48 GT in 2030.

1.2 ENVIRONMENTAL CONCERNS AND GREEN MANUFACTURING PRACTICES (GMP)

The rapid growth of the manufacturing industry has an adverse effect on the environment, which is a major concern of researchers and industrialists to resolve by taking proper environmental measures. The manufacturing industries should reduce resource depletion and ecological effects during the product cycle. With the development of the

industry, industrial risks like technological, organizational, financial, and circumstantial risks (Hua et al., 2005; Rao, 2011) have also increased, but the risk of acceptability of green products on the verge of the increasing population has decreased (Tixier et al., 2002). The growing environmental awareness and strict regulations pressure manufacturers and consumers to consciously produce and consume the products (Mittal and Sangwan, 2013). These days ecological issues like GHG, waste generation, energy consumption, and landfills are seen carefully (Yacob et al., 2019). But the stringent government regulations create additional design obstacles and increase the cost. The manufacturing sector of developing countries is still primarily focused on achieving good quality at low cost and high profit. Therefore, the developing countries are still working hard to increase the growth of the manufacturing sector to boost their economy.

With growing concerns about GHG emissions, global warming, and worsening environmental conditions, many business organizations are now assessing their environmental management and manufacturing processes. But many of them also compare the benefits of implementing proactive environmental practices to improve the financial performance of the business organization (Sen et al., 2015). Organizations believe that compliance with the rules enhances the environmental conditions, but it negatively impacts the financial situation of the firms. Hence, environmental rules and norms should be concise and straightforward to improve their triple bottom line (Digalwar et al., 2013).

Environmental concerns have forced manufacturing organizations to develop eco-friendly production processes with recyclable products. Ecofriendly production is an ecological protective initiative to reduce waste and emissions and maximize product output. The environmental consciousness and stringent rules also forced the business organizations to increase expenses on environmental safety by acquiring the latest equipment for creating green products.

There are many ways to deploy technologies and facilities to improve the environmental outcomes of the production processes, which are part of the green manufacturing philosophy. Green manufacturing helps minimize the use of natural resources and energy and reduces the adverse impact of the products on the environment. Usually, the production processes in green manufacturing are highly efficient, use inputs with relatively low environmental impacts, and have less or no waste and pollution (Atlas and Florida, 1998). Increasing e-waste also forces the implementation of green technology in the production processes.

The government faces societal pressure to introduce policies regarding better management of resources to transform the current society into a sustainable society. Manufacturing industries adopt a circular economy and sustainable manufacturing to reduce material usage, energy consumption, and waste generation (Moktadir et al., 2018). The circular economy is a production and consumption model in which the existing materials and products are used as long as possible by reusing, repairing, refurbishing, and recycling. Thus, in a circular economy, the products are not discarded after one cycle but reused and reprocessed in the form of another product. Hence, it is a part of sustainable development (Moktadir et al., 2018). The term circular economy gained momentum among the researcher to make society more sustainable (Lieder and Rashid, 2016; Batista et al., 2018; Dubey et al., 2019). After Industry 4.0, adopting GMP becomes easy in terms of technological advancement. On the other hand, increased cost and competitiveness create fear of failure and a drop in profit and market share. However, due to poor environmental conditions and increasing societal pressure, local companies are forced to adopt sustainable practices.

1.3 NEED FOR GREEN MANUFACTURING PRACTICES

India's fast economic and industrial growth coupled with urbanization causes increased GHG emissions, demand for scarce resources, and waste generation. To mitigate these challenges, the Indian manufacturing sector needs to act on (i) Green energy, (ii) Green products, and (iii) Green processes in business operations. Applying green technology combines environmental knowledge, green chemistry, and a framework that monitors and conserves natural resources (Bisoyi et al., 2019). Green manufacturing improves enterprises' competitiveness, productivity, and efficiency (Dief, 2011). Usually, the production processes in green manufacturing are highly efficient to use inputs with relatively low environmental impact and have less or no waste and pollution.

Ironically, no products can be genuinely green; however, sustainable manufacturing processes use less material and energy, producing the product with minimum waste, leaving no adverse impact on the environment known as green manufacturing processes. Naderi (1996) defined sustainability as meeting the needs of the present generation without compromising the needs of future generations. Dief (2011) described green manufacturing as the sustainable product development approach at the designing and engineering activities stage to reduce the environmental impact. The manufacturing organizations that think to improve their sustainable performance should adopt a GMP. But GMP alone could not be the complete solution to ecological problems. The adoption of green materials, minimum use, and reuse of materials to reduce the environmental impact are also necessary. Besides this, designing the products to minimize wastage and maximize the efficacy to meet the environmental challenges is equally important. The organizations should use '11R' approaches to reduce the product's environmental impact. The '11R' stands for Repair, Refine, Recycle, Reuse, Remanufacturing, Rethink, Refuse, Reduce, Refurbish, Repurpose, and Redesign (Bag et al., 2021; Jawahir et al., 2007). Repair is the treatment

for minor defects in the products, and Refine is an approach to increase the eco-efficiency of the existing products. Recycling converts the used products and, afterwards, is used to generate any other products (Kumar et al., 2017). Recycling effectively conserves energy and natural resources and minimizes waste by recovering raw materials from the used products. Reuse is the utilization of products after attaining their specified life without adding any new value to the product.

Remanufacturing is manufacturing new products from the raw material obtained from the old products to achieve the same function and performance level as the old ones. Rethinking is an approach to developing new products based on the new paradigm of society. Refuse means making a product redundant by abandoning its function or offering the same role with different products. Reduce means the use of fewer materials in the manufacturing of the product. Refurbish means bringing the functions of the old products to a newer level. Repurpose means using the discarded products or their parts with new products. Redesigning is an approach to redesigning products using the latest technology to reduce environmental impact.

1.4 THE PERFORMANCE MEASURES OF ORGANIZATIONS INVOLVED IN GREEN MANUFACTURING

An organization's environmental responsiveness motivates the employee, increases the market share and brand loyalty, and helps remain competitive in the market (D'Souza et al., 2006). The factors that restrict SMEs from adopting the green manufacturing process are the organisations' environmental, operational, social, and financial performance. Another factor is that the organizations must comply with the environmental standards the regulatory authority sets. The amount of non-hazardous materials used in the production, amount of GHG liberated during manufacturing, amount of air pollutants discharged, and

the optimum utilization of resources measured the environmental performance of the organizations. The operational performance is measured by lead time reduction, quality improvement, productivity, flexibility, customer satisfaction, digitization of manufacturing activities, communication gap elimination, reuse and reprocessing, and cost and inventory reduction. Social performance is measured by corporate social responsibility, health and safety issues of their employees, product responsibility, transparency maintained, ethical behaviour, respect for rules of law, respect for international norms, employee satisfaction and retention, employee empowerment, job creation and taking care of human rights. The financial performance is measured by local infrastructure development, investment in R & D, increase in sales, investment in preventive environmental measures, increased market shares, return on investment, and a profit raise of the organizations (Flynn et al., 2010).

The environmental orientation, a significant feature of environmentalism, shows the willingness of a company to overcome ecological degradation (Fraj-Andrés et al., 2009). Environmentalism offers the company's responsibility toward the environment and the various measures taken to reduce the harmful environmental impact of its daily activities (Yu and Huo, 2019). Nevado-Peña et al. (2015) stated that firms with better sustainability positions had improved financial performance. Hategan et al. (2018) highlighted that firms engaged in corporate social responsibility (CSR) could earn more profit. Cordeiro and Sarkis (1997) and Filbeck and Gorman (2004) found a negative relationship between environmental performance and the financial performance of GMP firms. At the same time, Dobre et al. (2015) and Zhang and Chen (2017) underlined that the negative relationship between economic performance and environmental performance exists in the short run. It becomes positive if firms opted GMP for the long-term run. Mcwilliams and Siegel (2000) demonstrate the neutral relationship between CSR and the financial performance of the firms after controlling the research and development activities (Li and Ramanathan, 2018).

With the increasing customer demand for green products, manufacturing organizations have begun to adopt sustainable practices (Green et al., 2015). According to Mollenkopf et al. (2010), lean and green practices may not always be compatible, but according to Inman and Green (2018), lean and green practices have a forerunner link and positively impact the environmental and operational performance of the organizations. According to Cahyono et al. (2020), with increasing societal pressure, enterprises are compelled to adopt green manufacturing practices to reinforce the green image of their own business. Green supply chain management positively impacts enterprises' financial and environmental performance.

1.5 THE ROLE OF CONSUMERS IN GREEN MANUFACTURING

The social paradigm is the most critical factor in addressing ecological problems. The manufacturing of green products depends upon their consumption pattern. The consumption pattern varies with the social paradigm, representing the rethinking option of green manufacturing. Although the increased level of environmental awareness brought a positive change amongst the consumers and started contributing to the green revolution to prevent further deterioration of the environment, a significant increase in their consumption pattern is required to address the environmental issues (Rahbar and Wahid, 2011).

Consumer behaviour is the action of the individual customers, groups, or organizations to select, buy, use, and disposes of goods, ideas, and services to satisfy their needs and wants. Consumer behaviour towards the utilization of green products is one of the essential factors affecting green production. The critical issues in developing green products are the knowledge about green consumers and their characteristics, higher prices, and poor quality of the products. People's behaviour concerning recycling, energy-saving, and buying environmentally friendly products depends upon their environmental awareness

(Bamberg, 2003). Consumer behaviour linked with consumption should not damage the natural environment or cause pollution (Paço et al., 2019). Barbarossa & Pastore (2015) found that consumption of a green product is costly and leads to the reduction of the profit margin of the organizations. Sustainable manufacturing and consumption are one of the goals adopted by UN sustainable development in 2015. Consumers' intention to buy green products influences by values and norms other than internal environmental attitudes (Salmivaara and Lankoski, 2019). Consumers are price sensitive. After comparing the price and output delivered by the products, they purchase the products.

1.6 INDIAN SMEs (SMALL AND MEDIUM-SIZED ENTERPRISES)

The employment of 60 million people and production of more than 8000 quality products by SMEs for the Indian and international markets is vital for a nation's economic development (EISBC, 2022). Hence, they should be given a substantial status in every governmental policy. In developing countries like India, SMEs need massive support from the government for their sustenance. Indian SMEs contribute about 45% to manufacturing and about 40% of products to exports (Gandhi et al., 2018). According to the Indian Ministry of micro, small and medium enterprises (2020), the manufacturing and service sector enterprises whose annual turnover does not exceed rupees two hundred fifty crores are known as SMEs. SMEs are playing an imperative role in maintaining the growth of developing countries. However, the number of SMEs, due to many obstacles such as insufficient financial support, fear of failure, loss of profit, loss of market share, location obstacles, and human resources obstacles, are reluctant to follow environmental regulations (Unnikrishnan et al., 2016). The SMEs are also not aware of the global technological advancement. These obstacles restricted them from adopting green manufacturing in their organizations. However, providing government incentives, tax rebates, support programs,

and imitative pressure by noble learning through industry association appears to be more effective in helping these SMEs adopt green manufacturing (Ashton et al., 2017). Several manufacturing organizations, including small and medium enterprises (SMEs), are possible agents for the deterioration of the environment by producing GHG and discharging solid and liquid wastes (Sen et al., 2015). The performance of SMEs on environmental issues like waste management, water pollution, or energy emission is abysmal. Over the last two decades, it has been observed that SMEs are the major contributors to environmental pollution (Parker et al., 2009; Waters, 2010; Yacob et al., 2019), drawing the attention of researchers, policymakers, and government agencies to formulate policies, tools, programs to reduce their footprints (Gadenne et al., 2009). Ignorance of environmental issues is not only hazardous for society but also to the sustainability of SMEs. The main objectives of most organizations, including SMEs, are to maximize their profit. Following the globalization model without considering their domestic region creates confusion amongst them. If the models are formulated, it is easy to formulate a policy to solve all the environmental and social issues. Hence, the model should be constructed considering the technological challenges, resource management expertise, and environmental regulations.

1.7 MOTIVATION FOR THE RESEARCH

Over time, the environment changes by the unconscious use of natural resources, causing severe environmental threats. The concept of sustainable development gained momentum after the Brundtland Report defined sustainable development as 'meeting the needs of the present without compromising the ability of the future generation to meet their own needs. (Purvis et al., 2019). Following are some ground realities that point out the significance of green manufacturing practices and motivation to pursue research in this area:

- Carbon emissions from India rank third on the global list (Bhattacharya, 2020).
- The contribution of SMEs to producing industrial waste and environmental pollution is significant (Agan et al., 2013; de Sousa Jabbour et al., 2020).
- The Indian SMEs are reluctant to adopt green manufacturing practices.
- Consumers do not prefer green products due to the high cost of production and hence the product's high price.
- There are many issues regarding the green approach and sustainable manufacturing in SMEs.

1.8 RESEARCH OBJECTIVES

The main objectives of the research are:

- To identify and prioritize the obstacles in implementing green practices in Indian SMEs.
- To study the consumer behaviour towards the purchase of environmentally friendly products and find the impact of consumer behaviour on the production of environmentally friendly products.
- To correlate the effect of green product development on the performance of the Indian SMEs.
- To develop a framework to measure the green performance of the Indian SMEs.

1.9 OVERVIEW OF THE RESEARCH

- An exhaustive literature review identified the gaps and relevant research issues in the GMP of Indian SMEs.

- Based on literature review, discussion with academicians, and industry experts, formulated hypotheses related to consumer behaviour and purchase intentions for green products and organizational performance.
- A questionnaire containing the issues of organizations involved in GMP and consumers' perceptions about green products was designed to get responses from the business organizations and consumers.
- The responses to the questionnaire helped us know the business professionals' and consumers' perceptions about GMP.
- The consumers' responses helped to enhance the manufacturing of green products.
- The responses collected through the questionnaire were analysed for content and construct validity.
- The factors influencing the consumer's perception of green products have been collected through literature surveys and validated through questionnaires directly from the people of different segments of society.
- A GTMA approach is used to find out the green performance index of the organizations, and the BWM is used to prioritize the obstacles to green manufacturing practices.
- The study is helpful for the researchers and practitioners working in the field of GMP. The study offers a comprehensive literature review on obstacles to green manufacturing, consumer behaviour towards green products, and the sustainable performance of the organizations involved in green manufacturing.

1.10. ORGANIZATION OF THE THESIS

Chapter 1 (**Introduction**): This chapter introduces the research and the various issues regarding green manufacturing practices in select Indian SMEs. This chapter also presents

the motivation for this research, research objectives, research methodology, the study's significance, and the thesis's organization.

Chapter 2 **(Literature review)**: This chapter contains a literature review regarding obstacles to implementing green practices in Indian SMEs., the consumer behaviour towards the purchase of environmentally friendly products and the impact of consumer behaviour on the production of environmentally friendly products, the effect of green product development on the performance of the Indian SMEs and a framework to measure the green performance index of the Indian SMEs. Besides this, the research gaps and relevant issues of green manufacturing practices are also identified and deduced to the relevant hypothesis. The study has also motivated the present research work.

Chapter 3 (**Research methodology**): This chapter covers the research process, the reason for adopting a particular philosophical approach and the strategy to conduct the research. This chapter explains the method of data collection analysis and the details of research design, source of data, and details of the questionnaire survey.

Chapter 4 (**Hypotheses development and questionnaire administration**): This chapter presents the result of a questionnaire-based survey to understand the issue of green manufacturing practices in Indian SMEs, a descriptive study of the survey.

Chapter 5 (**Structural equation modelling: a partial least square – path modelling approach**): This chapter contains the testing of hypotheses concerned with consumer behaviour towards the purchase of environmentally friendly products and finding the impact of consumer behaviour on the production of environmentally friendly products and the effect of the implementation of GMP on the performance of the Indian SMEs. The hypotheses have been tested based on the response received from the Indian consumers and the data received from the Indian SMEs.

Chapter 6 (**Ranking of obstacles in the implementation of green manufacturing practices**): In this chapter, various obstacles experienced in implementing green manufacturing practices in Indian SMEs identified earlier in the literature review are prioritized according to their priority of dealing.

Chapter 7 (**Framework for developing green index**): This chapter deals with the framework to measure the green performance index of the organization based on the factors of green manufacturing practices identified through the literature survey in the previous chapter with the graph-theoretic matrix approach.

Chapter 8 (**Summary, limitations and future research scope**): This chapter concludes with the summary of this research, the significant implications, the limitations, and the scope and future direction of future research.

The organization of the thesis are mentioned in Figure 1.1 and a brief description of the chapters. Given below

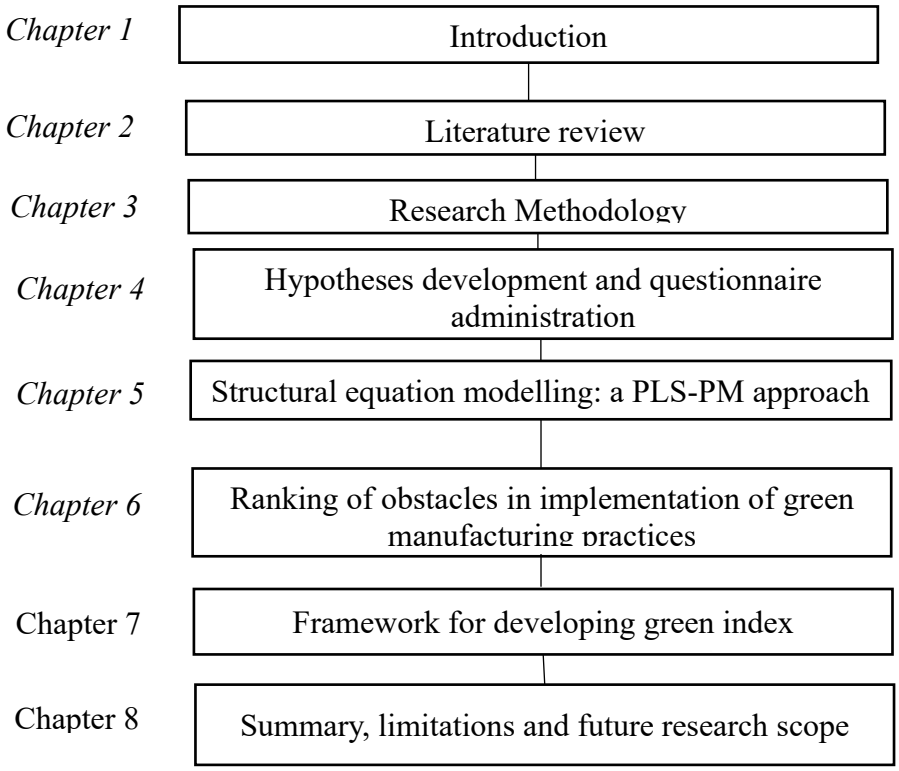

Figure 1.1: Organisation of the thesis

1.11 CONCLUSION

This chapter introduces this research and the various issues regarding green manufacturing practices in select Indian SMEs. Environment, resources, and population are significant issues, and any change in them leads to an imbalance of life on the earth. The manufacturing industries should reduce resource depletion and ecological effects during the product cycle to reduce the environmental impacts. Green manufacturing is the best alternative to minimize the use of natural resources and energy and reduce the products' adverse impact on the environment. Consumer behaviour towards the utilization of green products is one of the essential factors that can encourage organizations to adopt green manufacturing practices. This chapter also presents the motivation for this research, research objectives, research methodology, the study's significance, and the thesis's organization.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The fast-growing population and fledging economy forced the Indian government to enter the global market. However, environmental degradation has been compromised to meet the international competition. The manufacturing organization uses natural resources in a highly haphazard manner and consumes more energy, releasing greenhouse gases causing many economic, ecological and social problems (Mittal and Sangwan, 2014). Sustainable development gained momentum after the Brundtland report in 1987. Growing awareness of the Kyoto Protocol (1997) and Copenhagen Protocol (2009) further motivates the international community to think about sustainable development.

The excess use of resources like energy and materials acquired from natural resources and waste generation are troubling components that affect the environment. The developing countries boosted manufacturing to meet the requirements of their increasing population, whereas the developed countries exploit the natural resources to maintain their current standard of living (O'Brien, 2002). The rapid and unavoidable increase in the manufacturing sector resulted in the increasing average global consumption pattern causing an unsustainable situation. As manufacturing grew, it created many social, environmental, and economic problems, including global warming and waste disposal (Sangwan, 2011). There is a strong need for improvement in the manufacturing sector to reduce material consumption, industrial pollution, waste, etc. One solution to these problems is the introduction of environmentally friendly manufacturing processes. However, many obstacles exist to adopting green manufacturing practices, especially in developing countries like India.

2.2 OBSTACLES TO THE IMPLEMENTATION OF THE GREEN MANUFACTURING PRACTICES

Although the world is committed to implementing greener measures in manufacturing practices, various studies show that developed countries are more familiar with green manufacturing than developing countries (Hokoma et al., 2010). Consequently, green and lean manufacturing obstacles are more common in developing countries (Singh et al., 2020). The developing economies must bear more strengthened cultural hindrances as internal resistance to change than the developed countries (Delgado et al., 2010). The green manufacturing trend in India rises very slow compared to other countries.

Environmental pollution is increasing rapidly in many cities of developing countries. There is a need to find a solution to reduce pollution with continued efforts and development. Green manufacturing could be an attractive way for SMEs to find encouraging results in minimizing industrial pollution. Still, various attitudinal, financial, and technological barriers create obstacles to implementing green manufacturing practices. Singh et al. (2008) enunciated that SMEs act as a sister concern of large organizations and the engine for economic growth of the countries by contributing to employment generation. However, SMEs fail to exploit the opportunities and sustain their competitiveness because of insufficient resources and poor innovative capabilities.

Singh et al. (2012) observed green manufacturing as a lifesaving practice and suggested that various manufacturing firms should adopt it. Green manufacturing is a harmless process in which the environmental impact is felt at all stages of manufacturing practice to minimize waste and pollution. Green manufacturing is a necessity for our survival in today's competitive environment. The investigation shows that SMEs can adapt and make themselves greener by making organizational and strategic changes. Mathiyazhagan et al. (2013) perceived that after increasing customer awareness and

enforcing strict regulations, Indian auto industries, especially component manufacturing SMEs, are focused on implementing cleaner production but face many obstacles. According to Mittal and Sangwan (2011), green technologies in developing countries face many challenges. Because of increasing global concern about the pollution and exhaustion of natural resources, firms are rushing toward adopting environmentally conscious technology. However, the insufficient information, high cost, fear of failure, inadequate alternative technology, insufficient human resources, weak legal structure, poor public demand, insufficient government support, the pressure to lower prices, slow rate of return, and insufficient performance measures are creating an obstacle in the adoption of green technology.

Barve and Muduli (2013) studied the various challenges faced by the Indian mining industry. They observed that different harmful gases, including GHG emitted from the mines, deteriorate the air quality, discharge of oil and grease degrade the water quality, and noise and vibration cause hair loss and other health-related issues. Then also, many industries are reluctant to adopt green supply chain practices because of many challenges to their implementation. The major obstacles identified were poor human resource quality, insufficient societal pressure, poor legislation, lack of direct incentives, financial obstacles, technical barriers, management commitment, employee commitment, resistance to change and acceptance, poor environmental consciousness, and unsuitable approach to execution. Mittal and Sangwan (2013) have categorized the barriers to environmentally conscious manufacturing into policy, internal, and economic barriers. Global warming and increased customer awareness have attracted world organizations' attention to environmental sustainability. The strict regulations forced the industry to develop environmentally-friendly operations to reduce its carbon footprint (Xu et al., 2013). The poor ecological knowledge, training, the high initial cost of implementation, and good environmental policy

and regulations are the main barriers to adopting the environmental management system (EMS) in SMEs (Ferenhof et al., 2014).

The various environmental concerns and awareness forced the industries to adhere to the environmental regulations. However, the drivers and barriers to implementing green manufacturing practices in SMEs differ from that of large enterprises. Ghazilla et al. (2015) detected that the lack of data, resources, experience, and technical expertise is the main obstacle to implementing SMEs' green manufacturing practices. Jabbour et al. (2016) stated that the major problems are limited financial opportunities for environmental investment, low employee participation in decision making, inadequate technical information, communications, equipment, and low investment in research and development (R & D) limited the ability to handling the obstacles. It is a unique problem. Pressure from the government and customers was not a significant motivation. Nevertheless, government incentives and peer learning through industry associations appear to motivate SMEs to adopt green practices more effectively. Sometimes, firms are internally encouraged to adopt green practices for cost and competitive advantages.

Green supply chain management (GSCM) is one of the critical components of green manufacturing practices. With the rapid change in word-wide manufacturing scenarios, the need for a greener supply chain has become a more prominent issue in managing any business. Dube and Gawande (2016) defined GSCM as a supply chain combining economy and ecology to improve processes and products and achieve sustainability. GSCM is an integrated process of a traditional supply chain with environmental criteria to improve the performance of the products and processes according to the requirements of the regulations. Due to the increasing scarcity of natural resources, environmental concerns have become one of the most emerging issues for manufacturing organizations. The adoption of green manufacturing practices has become difficult due to many barriers. Lack

of commitment from top management, eco-skills between supply chain partners, corporate social responsibility, market demands, supplier readiness, integrated information systems, sound environmental performance indicators, regulatory support and guidance, inadequate strategic planning and adoption, reverse logistics practices, non-adoption of clean technology, poor supply chain integration, resistance to change and innovation, financial barriers and limiting companies associated with product/ process stewardship, policies are barriers that prevent environmental issues from being integrated into supply chain processes (Mudgal et al., 2010). Zhu and Geng (2013) researched implementing extended supply chain (ESC) practices to achieve energy saving and emission reduction programs set by the Chinese government. They found that besides strengthening the enforcement level of stricter regulations, consumer awareness, financial barriers, and insufficient resources and capabilities are the main obstacles to implementing ESC practices. Govindan et al. (2014) experienced that even after adopting green supply chain practices in the manufacturing industries, the industries are still unable to identify the factors creating hindrances in implementing green supply chain practices. Problems like outsourcing, technology management, poor environmental knowledge, financial scarcity, and low awareness about the ecological impact on the business need to be addressed.

GSCM includes all the aspects of green manufacturing gaining momentum these days. Insufficient necessary tools, management skills, and knowledge are the main barriers to implementing GSCM in the two-wheeler automobile industry, and incapability to accept suitable environmental treatment measures is the critical barrier for the four-wheeler automobile industry (Lalit et al., 2014). Sustainability has emerged as a crucial concept for manufacturing industries in today's scenario. However, the significant barrier to sustainable manufacturing is the poor awareness of sustainability concepts, lack of green consumers, insufficient finance, etc. (Bhanot et al., 2017).

The increase in carbon emissions and global warming forced the government to implement rules and regulations to protect the environment strictly. GSCM practices that consume optimal resources and energy are essential to maintaining sustainability. But some barriers like insufficient government support, poor management commitment, less consumer awareness, financial restrictions, poor IT implementations, and fear of failure are the main hindrance to the implementation of GSCM. Kaur et al. (2018) have observed that knowledge, commitment, and product design barriers created limitations to adopting GSCM in Canadian electronic industries. Sustainable consumption and production are the crucial ways firms can achieve sustainable development. Still, many barriers exist to incorporating sustainable consumption and production into the supply chain.

Mangla et al. (2017) found that organizational barriers are vital in implementing green supply chain practices (GSCP) in the industry. The industry is not able to analyze the effect of individual activities. The GSCM is a vital issue for profit and market advantages by reducing waste and emissions and improving environmental efficiency. Gupta and Barua (2018) categorized the barriers as managerial, organizational, human resource-related, technological, and green resource-related, financial, market, and customer-related, creating obstacles to SMEs' implementation of green manufacturing practices. Moktadir et al. (2018) observed that the Bangladeshi leather industry could not adopt sustainable supply chain management (SSCM). The main barriers are the information gap, poor economic conditions, absence of social pressure, poor support from a regulatory authority, lack of eco-literacy, less practice in reverse logistics, and cost of sustainability. According to Chand et al. (2018), the manufacturing organizations focus on the GSCM to reduce the consumption of harmful materials and waste, maintain the quality of natural resources and improve environmental and economic performances.

The products cannot be ecologically sound without considering the environmental impact on the raw material procurement level, manufacturing, sales, and disposal level. The managers of green manufacturing organizations think green is an opportunity to establish their position in a niche market by producing a higher value product from fewer resources to gain competitive advantages. Abu et al. (2018) realized that environmental issues become an integral part of the business, increasing consumers' ecological concern. The business organization is trying to develop an environmentally friendly product by implementing green new product development. However, implementing green new product development in SMEs engaged in conventional manufacturing and wanting to adopt green manufacturing practices faces many obstacles like shortages of finance, non-cooperative organizational culture, resource problems, poor availability of skilled workforce, and competition. Strict policies and a perfectly defined roadmap ensure effective and efficient implementation of green manufacturing practices in developed countries whereas, in SMEs of developing countries like India, the application of green manufacturing is still in the initial stage due to insufficient awareness and limited resources (Gandhi et al., 2018; Thanki et al., 2016).

Green manufacturing practices produce parts using minimum natural resources and minimizing waste with minimal environmental pollution. SMEs have vital importance in the manufacturing sector and should ensure environmental consciousness while making cost savings to profit. Currently, sustainability-driven management is a priority for all business organizations. Yacob et al. (2019) observed that SMEs adopt sustainable energy optimization and resource conservation practices. The major barriers to implementing green manufacturing practices are poor waste management, reliance on conventional methods, improper execution of laws, less motivation for green manufacturing practices, and more investment in innovations (Shahria et al., 2019). Green business practices are

desired for most SMEs worldwide, encouraging profitability, flexibility, and positive ecological and social impact. Lean and green thinking appears as better business strategies to deliver better-valued products to the customer and improve the efficiency of the enterprises. But when SMEs implement lean and green thought in their business practice, they face several barriers like insufficient financial resources, expertise, fear of market failure, and poor awareness of suppliers (Caldera et al., 2019). The Malaysian construction industry is the 30th most carbon-emitting industry globally. Klufallah et al. (2019) perceived that finance, knowledge, culture, capacity, design, and technology are the critical barriers to achieving sustainable practices in the Malaysian construction industry.

Previously, the industry was worried about quality products, but technological advancement helps meet the inconsistent customer demand, non-polluting quality products, and reduced non-value-added time. A lean, green, and agile manufacturing system (LGAMS) makes the supply chain more efficient and sustainable. It plays an essential role in perpetuating the company's name in the market in the present scenario. In green manufacturing practices, the inputs for the process generation have a negligible effect on the environment with almost zero waste. Implementing lean manufacturing in the supply chain increases profit through cost reduction; agile manufacturing raises profit by meeting the customer wants, while green manufacturing addresses sustainable and environmental policies. However, adopting GMP in the industry is difficult because of many factors like insufficient financial and trained human resources, awareness about environmental aspects of manufacturing, and government policies (Sindhwani et al., 2019). Xia et al. (2019) felt that implementing green technical solutions at the operation level helps achieve green sustainability in enterprises; however, there are specific physical and psychological barriers to adopting green technical solutions at the operation level. Majumdar and Sinha (2019)

witnessed that support of regulatory bodies, innovation, and consumer support is needed to implement green supply chain practices in the textile industry successfully.

Manufacturing organization has accepted the concept of sustainability to overcome environmental issues. Despite technological advancement and awareness, organizations have obstacles to adopting sustainable measures. Pathak et al. (2020) experienced obstacles like ineffective enforcement of the law, insufficient market demand, and unspecified return on investment, creating hindrances in adopting sustainable manufacturing practices. Whereas Karuppaih et al. (2020) felt that the most prominent business organization in developed countries had adopted green manufacturing practices, SMEs in developing countries still struggle to adopt green manufacturing practices due to a lack of internal abilities and strategies. Technology has dramatically impacted society and has become the backbone of business activities. Al-Zamil and Saudagar (2020) conducted a case study to determine the impact of green computing adoption on sustainable agriculture in Saudi Arabia. Green computing uses information technology resources in greening computer-related products' disposal, design, and manufacturing.

SMEs could be the most prominent contributor to greenhouse gas emissions without sufficient resources. Chien et al. (2021) observed that SMEs are responsible for around 70% of total industrial waste and environmental emissions. Although, after increasing awareness, the government has imposed some restrictions on SMEs to reduce the ecological impact (Wasif Rasheed and Anser, 2017; Ahmad et al., 2020), the political barrier is the most substantial barrier besides managerial, technical, information, and economic barriers. Environmental policies often applied by the government to alleviate the emission are further improved by the business organizations like SMEs (Mohsin et al., 2018; 2021). Almansoori et al. (2021) observed that the issue of sustainability gathered attention due to the depletion of natural resources. Sustainable development is significant for exploiting

resources, technological development, and investment direction. Green innovation can be the solution to the sustainability issue of SMEs. Implementing suitable environmental friendliness measures can boost SMEs' competitive advantages and profit in the long run. Ullah et al. (2021) stated that green innovation is essential for profit and reducing environmental deterioration. Several studies have shown challenges in implementing green manufacturing practices; some major challenges are summarised in Table 2.1.

Table 2.1: Studies on challenges of green manufacturing practices

S. No.	References	Country	Topic	Industry Type/size/sector
1.	Peters and Buijs (2022)	Netherlands	Strategic ambidexterity in green product innovation: Obstacles and implications	Domestic appliances
2.	Chien et al. (2021)	Saudi Arabia	Assessing the prioritization of barriers toward green innovation: small and medium enterprises Nexus	SMEs
3.	Ullah et al. (2021)	Pakistan	Mapping interactions among green innovation barriers	SMEs
4.	Asbahi et al. (2020)	Yemen	Assessing barriers and solutions for the Yemen energy crisis	Renewable energy sector
5.	Karuppiah et al. (2020)	India	Implementing GMP in SMEs	SMEs
6.	Majumdar and Sinha (2019)	India	Green Textile Supply Chain Management in Southeast Asia	Textile and apparel
7.	Agyemang et al. (2019)	West Africa	Green supply chain redesign and implementation of related practices	Cashew industry
8.	Mangla et al. (2018)	India	Effective circular supply chain management in a developing country context	SMEs, Manufacturing industry
9.	Belhadi et al. (2018)	Malaysia	Lean production	SMEs
10.	Ashton et al. (2017)	US	The adoption of green business practices	SMEs
11.	Kaur et al. (2018)	Canada	investigating barriers in green supply chain management	Electronic goods

12.	Thanki et al. (2016)	India	An investigation of lean-green implementation practices	SMEs
13.	Jabbour et al. (2016)	Brazil	Adoption of green operational practices	Automotive, electronic equipment, plastic
14.	Singh and Singh (2016)	India	Implementing lean manufacturing	SMEs
15.	Ghazilla et al. (2015)	Malaysia	Analysis of green manufacturing practices	SMEs
16.	Lalit et al. (2014)	India	Relative Importance to the Adoption of Green Supply Chain Management	Automobile
17.	Mittal and Sangwan (2014)	India	Environmentally conscious manufacturing implementation	Not specified
18.	Govindan et al. (2014)	India	Green supply chain management implementation	Not specified

However, the main barriers to green innovation in developing countries are the poor enforcement of laws for return goods and recyclable products, insufficient regulations for green products, and lack of collaboration with government and environmental institutions. Some important obstacles explored through the literature review are summarized in Table 2.2:

Table 2.2: The obstacles to the GMP identified through the literature survey

Obstacles	**References**
Technology procurement cost	Mittal and Sangwan (2014), Majumdar (2019)
Green packaging cost	Gavrilescu et al. (2017); Jermsittiparsert et al. (2021).
Waste disposable cost	Gavrilescu et al. (2017); Papadas et al. (2019); Handa et al. (2019).
Insufficient resources	Gandhi et al. (2018); Moktadir et al. (2018); Karuppiah et al. (2020)
Ineffective tax policy	Seth et al. (2018), Wang & Yu (2021)
Lack of supplier development and commitment	Mathiyazhagan et al. (2013); Singh et al. (2020)
Lack of top management commitment	Kaur et al. (2018); Gandhi et al. (2018).
Lack of strategic planning	Gandhi et al. (2018); Majumdar (2019)
Ineffective information technology	Chien et al. (2021)
Poor availability of skilled labour	Gandhi et al. (2018); Gupta & Barua (2018); Majumdar (2019)

Insufficient training and educational facilities	Gandhi et al. (2018); Karuppiah et al. (2020)
Lack of mutual trust and motivation	Luo et al. (2018); Karuppiah et al. (2020); Chien et al. (2021.)
Low investment in research and development (R & D)	Luo et al. (2018); Karuppiah et al. (2020); Chien et al. (2021.)
Poor awareness	Mangla et al. (2017); Chien et al. (2021)
Scarce advanced technology	Jabbour et al. (2016); Kaur et al. (2018); Singh et al. (2020)
Poor organizational management	Karuppiah et al. (2020), Noranarttakun and Pharino (2021)
Insufficient incentives for green technology	Chein et al. (2021), Zhu et al. (2012)
Poor understanding of green standards	Mangla et al. (2017); Chien et al. (2021)
Ineffective regulations for reverse logistics	Majumdar (2019); Karuppiah et al. (2020)
Insufficient government support	Shi et al. (2008); Zhang et al. (2008); Singh et al. (2020)
Ineffective implementation of rules and regulations	Mittal and Sangwan (2014); Majumdar (2019)
Insufficient funds for the implementation of green practices	Moktadir et al. (2018); Karuppiah et al. (2020)
Scarce green materials for product design and developments	Xiong et al. (2020)
Insufficient facilities for the management of end-life products	Mathiyazhagan et al. (2013); Olah et al. (2020); Xiong et al. (2020)
Poor knowledge about environmental impacts	Brave and Muduli (2012); Ghazilla et al. (2015); Singh et al. (2020)

2.3 CONSUMER BEHAVIOUR FOR UTILIZATION OF GREEN PRODUCTS AND ITS IMPACT ON THE PURCHASE INTENTION AND MANUFACTURING OF GREEN PRODUCTS

Green manufacturing aims to reduce the consumption of natural resources through efficient manufacturing processes and lower the negative externalities coupled with waste and pollution. Green manufacturing uses green energy, develops green products, and employs green techniques to reduce resources and wastage. The goals of green manufacturing align well with the innate desire of companies to improve their competitive advantage, making a compelling business case for going green. With the increase in environmental awareness, there is an emergence of ethical consumers who are very much concerned about environmental problems. Consumers need information about their

environmental concerns as they are confused about green products. The advertisement is a credible source to influence consumer purchase intentions.

It isn't easy to reflect the environmental attitude in socio-demographic characteristics, and it would be more beneficial to explore their ethical belief to understand consumer purchase behaviour. The demographics and psychological behaviour of the consumer willing to pay more to support the growth of environmentally friendly products show the increasing environmental concerns. There is a complex relationship between the demographic profile and an accurate profile of green consumers with his environmental consciousness without considering all aspects of ecological consciousness. Jansson et al. (2010) felt that for a successful business organization, it is necessary to understand the consumer's behaviour as the beliefs, norms, and value determines willingness to curtail and eco-innovation adoption. Mazar and Zhong (2010) found that consumers' social and moral values are equally important as price and quality. The green consumer does not use products which endanger the species, environment, or the health of others. However, the environmental concern level does not match their purchase behaviour since the green marketing strategies depend on consumers' willingness to pay more for green products. The ecological concern did not directly measure the people's environment-related behaviour.

The environmental concern is the consumer's orientation towards the environment, which is a critical predictor of green behaviour. Ecological problems are also related to the belief or values of an individual and are a direct predictor of green purchase behaviour. D'Souza et al. (2006) observed the same for consumers. However, it is hard to understand the information provided on the label of the products. Some customers are ready to buy greener products even though they are comparatively lower in quality than conventional ones. Companies that prefer profit-making over reducing environmental impacts have poor reputations and negative perceptions of green products. The perceived product experience,

quality, and lower prices positively contributed to purchase intentions, but the product label, packaging, and ingredients alone did not influence consumers. The increasing environmental concern changes the individual's values and lifestyles. Values and lifestyles being psychographic variables give a better opportunity to identify the ecological behaviour of the consumer. With the increasing interest in sustainability, consumer attitudes also become positive but not converted uniformly into purchase behaviour.

Consumers are emerging as a reckoning force for sustainable development. But all the consumers are not demanding green products. Hence, marketers should use different strategies for different segments. There is a significant link between socio-demographic characteristics and the consumer's environmental consciousness (Jain and Kaur, 2006). Haanpää (2007) considers green consumer behaviour an essential factor in understanding the sociology of consumption. The lifestyle and green commitment show consumption style and environmentally related consumer choices. D'Souza et al. (2007) suggested that the company should target the consumers according to their environmental beliefs and think about reducing pollution rather than increasing profitability.

Fraj and Martinez (2007) found environmental attitude significant in consumer ecological behaviour. With improved environmental awareness, people purchase green products for health reasons and to maintain sustainability for future generations. The industries are also developing products according to the change in the consumers' attitudes. Consumers differ in price, packaging, brand, and convenience in use, but most consumers prefer environmentally labelled packaging. do Paço et al. (2009) observed that the purchasing pattern of consumers shows the impact of the world's modernization on their environmental concerns,

Developing a sustainable production system depends on consumers' willingness to consume green products. Green consumption depends upon consumer values, norms,

income, habits, lifestyles, beliefs, economic rationality, and environmental knowledge (Peattie, 2010). Ali et al. (2011) realized that consumers often buy green products if the green products compete with the conventional products in features, performance, and quality for the same price. Ishaswini and Datta (2011) stated that the current trend of economic growth and resource consumption worsens the environmental condition. According to Jansson et al. (2011), the ecological problem is a burning issue for international organizations and local governments. Borin et al. (2011) observed that a positive environmental message has a better impact than a product with a negative ecological message and a more significant effect on consumable products. Akehurst et al. (2012) found that psychographic variables emphasizing perceived consumer effectiveness and altruism more appropriately explain consumers' environmentally-conscious behaviour and positively impact green purchase behaviour. So, consumers' awareness of eco-friendly product consumption should be promoted.

The understanding of consumer behaviour towards environmental value becomes essential. Socio-demographics, values, beliefs, and norms brought significant changes in consumer behaviour compared to past decades. There are many factors responsible for the shift in consumer behaviour. But green marketing, environmental advertisement, green label, and green brands increase consumers' positive perception and awareness (Rahbar and Wahid, 2011). Although, the consumers are willing to buy green products but not at a higher cost. The increase in consumer demand helps reduce the price of green products. Carrete et al. (2012) believed that the confusion in consumers about green products, trust and credibility of the green products, and compatibility of the green product with conventional products is the dominant factor of uncertainty in adopting green consumer behaviour.

Chen and Chang (2012) stated that the green perceived value of the product mediates in improving trust and green purchase behaviour. Hence, the green perceived value of the product with less risk should be elevated to increase confidence and green purchase intentions. Kaufmann et al. (2012) observed that the consumer's pro-environmental behaviour differs from his general purchasing behaviour, driven by the benefits and costs associated with the products. Lin and Huang (2012) found that environmentally conscious consumers prefer green products. Still, psychological benefit, knowledge, price, and quality are the main factors influencing consumer behaviour toward green products. Business organizations have realized the consumer's increased environmental concern, resulting in the development of green products and a new segment of consumers known as the green consumer (Mayekar and Sankaranarayanan, 2014). Green products are gaining popularity amongst consumers with increased awareness of health and the environment. Health, product availability, and education positively affect consumers purchasing organic foods (Paul and Rana, 2012). Albayrak et al. (2013) compare the environmental concern and scepticism on the green purchase behaviour of the customer and found that the customers with severe ecological problems are less sceptical, and their high positive norms and perceived behavioural motivate them to subscribe to e-invoices.

Sustainable production helps gain advantages in a globally competitive market, but the price is still the most influencing consumer purchase behaviour. Despite many developments in functional performance, green product does not have significant advantages over perceived quality (Borin et al., 2013). Consumers' environmental concerns make them socially more responsible, like saving energy, using recycled products, buying eco-labelled products, and reducing waste. Ecological awareness and increasing consumer demand for environmentally friendly products are motivating forces behind the revival of green marketing, revealing the significance of consumer perception in an effective green

business. The corporate image combines many factors reflecting and conveying an organisation's identity. The product image and corporate reputation have a direct impact, whereas social responsibility indirectly affects the products' purchase intentions (Ko et al., 2013). With the revival of green marketing, the problems of greenwashing have also become common. Greenwashing intentionally deceives consumers by making a false claim in the name of green products. Buyers are becoming very sensitive and unconvinced by organizations, as many organizations confess to protecting the environment but fail to explain them in their activities and performance. The firm's low performance negatively influences the brand image and consumer price intentions in the presence of green advertisements (Nyilasy et al., 2013). Barbarossa and Pastore (2014) found that higher prices and scarce availability are the main barriers hamper consumers' purchasing of green products despite their environmental consciousness. The marketers should focus on these issues to change the perception of the environmentally-conscious consumer. Chowdhury and Samuel (2014) found that the social dilemma of green consumerism creates a gap between consumers' actual behaviour and purchase intentions. Marketers should convey the clear benefit of the green product to the customers.

Johnstone and Tan (2014) observed that even environmentally conscious consumers do not regularly purchase green products. The three main reasons that emerged are the consumer's perception that '*it is too hard to be green*', the reluctance of the consumers, and '*green reservations*. Consumer perception is a significant factor that influences consumer attitude and behaviour. Khaola et al. (2014) also found a gap between consumers' environmental concerns and shopping behaviour. The study shows that environmental concern has solid relationships with attitudes but failed to convert into purchase intentions. The ecological crisis indirectly affects the green purchase intentions through mentality. Khor and Hazen (2014) studied consumer behaviour toward accepting

remanufactured parts and found that it is gaining attention. There is a significant relationship between consumer behaviour, price, quality of the products, and green marketing and a weak association of brand and demographic variables with green consumer behaviour (Sheikh et al., 2014).

Weisstein et al. (2014) observed that despite raising awareness about the environment, price and promotion affect the consumer's decision of green purchase. The price promotion affects their purchase decision according to their inclination towards greenness. The perceived value also intercedes the moderated effect of perceived quality and saving when deciding the green purchase. The marketers should design the price promotions according to the consumer's level of greenness. Sreen et al. (2018) stated that green purchase helps build a brand image and goodwill.

The impact of the consumer's attitude, norms and purchase behaviour is positively related, and gender is a moderator to test the perceptual differences regarding green purchase intentions. The survey (Dupont green living survey, 2014) shows that India's awareness of green products is about 63%. In developed countries like Canada and the USA, it is about 78% and 73%, respectively. Poor awareness causes the organizations not to develop green products for India. Hong et al. (2018) stated that green products are gaining attention due to environmental benefits, and more firms are inclining toward their production. However, the pricing of green products is still one of the significant issues.

A study examining the pricing strategies compared to conventional products of the same functional attributes shows that environmentally aware people recognize the benefits and quality of green products. The manufacturer should adopt low pricing strategies for green products and high prices for conventional products. Attitude is the most critical factor in altering purchase behaviour. Depending on age, income, and perceived consumer effectiveness, customers' behaviour influences recycling behaviour (Zhao et al., 2014).

Increasing consumption is an essential worry for the degradation of the environment. Consumers are price-sensitive and ignore their choices if the cost is high. The social value factor is also a crucial dominating factor influencing consumer behaviour. Li et al. (2015) stated that the corporate environmental action also affects the consumer's legitimacy about the environment and his purchase intentions for green products. In the present ecological crisis, the critical activity of the corporate induces a remarkably higher perception of environmental legitimacy, which can improve consumers' green purchase intentions. Consumers' willingness to pay and norms are great predictors of their purchase behaviour. Marketers should adopt promotional strategies to create consumer awareness about their consumption behaviour that can make a difference (Moser, 2015).

Aagerup and Nilsson (2016) stated that the solution to the environmental problem is to produce more green products, but the consumer should also be motivated to consume green products. The values and norms are the motivational factors other than the internal attitudinal behaviour to improve green consumption behaviour. Felix and Braunsberger (2016) found that the policymakers should try to induce positive attitude change, and marketers should encash the internal religious orientation to protect natural resources and improve green purchase behaviour. Narula and Dasore (2016) suggested that consumers being the most critical stakeholder of green consumption, special attention should be given to green marketing. The few highly motivated consumers are ready to buy green products with more price. Still, despite their environmental awareness, the more significant segment of the people hesitates to purchase green products. Many barriers like cost, trust, and certification hinder consumers from buying green products. Suki (2016) suggested using green brand positioning to improve green brand knowledge and the green brand purchase intentions of the consumer. The green brand image can help differentiate the products from the competitor and generate increased buying behaviour of the green products.

Consumers are the key drivers of the increase in sustainable production. They significantly influence production by improving their behaviour to support environmental goals and purchasing green products. Tan et al. (2016) stated that consumers' green perception is a multifaceted concept that influences green consumer behaviour to a varying degree to overcome the barriers to green consumption behaviour. Even though green consumerism is increasing, but attitude behaviour gap persists. Green buying behaviour depends upon the type of product and consumer involvement. Environmental involvement, environmental consciousness, knowledge, perceived product price and quality, environmental advertising, and a company's environmental reputation are the critical factors that improve green purchase behaviour amongst young Indian consumers (Uddin and Khan, 2016). In developed countries, the impact of production and consumption depleting natural resources becomes part of their cultural consent. But in developing countries, it is still in the early stage because of variation in culture for environmental problems.

Ferraz et al. (2017) found a positive relationship between consumer intentions and behaviours concerned with green products. Consumers' purchase behaviour can be enhanced by lowering the product's price and improving quality and availability. Price plays a significant role in evaluating alternative products and final buying decisions (de Medeiros et al., 2016; Li et al., 2016; Moser, 2016). While deciding on alternative products, the consumer checks the amount he must spend and the quality of the product for that price. Price also plays a significant role in assessing advertisement attractiveness while undertaking price judgment relating to the brand and its competing brands. Hsu et al. (2017) found that attitudes, norms, perceived behavioural control, and the country of origin remarkably impact purchasing green skincare products.

Green purchasing behaviour is affected by consumers' traits and behaviour. Consumers' intention to pay higher prices for green products depends upon their eco-literacy, demographic characteristics, values, attitude, and behaviour. Khan and Mohsin (2017) found that the product's price, social value, and environmental value directly impact the consumer's product choice behaviour and conditional value, epistemological value, and emotional value. However, emotional value moderates all morals, including environmental values. Marketers often keep the price of green products on the higher side than the price of conventional products. Witzel and Zielke (2017) found that price is a significant barrier; a partly defining factor is income superseded by psychographic variables to purchase organic food. Consumer's response to green marketing occurs primarily among the wealthier consumers. Price plays a vital role in consumer purchase behaviour depending on their economic background, price sensitivity, and price trade-off between price and value.

Sangroya and Nayak (2017) stated that only government regulations could not motivate consumers to use green energy. Instead, there should be a willingness to use green energy for the well-being of society. The study shows that social and emotional attributes, along with financial attributes, are the factors that motivate the consumer to adopt green energy. The policymakers should formulate the policy based on these attributes to encourage consumers to adopt green energy voluntarily. Dabija et al. (2018) observed that consumer loyalty helps the company satisfy customer needs and make a reputation in the competitive market. The result shows that Romanian companies follow the principle of sustainability and get customer loyalty. But in the market, the behavioural antecedents differ for different customers, which creates a challenge for retailers. Chen et al. (2018) found that a productive attitude most significantly affected purchase intentions. In contrast, environmental attitude, social influence, and perceived monetary value influence

consumers' purchase intentions. Subjective knowledge affects the product attitude, whereas objective knowledge and individual environmental literacy do not affect ecological attitude.

Consumer's green buying behaviour helps in achieving global sustainable development. Personality traits such as extroversion, coordination, and openness to experience positively impact consumers' green purchasing behaviour. Jaiswal and Kant (2018) stated that unsustainable consumption leads to severe environmental problems, forcing society to change its purchase behaviour. Consumers' attitudes toward the green product, ecological concerns, and perceived consumer effectiveness directly influence consumer green purchase intentions. Trang et al. (2019) studied green hotel attributes and found that customer benefits, energy efficiency, and green characteristics positively contribute to customers' pro-environmental values and attitudes. According to do Paço et al. (2019), green behaviour is essential for sustainability. Green behaviour is associated with the feeling of social awareness and social responsibility. Prosocial attitude is positively related to green consumption, directly impacting green buying behaviour. With the increase of prosocial perception, environmentally friendly consumption also increases. Whenever the individual combined with a social group and member of that social group takes environmental action, the individual is also inspired to do the same. Green purchasing is commonly associated with buying sensible, ethical, sustainable, and environmentally friendly products. The green advertisement alone weakly influenced green buying behaviour.

Eco-labelling containing the information about the product's characteristics pertains to the consumer's environmental concerns and plays a significant role in altering consumer behaviour. Most customers are willing to pay a higher price for green products. However, a well-designed pricing policy can improve green activities to gain market

advantages. The eco-labelling, premium, and price are the most influencing factors and consumer belief towards the environment to change consumer behaviour (Shabbir et al., 2020). The knowledge, awareness, and commitment to green products influence consumers' purchase decisions. In the absence of understanding, consumers do not accept green products. Hence a clear message about the advantages of green products should be given to them. Higher-income people with higher education are more concerned with the environment and more likely to engage in green purchases. The young generations have a high environmental awareness, which motivates them to buy green products (Majhi, 2020). When the individual is more concerned with the welfare of the other human being and non-human elements of the environment, he might be more careful about the harmful effects.

The increasing health consciousness, philanthropy attitude, and dissemination of knowledge about environmental protection and society may enhance green consumption (Nguyen et al., 2020). Multiple factors influence consumer behaviour towards green products. According to the theory of planned behaviour, consumer behaviour depends upon attitude, subjective norms, and perceived behavioural control. People prefer eco-friendly products if they possess a constructive attitude towards environmental conservation. The price of green products and the individual's environmental concern play a vital role in the purchase decision of green products (Varah et al., 2021; Kripa and Vinod, 2021). The threat of environmental degradation shifts consumers towards ecologically responsible purchasing.

Rajadurai et al. (2021) observed that societal pressure, willingness to pay higher prices for green products and government initiatives influence young consumers' online purchasing of green products. Several studies have shown consumer buying behaviour toward green products; a few of them are summarized in Table 2.3.

Table 2.3: Studies on consumer buying behaviour for green products

S. No	References	Country	Topic	Industry Type/size/sector
1.	Majid et al. (2022)	Pakistan	Investigating influencing factors on consumers' choice behaviour and their environmental concerns while purchasing green products in Pakistan	Consumer choice behaviour
2.	Laheri and Malik (2021)	India	Consumer Buying Behaviour for Green Products	Organic food products, organic personal care products, and energy-efficient products
3.	Nittala and Moturu (2021)	India	Role of pro-environmental post-purchase behaviour	Not specified
4.	Witek and Kuz´niar (2021)	Poland	The Effectiveness of Sociodemographic Variables for Explaining Green Purchases in Emerging Markets	Not specified
5.	Khan et al. (2020)	Malaysia and Thailand	Consumer green behaviour: An approach towards environmental sustainability	Plastic bags
6.	Sharma et al. (2020)	India	Relating the role of green self-concepts and identity on green purchasing behaviour	Not specified
7.	Testa et al. (2020)	Italy	The circular economy and consumer behaviour: The mediating role of information seeking in buying circular packaging	Circular packaging
8.	do Paço et al. (2019)	Portugal and UK	A new model for testing green consumer behaviour	Not specified
9.	Álvarez-García et al. (2019)	Spain	Influence of brand equity on the behavioural attitudes of customers	Tourism sector
10.	Jaca et al. (2018)	Spain	What should consumer organizations do to drive environmental sustainability?	Not specified
11.	Dabija et al. (2018)	Romania	The impact of green consumer behaviour on	Retail stores

			green loyalty among retail formats	
12.	Su et al. (2017)	China	How does perceived corporate social responsibility contribute to green consumer behaviour?	Hotel context
13.	Ferraz et al. (2017)	Brazil and Canada	Green products: a cross-cultural study of attitude, intention and purchase behaviour	Green products
14.	Suki (2016)	Malaysia	Green product purchase intention: impact of green brands, attitude, and knowledge	Organic vegetables
15.	Wang et al. (2016)	China	Green information, green certification, and consumer perceptions	Automobile parts
16.	Moser (2015)	Germany	Thinking green, buying green? Drivers of pro-environmental purchasing behaviour	Daily consumer goods
17.	Biswas and Roy (2015)	India	Green Products: An Exploratory Study of the Consumer Behaviour in Emerging Economies of the East	Not specified

Sociodemographic factors like age, gender, financial situation, and education level affect consumer behaviour toward purchasing green products. Female consumers have a more positive attitude towards green purchases than male consumers, but young consumers are susceptible to green products. People with better financial conditions are more inclined to purchase green products (Witek and Ku´zniar, 2021). The factors influencing consumer behaviour and purchase intentions of green products observed through the literature review are summarized in Table 2.4.

Table 2.4: The factors influencing consumer behaviour and their purchase intentions for green products

Factors	Sub-factors	References
Purchase Intentions	Need Fulfillment	Talim et al. (2021); Yoong and Lian (2019)
	Environmental Consciousness	Prakash et al. (2019); Sun and Wang (2019)
	Personal Attention	Prakash et al. (2019); McLean et al. (2020)
	Post-Sales-Service	Katta et al. (2021); Grewal & Stephen (2019)
Perceived Quality	Consumer Producer relationship	Vrontis & Thrassou (2007), Grunert (2006)
	Empathy	Cornish et al. (2020); Murray et al. (2019)
	Responsiveness	Brunner et al. (2019); Prakash et al. (2019)
	Reliability	Tran (2020); Katta et al. (2021)
	Assurance	Goddard & Muringai (2019); Xiao et al. (2019)
Consumer Behavior	Product cost	Kahraman and Kazançoğlu (2019); Katta et al. (2021)
	Green initiatives	Khare (2014), Rettie et al. (2014)
	Addressing social issues	Cornish et al. (2020); Hsu et al. (2019)
	Product quality	Chang et al. (2019); Li et al. (2021)
	Income level	Wekeza & Sibanda (2019); Coderni & Perito (2020)
Brand Loyalty	Organizational commitment	Kurdi et al. (2020); Zasuwa (2019)
	Respect for rule of law	He & Lai (2014)
	Advertising & Promotions	Grewal & Stephen (2019); Prakash et al. (2019)
	Transparency with consumer	Cambier & Poncin (2020)
	Consumer expectations	Tran (2020); Chatterjee et al. (2020)
Green Production	Use of alternative materials	Tsai et al. (2020)
	Green packaging	Prakash et al. (2019); Xiao et al. (2019)
	Energy conservation	Joshi et al. (2019); Huang & Ge (2019)
	Waste management	Hajar et al., (2020);
	Improvement in life expectancy	Stukalo & Simakhova (2019); Pandey et al. (2020)
	Production cost	Zhang et al. (2020); Zhao et al. (2020)

2.4 THE EFFECT OF THE GREEN PRODUCT DEVELOPMENT ON THE PERFORMANCE OF THE INDIAN SMEs

Environmental friendliness is an essential part of social responsibility. Environmentally aware consumers prefer the product of environmentally oriented firms. Green purchasing is positively related to a firm's performance. Corporate reputation is an immaterial asset to marketing and financial performance. The firms with good

environmental bailiff have an excellent reputation, increasing their marketing and financial performance. In this situation, social issues become equally important as a market factor. Environmental concerns have led manufacturing firms to take a proactive role in developing cleaner manufacturing processes by using recyclable products.

There is much evidence showing that the firms with higher environmental performance have a higher market share and, consequently, more financial gain. But conflicting observations regarding the companies' environmental and financial performance are also available. Some literature shows an increase in the cost of adopting environmental measures, while others show an increase in sales with an increase in environmental performance and, ultimately, profit increases. Some literature also reveals that environmental performance is not helping much in improving yield, but systematic environmental management may improve the financial performance of the firms.

The traditional belief is that improving environmental performance is a win-win situation for larger firms. In contrast, the extra money needed to achieve environmental performance causes the already financially scared small firms to lose. But it has been realized that green performance also improves the financial performance of organizations. Further, few green incentives improve the firms' green performance and financial performance (Clemens, 2006). Green manufacturing systems have better competitive advantages over non-green performing manufacturing organizations. A positive relationship exists between corporate environmental and financial performance. The company that has adopted green procurement and green manufacturing practices have better environmental and financial performance than others. It is an old convention that ecological protection is associated with extra cost. The greener firms have better market access and an image of the ethical manufacturer with a better environmental management system and without any environmental litigation. These factors generate a win-win

situation for the firms, leading to better environmental and financial performance (Ambec and Lanoie, 2008).

Darnall (2009) found that there are two kinds of literature available. Some show that stricter environmental regulation constrains organizational and financial gain, while others show that stricter regulation provides a chance for innovation and increased operational efficiency. Neoclassical economic theory argues that compliance with environmental regulations imposes an extra cost and reduces a firm's competitive advantages. The stricter ecological policy reduces facility; however, measures taken to improve environmental performance have the probability of recapping financial gains. Lai and Wong (2012) stated that green logistics management improves firms' environmental and operational performance. However, it is not having any economic motivation. Compliance with the regulations improves the environmental conditions. Still, it fails to create a positive impact on the financial situation of the firms, due to which organizations always try to avoid complying with these regulations and norms. So, the environmental rules and standards should be concise and straightforward to improve their bottom line by embracing these regulations and standards (Digalwar et al., 2013). Consequently, the investments in implementing regulations change the firm's financial conditions and may also impact the firm's environmental management.

Firms that do not earn profit legally, ethically, and responsibly cannot sustain themselves in the market. It is believed that environmental integrity and social equity are at odds with financial prosperity. However, green innovation is critical to economic growth, environmental sustainability, and social improvement. Green innovation makes a technological enhancement to save energy, reduce pollution, recycle, reuse waste, and improve product design and corporate environmental management. Green innovation also helps business sustainability by improving organizations' financial, social, and

environmental performance (Caracuel and Mandojana, 2013). Green innovation is developing a new idea, product, and process that contributes to reducing environmental threats and helps achieve the economic target. Organizational ecological performance is the systematic measuring and assessment of the industry's environmental performance, including corporate and environmental performance indicators. Green innovation had a positive effect on green operations and environmental performance.

The manufacturers should formulate a strategy to satisfy the customer in achieving a sustainable process (Chen et al., 2013). During globalisation, the fast-growing industrialisation causes significant growth of problems associated with the environment like global warming, ozone depletion, water, air pollution, and land erosion. Because of lower eco-literacy and limited understanding of the benefits of green manufacturing, the SMEs consider green manufacturing practices too costly and risky to implement. Leonidou et al. (2014) stated that more firms became involved in environmentally friendly activities with the remarkable rise of environmental problems. The external environmental forces can be encouraged to generate an eco-friendly orientation behaviour within the SMEs, which improves SMEs' financial performance.

The environmental regulations, public environmental awareness, competitive passion, and market energy yoke an ecological orientation of small firms by enhancing their financial gain. Chan et al. (2016) stated that stricter regulation positively impacts cost efficiency and a firm's profitability through product innovation. Green innovation in product design and services reduces the adverse effects on the environment for the whole product life cycle. Green product innovation also improves a firm's competitive advantages and image and thus positively impacts a firm's performance. Environmental dynamism has intense mediation between green product innovation and cost efficiency and marginal effect on a firm's profitability.

Li and Ramakrishnan (2019) investigated the impact of technical innovation on environmental performance and the financial performance of business organizations. Technological innovation significantly affects firms' environmental performance and financial performance. Product innovation consists of modifying existing products and developing new products. Process innovation may include the change of equipment, methods, technology, etc., to reduce costs, increase flexibility and production efficiency to improve the competitiveness of the firms. The operational viewpoint of leanness also improves competitiveness by lowering costs and improving the firm's efficiency. The significance of adopting leanness and innovativeness in Indian SMEs is still inconclusive due to the lack of committed resources, core skills, long-term commitment, and high implementation cost. However, leanness and innovativeness in manufacturing significantly impact a manufacturing organisation's financial and environmental performance (Centobelli et al., 2019).

Green technology innovation integrated with green product and process innovation continuously receives attention from business organizations because of increasing environmental problems. Heavy polluting industries must care for the environment, customer needs, and corporate social responsibility. New technology with green innovation is essential to meet environmental issues. The green process innovation appears costlier but has proven more effective by optimizing production processes. Green product innovation prevents environmental protest and legal penalties. It helps create a new market and product status. Green process innovation positively impacts green product innovation. Both green product and green process innovation have a positive effect on the financial performance of the organizations through the mediating effect of green product innovation. The green image of the firms also improves the relation between green product innovation and

financial performance. Green practices are helpful for SMEs in terms of economic and environmental performance (Rekik and Bergeron, 2017; Xie et al., 2019).

Green operation is an operational process that integrates supplier-manufacturer and manufacturer-customer relationships. Product manufacturing, handling, usage, waste management, and logistics features are part of a green operation. The overall impact of green operations is different for manufacturing and service organizations. The prevailing view is that adopting environmental variables in the organization's activities adds to the cost, affecting the organization's financial performance. Ngniatedema and Li (2014) found that green policies, environmental impact scores, and ecological performance scores positively impacted a firm's performance in green manufacturing.

In contrast, a green reputation plays an essential role for the organizations involved in the green service sector. With increasing awareness, there has been a change in attitudes towards greener lifestyles to reduce the negative impacts on the environment. Business organizations also need sustainable business practices to stay competitive. Thus, strategies for sustainable development should be part of their business plan. Sustainable action generates money from the product and services and reduces resource efficiency costs, building trust and brand value among stakeholders. The environmental performance and the natural resource use efficiency positively influence the organisation's financial performance. The organizations involved in sustainable business also get competitive advantages (Ong et al., 2014). Environmental issues have become a regular aspect of everyday life. The business organization should integrate 'greening' terminology in their philosophy to take advantage of the firm's position within the marketplace. Green marketing is a broader term that contains green marketing, design, logistics, positioning, etc. It integrates product modification, production process modification, packaging and advertisement change. The firm performance includes environmental performance,

operational performance, and financial performance. Studies in the case of Kenya tea firms show that green marketing strategies positively impact the firm's performance (Afande, 2015).

The varying political, social, and economic pressure forces the firms to adopt sustainable business practices. Still, the increasing cost of adopting sustainable practices outweighs the financial benefits. Profit is the best interpreter of financial gain for SMEs, and pollution prevention has a significant positive relationship with profit, whereas recycling has a significant negative relation to profit. Communication with stakeholders, stricter regulations, advertisement, networking, total quality management (TQM), reliability, and durability results in a concrete financial gain for SMEs (Jayeola, 2015). Green manufacturing practices produce a product with minimum pollution and optimum use of resources without adversely impacting the environment. Green manufacturing has a remarkable positive effect on the environmental and social performance of the firms. Sen et al. (2015) realized that Manufacturing organizations worldwide are commencing incredible changes in their production strategies by integrating the concept of sustainable development. The overwhelming concern for environmental degradation forced business organizations to incorporate manufacturing practices and environmental management systems. The environmental pro-activity positively correlates with the financial and operational performance of the organizations.

Rehman and Srivastava (2016) stated that only superior-performing companies can stay in the market in the current competitive environment. Strict regulation can play a significant role in promoting green manufacturing practices. More stringent policies and regulations help develop efficient green manufacturing practices in developed countries, but it is still in its infancy in developing countries like India. The factors of green manufacturing practices have a significant correlation with organizational performance.

The environmental framework helps the companies integrate the design, purchase disposal, and recycling with ecological thinking. To comply with the strict environmental regulations and attain financial gain by improving performance, the Indian company must adopt green manufacturing practices. The sequence of actions a company takes to reduce the negative impact of a product or service, from product design, raw material procurement, and product use to final disposal, is called a green initiative. Green performance is the positive impact of the green initiative on the natural environment. While green initiatives negatively impact energy production and reputation, green performance significantly impacts a company's financial performance. The green initiative indirectly improves a company's financial performance by improving its environmental performance (Li et al., 2017). Pollution is associated with the underutilization of raw materials and the waste of resources. Pollution prevention green technology can help minimize costs and develop sustainable skills for the future. The external business practice can help incorporate participants' views into business practice to formulate future business paths.

The pollution prevention approach helps achieve a competitive advantage by increasing the demand for the product and improving productivity. A firm producing green products can reduce sustainable costs and improve its services and product quality. Green practices play a positive role in improving financial performance (Miroshnychenko et al., 2017). The environmental degradation forced the firms to switch to a low carbon resource-efficient economy. Qian and Xing (2018) stated that carbon performance confirms the effect on financial returns in private firms. The company emitting less carbon means consuming less energy and achieving higher financial gain. The positive impacts of carbon performance on financial performance are weaker in environmentally sensitive companies.

A company with excellent economic conditions can achieve better environmental performance. Governmental and corporate actions are desirable for sustainable corporate

performance (Alexopoulos et al., 2018). The increasingly competitive market puts unprecedented pressure on firms for sustainable success. Incorporating social and environmental aspects in their corporate strategies becomes a must to lead in the future market. The value-destruction theory anticipates that firms engaged in social and ecological responsibility losses focus on profitability. The resource-based view states that firms can attain competitive advantages with better financial performance by strategically exploiting their capabilities. Around 78% of the literature shows a positive link between corporate sustainability and corporate financial performance (Alshehhi et al., 2018).

Chen et al. (2018) studied the relation between green initiatives, green performance, and a firm's financial performance globally. The findings show that green initiatives positively correlate with financial performance with the mediating effect of green performance. However, the green initiatives varied from country to country. Hang et al. (2018) found that financial resources can help achieve environmental performance in the short run. Similarly, raising environmental performance did not have any noticeable impact in the short run, but the firm gets significant financial benefits in the long run. Manufacturing organizations have initiated implementing green practices due to the increasing demand for green products and environmentally friendly services.

Lean manufacturing practices aim to produce a product with minimum wastage. It includes just in time (JIT), TQM, total preventive maintenance (TPM), and human resource management (HRM). Green manufacturing incorporates green design, green process planning, green product development, etc. Lean manufacturing has a positive link to environmental performance. Operational performance and green manufacturing have a positive correlation with environmental performance and a positive correlation with operational performance (Inman and Green, 2018). Green operations enhance the beauty of ecology and improve long-term business performance. Green

practices improve product quality, reduce costs, improve corporate performance and customer satisfaction, and help improve a company's performance, except for purchasing green materials (Khan et al., 2017). Malesios et al. (2018) found that only certain practices and outcomes of environmental, operational and social sustainability appear to benefit SMEs' economic performance. Li et al. (2018) discovered that green supply chain behaviour positively impacts corporate performance.

According to Zhu and Sarkis (2004), China has much pressure to improve its environmental performance after joining the World Trade Organisation (WTO). Green supply chain management (GSCM) is essential for improving environmental performance. The GSCM enhances the firm's financial performance and improves environmental performance. The implementation of GSCM improves ecological performance by reducing air emissions, waste reduction, and minimizing the use of toxic materials. GSCM improves ecological and economic performance, which improves operational performance and operational performance and improves organizational performance (Green Jr. et al., 2012). There is no direct relationship between GSCM and corporate performance (Lee et al., 2012; Younis et al., 2016). But an indirect relationship exists between GSCM and organizational performance with a mediating role in SMEs' operational and relational efficiency. Green purchasing and environmental cooperation have a positive impact on the operational performance of the firms. Green purchasing alone plays a role in improving the firm's financial performance, and reverse logistics practices positively impact the social performance of the firms (Younis et al., 2016).

GSCM is the contemporary concept of the conventional supply chain where various activities like green design, green purchasing, and minimization of harmful materials are achieved to reduce environmental impacts. GSCM is gaining popularity, and organizations are sincerely adopting green practices. The leadership and institution also create pressure

to adopt green practices and external green collaboration. The study found that green practices positively influence a firm's economic performance (Ahmed and Najmi, 2018). Performance enhancement is the primary motivator of the firm that inspires to adopt GSCM practices. However, studies on the relationship between firm performances and GSCM reached mixed, conflicting, and confusing conclusions.

Feng et al. (2018) surveyed automobile manufacturers in China. They found that GSCM as an integrated supply chain strategy has a significant positive association with environmental and operational performance, leading to better financial performance. The supply chain's inbound and outbound logistics service is the leading environmental polluters. Greening the entire supply chain is necessary to ensure firms' activities do not harm the environment. Implementing GSCP is specifically essential for developing nations where the effect of pollution is a more severe cause of ill health and death.

The impact of different green practices on various performances varies from industry to industry. Eco-design with internal environmental management practices influence environmental performance, whereas green purchasing with internal environmental management practices influences financial performance (Namagembe et al., 2018). Çankaya and Sezen (2018) found that the GSCM had positive relationships with ecological performance but did not have effective social and economic relationships. The green production, distribution, and packaging of GSCM practices positively affect the business's financial, environmental, and social performance. In addition to the above GSCM dimensions, environmental education positively affects economic performance; the environmental management and investment recovery of the GSCM dimensions positively relate to the business's environmental performance and social performance, and green marketing positively impacts the business environment performance. SMEs in developing countries require financial resources to implement proactive ecological strategies. The lack

of financial credit, institutional support, and inadequate legal enforcement system also prohibit their ability to compete. SMEs often complain about the implementation of environmentally sustainable measures to increase costs. However, environmental sustainability orientation has a positive relationship with a firm's performance when the firm adopts a differentiation strategy (Danso et al., 2019). The environment has always been an important issue for global business with financial development. The fast-growing economy also causes environmental deterioration. Thus, it is necessary to balance economic growth and environmental degradation.

Incorporating environmental management in the supply chain is necessary as society becomes aware, and firms' effort to shape environmentally friendly products has become popular. Green management lowers costs and actively fulfils its social responsibility by keeping out ecologically friendly activities. Resource-based view and organization capability theory opined that environmental orientation could help firms build green management capabilities and stimulate suppliers to adopt green practices. Environmental orientation shows how companies are inclined to overcome the ecological threat. It also reflects how companies adopt different measures to reduce harmful environmental impacts from their day-to-day activities. Supplier green management positively relates to environmental orientation and financial performance of the business organization. Relational capital mediates the link between ecological orientation and financial performance, and it becomes more substantial with the rise in relational capital (Yu and Huo, 2019). According to Baah et al. (2020), regulatory and organizational stakeholder pressure plays a positive role in adopting green production practices and increasing the firm's reputation and financial and environmental performance. Green production is an effective weapon to gain a competitive advantage and superior performance in existing business environments. Green manufacturing practices show

systems and processes that produce goods and services using less energy to preserve natural resources. The increasing resource shortage, customer awareness, more environmentally conscious laws, and the organization's impact on the environment create real challenges for today's firm. The GSCM is an approach to management theory that integrates all aspects of the supply chain, a humanitarian and sustainable activity for companies offering economic advantages. Cahyono et al. (2020) found a positive relationship between GSCM and a firm's financial and environmental performances.

In contrast, Mensah et al. (2020) observed that green logistics management practice significantly influences the environmental performance of organizations. Still, the impact on social market financial performance is insignificant. The manufacturing sector consumes about one-third of energy with around 38% carbon dioxide emission (IEA 2015). These noticeable impacts on the manufacturing industry have created the need to comply with environmental regulations and guidelines to ensure safer production processes. Institutional and stakeholder pressure forces manufacturing organizations to adopt green manufacturing practices. Green products and procurement significantly impact organizations' organizational legitimacy and financial performance, whereas process innovation positively influences economic performance (Acquah et al., 2021). Regulatory obstacles and stakeholder consciousness pressure the organizations to adopt sustainability measures explicitly. The idea of the triple bottom line forced organizations to take responsibility for the environment and society rather than think about economic benefits only. GSCM is the mindset of greening the environment through ecological practice, increasing a firm's profitability. Firms can reduce the costs and environmental burden by adopting the energy-efficient method and reducing carbon emissions. Manufacturing practices directly affect socio-environmental sustainability with economic implications. Internal environment management is the awareness and seriousness of the higher

executives to implement eco-friendly policies are called the backbone of GSCM. The Green Information System is a monitoring system for measuring the performance of environmental efforts.

Implementing green practices in the supply chain can eliminate waste from the entire process and increase the company's brand equity, sales, profitability and sustainable competitive advantage. Green manufacturing practices significantly correlate with the financial performance of the firms. Internal environment management and green information systems strongly and positively support GSCM. GSCM significantly improves the competitiveness, and economic and environmental performance, which finally improves the organizational performance of the firms (Khan and Yu, 2021). Khan et al. (2022) observed that businesses pursue to prevent ecologically damaging actions in their supply chains. Besides, optimising their resources is significant anxiety for industries to curtail carbon emissions, raise sustainable practices, and improve a country's long-term economic development. Though several studies are available on the impact of the adoption of green manufacturing practices on the organization's performance, a few are summarised in Table 2.5.

Table 2.5: Studies of the impact of the adoption of green manufacturing practices on the organization's performance

S. No	References	Country	Topic	Industry Type/size/sector
1.	Trujillo-Gallego et al. (2021)	Colombia	Identification of practices that facilitate manufacturing companies' environmental collaboration	Coffee region
2.	Khan et al. (2021)	Pakistan	Assessing the eco-environmental performance	Not specified
3.	Mousa and Othman (2020)	Palestine	The impact of green human resource management practices	Healthcare sector
4.	Afum et al. (2020)	Ghana	The link between green manufacturing, operational competitiveness, firm	Food and beverage, metal and roofing, plastics, chemical processing

			reputation, and sustainable performance	
5.	Baah et al. (2020)	Ghana	the correlations between stakeholder pressures, green production practices, firm reputation, environmental and financial performance	SMEs
6.	Sellitto and Hermann (2019)	Brazil	Influence of Green Practices on Organizational competitiveness	Electrical and Electronic
7.	Yu and Huo (2019)	China	The impact of environmental orientation on green supplier management and financial performance	Metal, machinery, and Engineering
8.	Seth et al. (2018)	India	Green manufacturing drivers and their relationships	SMEs and large industry
9.	Ghosh (2018)	India	Determinants of green procurement implementation	Not specified
10.	Li et al. (2017)	USA	Understanding the Impact of Green Initiatives	Energy, financials, health care, industrials, information technology, materials, telecommunication Services
11.	Miroshnychenko et al. (2017)	Italy	Green practices and financial performance	Not specified
12.	Younis et al. (2016)	UAE	The impact of implementing green supply chain management practices	Not specified
13.	Chan et al. (2016)	China	The moderating effect of environmental dynamism on green product innovation and performance	The automotive industry, electrical and electronic industry, chemical industry, manufacturing industry, textile industry, and toy industry.
14.	Jayeola (2015)	UK	The Impact of Environmental Sustainability Practice on the Financial Performance of SMEs: A Study of Some Selected SMEs	SMEs
15.	Ngniatedema and Li (2014)	US	Green Operations and Organizational Performance	Manufacturing and service industry

The various factors observed through the literature survey influencing the performance of the organisations involved in green productions are summarised in Table 2.6.

Table 2.6: The factors influencing the performance of organizations involved in green productions

S. No.	Constructs	Indicators	Reference
1.	Financial Performance	Increase in market share	Seiler et al. (2020); Omran et al. (2021)
		Profit increase	Cho et al. (2019); Nguyen et al. (2020)
		Increase in sales	Khan et al. (2019)
		Return on investment	Tran et al. (2020)
2.	Social Performance (SP)	Corporate social responsibility	Cho et al. (2019); Ali & Danish (2020)
		Ethical behaviour	Landi & Sciarelli (2019); Saha et al. (2020)
		Respect for rules of law	He & Lai (2014)
		Job creation	Brammer & Pavelin (2006)
3.	Environmental Performance (EP)	Use of non-hazardous materials	Kraus et al. (2020); Seman et al. (2019)
		Waste reduction	Leksic et al. (2020); Kamble et al. (2020)
		GHG emission	Bhatt & Abbasi (2021); Mustafa et al. (2019)
		Optimal utilization of resources	Shen et al. (2005)
		Global warming	Masson-Delmotte et al. (2018); Al-Ghussain (2019); Nordhaus (2020)
4.	Green Manufacturing (GM)	Use of cleaner technology	Bhandari et al. (2019); Singh et al. (2020)
		Green packaging	Prakash et al. (2019); Xiao et al. (2019)
		Renewable energy sources	Østergaard et al. (2020); Quazi et al. (2019)

2.5 FRAMEWORK FOR DEVELOPING THE GREEN INDEX FOR ASSESSMENT OF GREEN PRACTICES

Very few studies are available to identify the factors influencing implementing green practices in Indian SMEs. Most of the studies in this field are inappropriate in actual practice. The main objective of this study is to identify the factors and sub-factors

influencing the implementation of green manufacturing practices in SMEs and produce an index for assessing green practices.

External pressure from government regulations, stakeholders, competitors, community groups, and the media increasingly forces companies to integrate environmental management systems into their business processes (González-Benito and González-Benito, 2006). In this regard, some valuable articles analyze the determinants and their impact on the development of green initiatives in the supply chain (Zhu et al., 2005; Zailani et al., 2012; Wu et al., 2012; Walker et al., 2008; Lee and Klassen, 2008; Large and Thomsen, 2011; Diabat and Govindan, 2011; Kumar et al., 2021). Most studies focus on external pressures placed on the organization by external stakeholders and regulators to develop green initiatives, ignoring internal factors under the control of the enterprise. Organizations can initiate voluntary environmental activities to gain a competitive advantage following government initiatives despite external pressure. Top management can proactively set strategies for implementing green supply chain practices. It is generally understood that green management only adheres to regulations while assessing environmental and economic performance (Walley and Whitehead, 1994).

Zhu et al. (2007) also found that China's Green Supply Chain Management (GSCM) has slightly improved environmental and operational performance. Molina-Azorín et al. (2009) pointed out that most studies investigating green management suggest that it significantly enhances organizational performance. Klassen and McLaughlin (1996) advocated green practices and said environmental performance influences financial performance by reducing the cost and marketing performance by increasing the market share. Rao and Holt (2005) observed that the companies in South East Asia adopting green supply chain management have better competitiveness and economic performance.

Mefford (2011) highlighted the consensus of the researchers on creating more economic values through the green supply. Zhu et al. (2007) have suggested the effect of green manufacturing on company performance in environmental, economic, and operational performance.

The manufacturing firms are under pressure from society and governmental agencies to operate sustainably. The lean manufacturing practices may provide sustainable benefits to the firm, even though the firms were not implementing them. Toyota's production system introduced the concept of lean manufacturing to improve the quality of the product, reducing cost by eliminating waste and avoiding non-value-added activities (Iranmanesh et al., 2019). There is a growing interest in implementing environmentally friendly manufacturing practices to improve ecological standards that develop sustainability (Strandberg and Kjellström, 2019). The firms are under constant pressure to execute responsible practices to build sustainable management (Dubey et al., 2017). Employee motivation and leadership also play an essential role in sustainable management practices (Ahuja et al., 2019). To satisfy customer demands, the manufacturing firms produce hazardous waste harmful to the environment. Hence, it befits them to know the acceptable level of exploitation of natural resources, investors, and the ecosystem. Green manufacturing practices provide sufficient opportunities to balance their social, economic, and environmental performances (Afum et al., 2020). The fast-growing industrial sector and population depleting the natural resources fast cause acute shortages of resources for the global community (Kothawade, 2017). Green manufacturing practices help the organization improve financially by optimal resources and minimum wastages. Though green manufacturing practices are equally crucial for both large and SMEs, SMEs are more hesitant to implement green manufacturing practices (Tumpa et al., 2019). The SMEs play a vital role in the growth of the countries, and the survival of SMEs in the global

competitive era becomes difficult without implementing green manufacturing practices. Green manufacturing practices are zero waste generation to alleviate negative environmental impacts.

Green and lean manufacturing practices also provide a solution to the manufacturing industries to reduce the ecological impact (Thanki et al., 2016; Dieste et al., 2019). According to Singh et al. (2020), several manufacturing organizations adopt cleaner processes to meet the rapid changes in business activities because of globalization and increasing environmental concerns (Cherrafi et al., 2017). Green, lean practices also help manufacturing organizations in improving their organizational performance. Combining green and lean manufacturing practices enhances the capacity to address an industrial manufacturing system (Verrier et al., 2014). Integrating green with lean practices could help the firms take favourable environmental decisions and improve the ecological efficiency of the organizations (Farias et al., 2019; Cherrafi et al., 2017).

The implementation of green initiatives changes the operational capabilities of the firms because green manufacturing practices produce less environmental pollution (Zhang et al., 2017; Karuppiah et al., 2020). The essential factors of green manufacturing identified through the literature survey are summarised in Table 2.7.

Table 2.7: List of the essential factors identified for green manufacturing

Factors	Remarks/Concerned Subfactors	References
Top management commitment	• Written policy and goals of the organization • Implementation of Environmental management systems • Regular assessment of the green performance • Dedicated workgroup for the environmental initiatives	Ravi and Shankar (2005); Mittal et al. (2013); Luthra et al. (2014); Ghazilla et al. (2015), Karuppiah et al. (2020), Baah et al. (2021), Bhatia and Kumar (2022)
Government legislation	• Reduction in carbon emission • Restriction on the use of hazardous materials	Luthra et al. (2010, 2011); Qadri et al. (2011); Balasubramanian (2012),

	• Effective water consumption • Reduced energy consumption and use of an alternative source of energy	Li et al. (2020), Baah et al. (2021), Kuo et al. (2022)
Economic interest	• Energy-efficient power systems • Green packaging • Collection of end-life products from the consumer • Recycling of end-life products	Mudgal et al. (2009); Luthra et al. (2011), Prakash et al. (2019); Xiao et al. (2019)
Consensus on Green Management	• General awareness of environmental management program • Coordination of inter-functional managers • Collaborative quality management program • Environmental compliance and auditing systems	Mudgal et al. (2009); Reijonen (2011); Luthra et al. (2011), Baah et al. (2020)
Firm's Competitiveness	• Brand value in terms of green • Development of environmental management system • Green certification	Mudgal et al. (2009); Dheeraj and Vishal (2012); Lee et al. (2015), Afum et al. (2020), Baah et al. (2020)
Green Product Design and Development	• Standardization of common parts • Waste reduction • Optimal utilization of resources • Improvement in life expectancy	Jugend et al. (2017); Kamble et al. (2020); Stukalo & Simakhova (2019); Pandey et al. (2020)
Supplier relationship management	• Commitment of supplier • Certification of the supplier organisations • Capability to produce green products • Technological support between buyers and suppliers	Ravi and Shankar (2005); Hasan et al. (2007); Luthra et al. (2014); Andiç et al. (2012), Li et al. (2020)

2.6 RESEARCH METHODS

To achieve the research objectives, various research methods like partial least square path modelling technique of structural equation modelling, graph theory and matrix approach, and best worst methods are used in the current research. The details of the different research methods are stated below.

2.6.1 STRUCTURAL EQUATION MODELLING: A PARTIAL LEAST SQUARE–PATH MODELLING (PLS-PM) APPROACH

There are two approaches in structural equation modelling (SEM), i.e., covariance-based SEM (CB-SEM) and variance-based SEM (Partial least Square Path Modeling (PLS-PM)). Large sample size and model complexity is some of the issues in CB-SEM. Confirmatory factor analysis is a statistical technique used to test the hypothetical relationship between observed variables and the latent constructs with the variable. In a first-generation statistical method, the assumption was that data are error-free. In a second-generation statistical process, the models using structural equation modelling (SEM) account for observed variables, and unobserved variables try to identify the error component of the data. Measurement error is the difference between the actual and value obtained using scale. There are two types of measurement error:

- The random error that can affect the reliability of construct and
- The systematic error, which is more dangerous, can affect the validity of the construct (Hair et al., 2014).

Some of the sources of errors are:

- The survey questions were poorly framed
- Incorrect application of the statistical method
- Misunderstanding of scaling approach

In SEM, an advanced statistical tool is used to access the complex models with many relationships, perform confirmatory factor analysis, and incorporate observed and unobserved variables. It uses factor analysis and multiple regression characteristics to simultaneously examine the direct and indirect effects of dependent and independent variables.

Research problems are generally prediction based; hence, in CB-SEM, there is an error, and data normality is required. PLS-SEM is suitable for smaller sample sizes and complex models where more constructs are to be dealt with and no normality of data is needed. In the case of PLS-PM analysis, generally, ten times rules are being followed. The minimum sample size should be ten times the number of formative indicators used to measure the single constructs. It supports both reflective and formative measurement models as well as single-item constructs. A partial least square focuses on predicting a specific set of hypothesized relationships that maximize the explained variance in the dependent variables (Hair et al., 2011). Partial least Square Path Modeling (PLS-PM), developed by Herman Wold in the early 1980s, is a regression analysis technique used for analyzing associations between latent variables and items. PM is the diagrammatic representation of the relationship of hypotheses with variables containing two elements, namely 1). The structural model, also called the inner model, shows the relationship between the constructs and the 2). The measurement model, also called the outer model, describes the relationship between constructs and their indicators (Sanchez, 2013). The structural model is the path relationship between the constructs. The left-side constructs are independent variables, whereas the right-side constructs are dependent variables. The independent variables are exogenous constructs with a single-headed arrow coming from them. The dependent or independent constructs from which a single-headed arrow comes into it or both coming and going out from it are known as endogenous constructs.

The measurement model shows the relationship between constructs and indicators. There are two ways of measuring latent variables. One way is a reflective measurement in which latent constructs are causing the indicators. The second is the formative measurement, in which the indicators are the effect of latent variables. The reflective measurement models can be evaluated by checking the internal consistency reliability,

indicator reliability, convergent validity, and discriminant validity. The reliability of constructs shows the ability to measure the same phenomenon accurately and repeatedly.

In the formative measurement models, the construct convergent validity can be examined using reflective measures through correlation with an alternative effort of the constructs. The correlation between the constructs should be equal to 0.7 or more. Collinearity is a phenomenon in which one predictor (indicator) can be predicted from the others with considerable accuracy. The variance inflation factor (VIF) can check indicators' collinearity. VIF shows the degree to which the standard error has been increased due to collinearity. Many researchers have used PLS-PM in different fields; some are summarised in Table 2.8.

Table 2.8.: Recent applications of PLS-PM

References	Recent applications of PLS-PM
Schuberth et al. (2022)	Assessing the overall fit of composite models estimated by partial least squares path modelling
Catldo et al. (2021)	Use of PLS-PM to build sustainable development goals (SDGs).
Singh et al. (2021)	To observe the effect of stakeholder pressure, green dynamic capabilities, green innovation, and performance of the emerging market on SMEs
Jermsittiparsert (2021)	To study the relationship between green intellectual capital and the sustainability of businesses.
Jabeen et al. (2021)	To investigate the factors impelling the consumers' willingness to buy green energy technologies (GETs).
Shahmohammadi et al. (2020)	To study the effect of flowering characteristics on increasing the fruit yield of strawberries.
Negrão et al. (2020)	To study the relationship between adopting lean manufacturing practices and business performance.
Pimonenko et al. (2020)	To study the impact of greenwashing on companies' green brand
Ardakani and Soltanmohammadi (2019)	To investigate the drivers of sustainable supply chain management.
Seles et al. (2019)	To analyze the effects of economic crises on the relationship between environmental practices, environmental performance, and business performance

2.6.2 MULTI-CRITERIA DECISION MAKING: BEST-WORST METHOD (BWM)

There are several methods like TOPSIS, AHP, DEMATEL, and VIKOR (Gencer and Gürpinar, 2007; Thangchattu and Siripokapiram, 2010; Senthil et al., 2014; Awasthi and Kanan, 2016; Prakash and Barua, 2016) through which the weight of the criteria can be calculated, but all these techniques require pairwise comparison matrices which often suffers consistency issue due to more amount of data involves. In a multi-criteria decision-making (MCDM) problem, several options must be evaluated concerning different attributes to select the best options, rank all possibilities, or sort other options in a group. In an MCDM technique, goals/alternatives/criteria are to be identified, evaluate the alternatives concerning measures, determine the importance of measures by synthesizing the data to find the solution, and check for reliability and validity of the outcomes. To mitigate these issues, a new multi-criteria decision-making (MCDM) tool, which requires less amount of data and is more consistent, is developed called the best-worst method (BWM) (Rezaei, 2015). The best and worst criterion is decided initially based on their experience. After that, concerning each standard, the best and worst alternatives are selected and compared with the best and worst options separately. The concluding scores are decided based on the weights of different sets and alternatives. According to Rezaei (2020), the structured way of comparison offered by BWM has several advantages:

- BWM carries a more consistent pairwise comparison that gives the decision-maker a clear understanding of the comparison's reliability.
- BWM considering the opposite references (best and worst) is an effective strategy to lessen the anchoring bias.
- BWM is the most data and time-efficient method considering two specific alternatives that give a complete pairwise comparison.

- The linear BWM model provides a unique solution.

BWM, since its development, has been used by many researchers like Rezaei et al. (2016) used in the food supply chain to find the best suppliers, Gupta et al. (2017) used to find the most critical enablers of technological innovations, Ren et al. (2017) used to decide the criteria and priority of the technologies in urban sewage sludge treatment, van de Kaa et al. (2019) to determine the better battery technologies available in the market, Kaushik et al. (2020) to find out the probable reason of return of apparel in the online market, Sharma et al. (2021) to find out the barriers in adoption of big data analytic. Many researchers in different fields have used BWM; some are summarised in Table 2.9.

Table 2.9.: Recent applications of BWM

References	Recent applications of BWM
Amiri et al. (2021)	Evaluating and selecting a sustainable supplier
Ecer and Pamucar (2020)	Sustainable supplier selection
Rahimi et al. (2020)	Sustainable landfill site selection
Kumar et al. (2020)	Evaluating the green performance of the airport
Zolfani and Chaterjee (2019)	Comparative evaluation of sustainable design-based household furnishing materials
Yadav et al. (2018)	Effective offshore outsourcing adoption
Gupta and Barua (2018)	To overcome barriers to green innovation in SMEs
Badi and Ballem (2018)	Supplier selection
Rezaei et al. (2018)	Quality assessment of airline baggage handling system
Gupta and Barua (2017)	Supplier selection among SMEs

2.6.3 GRAPH THEORY AND MATRIX APPROACH (GTMA)

Graph theory is a logical and systematic approach. Identifying the system to the component level helps you analyze and understand the system. It offers the best option among the many options available for the problem. Graph / directed graph model representations have proven useful in modelling and analyzing different systems and

problems in different areas of science and technology. The matrix approach helps you quickly analyze graphs / directed graphs to derive indicators of system functionality and goal achievement (Safari et al., 2013). The graph-theoretic approach is a powerful decision-making method that has played an essential role in system modelling, network analysis, functional expression, conceptual modelling, diagnosis, etc. (Sabharwal and Garg, 2013).

In the Graph Theory matrix approach, the pairwise comparison of the attributes is mapped in both directions. It is the uniqueness of the method. An index is prepared using the digraph mapping of the factors and sub-factors with the help of a permanent matrix. This method comprises the digraph technique, the matrix formulation, and the permanent function representation. The relationship between different variables is represented by a directional graph based on which a matrix is formed. Interdependencies between variables and their contribution to the system are assigned numbers on a fixed scale, and the overall index is calculated. A complete directed graph is used to create the mathematical form of a matrix, and the persistent function of the matrix represents a numeric index (Malhotra et al., 2012).

To derive a system function by indexing the performance, the GTMA is a systematic and logical approach (Rao, 2007). Various researchers have adopted GTMA for various applications in science and technology. Gandhi et al. (1992) used GTMA for the analysis of the mechanical system, Venkatasamy et al. (1995) used it for structural analysis of automobiles, Singh and Sekhon (1996) used it in component manufacturing, Wani et al. (2002) used it in the field of tribology, Rao (2006) used it in selecting robot for industrial applications, Upadhyay (2008) used it in software development. GTMA has served a significant role in network analysis, conceptual modelling, diagnosis, etc. Bridjesh (2015) used GTMA to consider various performance parameters such as braking performance,

brake-specific fuel consumption, thermal braking efficiency, and various emission parameters such as NOx, CO, and hydrocarbons to provide the optimum combination of diesel engine operating parameters. A few recent applications of GTMA are summarised in Table 2.10.

Table 2.10: Recent applications of GTMA

2.7	Recent applications of GTMA
Banik et al. (2022)	Selecting unmanned aerial vehicle for medical supplies
Bakar et al., (2021)	Smartphone selection
Goyal et al. (2020)	Determining the adoption index of electric vehicle
Gupta and Singh (2020)	Evaluating sustainability index for a logistic service provider
Singh and Kumar (2019)	Measuring the flexibility index for a supply chain
Muruganandham et al. (2018)	To identify the significant influencing factor for customer preferences in the construction industry
Geetha and Sekar (2017)	Optimization of an operating parameter of a diesel engine
Kumar et al. (2017)	To fix the agility index of an automobile manufacturing organization
Zhuang et al. (2017)	Paper shredder selection
Agrawal et al. (2016)	Disposition decision in reverse logistics
Jain and Raj (2015)	Evaluating the intensity of variables affecting flexibility in FMS

2.7 RESEARCH GAPS

Several studies raise the challenges of implementing green manufacturing practices in different manufacturing organizations. But all the studies focus on large manufacturing organizations. There is a big difference between a big firm's financial power and other infrastructure capacities and SMEs, especially in developing countries like India. The SMEs contribute much more to the countries' GDP with little economic power. Hence, the obstacles to implementing green manufacturing practices are different for different organizations.

Further, the Indian SMEs can't handle all the obstacles simultaneously due to poor economic power. Therefore, prioritizing these obstacles is required to properly implement environmentally sustainable measures in the organizations. In this study, the obstacles to green manufacturing implementation have been explored and prioritized to handle with minimum cost.

Consumer awareness about green products is relatively low in developing countries because of lower literacy rates and poor financial power. Numerous studies show that environmentally aware people are also not consistently purchasing green products because of the higher prices. The people of developing countries like India compare the performance of the green products with their regular products based on their cost. Hence to improve green consumption, it is also necessary to study the factors that affect the purchase of green products by the consumer. The various factors influencing the behaviour of consumers and affecting their purchase intentions for green products are evaluated in this research so that those factors can be motivated to improve green consumerism. There is also a myth that adopting green manufacturing is affecting the financial performance of the firms. Many studies show a financial burden of acquiring the latest technology for green manufacturing, hiring skilled personnel, losing market share, and decreasing profitability. This research also studies organizational performance after adopting green manufacturing practices. After the comprehensive literature review following research gaps have been observed:

Research Gap 1: Many obstacles have been observed in implementing green manufacturing in big organisations, but limited studies have been conducted for SMEs.

Research Gap 2: The consumer behaviour towards the purchase of environmentally friendly products is inconsistent. Limited references have been

found on the impact of consumer behaviour on the production of green products.

Research Gap 3: The study shows that a limited number of studies on green manufacturing and its impact on the organisation's performance in the Indian context have been conducted, and the results are inconclusive.

Research Gap 4: Significant variations observed in developing the framework for measuring green performance vary from one organization to another.

2.8 CONCLUSION

This chapter contains a literature review regarding obstacles to implementing green practices in Indian SMEs., the consumer behaviour towards the purchase of environmentally friendly products and the impact of consumer behaviour on the production of environmentally friendly products, the effect of green product development on the performance of the Indian SMEs and a framework to measure the green performance index of the Indian SMEs. Besides this, the research gaps and relevant issues of green manufacturing practices are also identified and deduced to the relevant hypothesis. The study has also motivated the present research work.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter describes the research methods adopted to answer the questions prepared to describe the research gap that fulfils the purpose and objective of the study. This chapter presents the logical assumptions supporting this research and introduces the applied research strategies and empirical techniques.

3.2 RESEARCH OBJECTIVES

Based on the research gap analysed in Chapter 2, the main objectives of the research are:

- To identify and prioritize the obstacles in implementing green practices in Indian SMEs.
- To study the consumer behaviour towards the purchase of environmentally friendly products and find the impact of consumer behaviour on the production of environmentally friendly products.
- To correlate the effect of green product development on the performance of the Indian SMEs.
- To develop a framework to measure the green performance of the Indian SMEs.

After selecting the research topic, comprehensive literature reviews were conducted to identify the research gaps. The research objectives were established based on the research gap analysis. With the help of a questionnaire developed in association with industry experts and a literature review, the survey was conducted to address consumer behaviour issues regarding green consumption in India. The quantitative research methodology approach has been used to obtain the data to know the organization's performance adopting GMP. The quantitative approach is an independent technique that takes less time-

consuming to calculate the generalised results for the entire population. The data to prioritize the obstacles of GMP were arranged through experts from the small and medium-scale electrical and electronic enterprises (SMEs) in Delhi NCR. The internet and personal contacts have been used to find the manufacturing and business organizations' lists. The Best Worst Method of multicriteria decision-making tool is used to prioritize the obstacles. The factor analysis method is used to categorize them into a concise group. A partial least square path modelling technique of structural equation modelling (SEM) method is used to identify the factors affecting consumer intentions, their effect on the production of green products, and the impact of adopting green manufacturing practices by the organizations. Framework for developing the green index for assessing green practices, a graph-theoretic modelling approach is used. The research plan framework used in the thesis is presented in Figure 3.1.

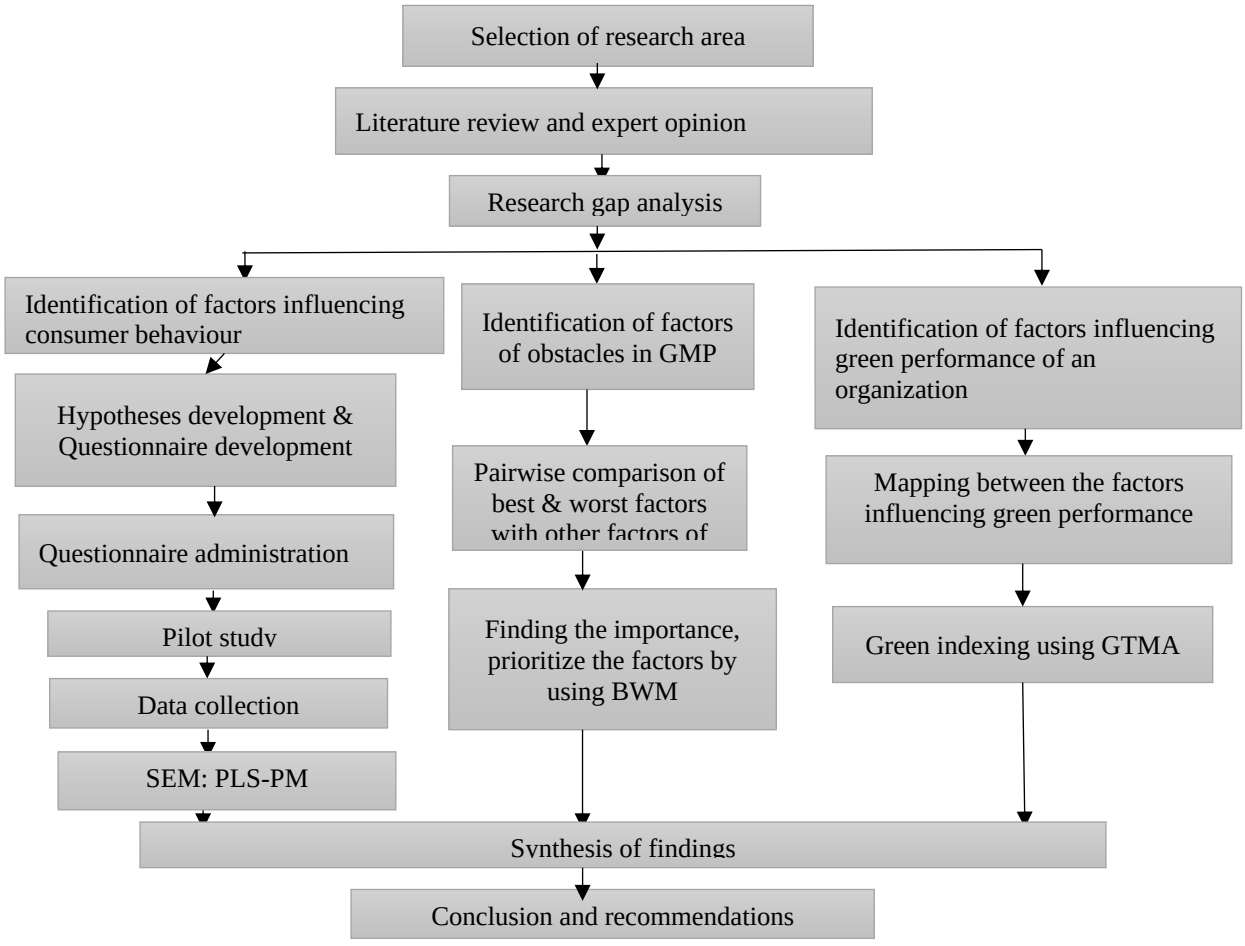

Figure 3.1: Research plan

3.3 RESEARCH PHILOSOPHY

Johnson and Clark (2006) said that it isn't always crucial for the research to be philosophically informed; as a substitute, it should additionally mirror the philosophical choices and shield them concerning the alternatives that would have been adopted. The ontology and epistemology studies philosophy impact our thinking about the studies tactics. The debate on ontology and epistemology is often among positivist and interpretivist studies philosophies. The positivist researcher uses a properly organized method to ease replication (Gill and Johnson, 2002). The 'resources' researcher adopts the positivist philosophy, whereas the 'feelings' researcher assumes interpretivist philosophy to develop knowledge. The positivist paradigm, sometimes called scientific, specifies quantitative methods, and the interpretivist paradigm, also known as anti-positivist, defines qualitative methods.

Realism is another philosophical position associated with scientific enquiry. The realism philosophy is entirely separate from the mind, i.e., what the senses show us as truth is the truth. Realism is the opposite of idealism, in which the best reason and context exist. Realism is a branch of epistemology and assumes a systematic approach to improving knowledge. Realism is of two types; direct realism says that what you see is what you get and that what we experience through our senses accurately portrays the sector. And crucial realism argues that what we experience is sensation, the picture of the gadgets within the real world, no longer the things directly. Crucial realism factors out how often our senses lie to us.

Pragmatism argues that the maximum vital determinant is the final study question to address unique troubles. This research adopted the pragmatism philosophy. Tashkori and

Tedley (1998) pointed out that pragmatism is innately attractive, mainly because it avoids seeing the researcher as a pointless debate about concepts such as truth and reality.

3.4 RESEARCH APPROACH

According to Easterby-Smith et al. (2008), the research approach is essential for three reasons, i.e., it keeps more informed about the research design. It helps choose better research strategies according to the research and enables research design to accommodate the obstacles. A hypothesis (hypotheses) is developed based on theory and design research strategies to test the ideas in a deductive approach. On the other hand, in the inductive research approach, the view is developed based on the result of the data analysis. In this way, the deductive method is nearer to positivism and inductive to interpretivism. But such labelling is probably misleading and has no realistic price. Combining deduction and induction within the same piece of research is perfectly possible. In their experience, it is often advantageous to do so (Saunders et al., 2011). A deduction is a scientific approach where the law is present to explain, allow the expectancy phenomenon, predict their occurrence, and control them (Collis and Hussey, 2003).

In the deduction approach, hypotheses from the theory verify the relationship between variables, indicating how the variables are measured, testing the hypotheses, examining the outcomes, and modifying the idea in light of findings (Robson, 2002). The inductive approach is more suitable for a small sample size and mainly concerned with the events. Eisenhardt (1989) proposed another theory-building approach from the case study. In the theory-building approach, hypotheses are developed based on the analysis of data collected from the case companies through questionnaires and the results are compared with the literature. Priyono et al. (2020) used this method in Identifying Digital Transformation Paths in the Business Model of SMEs during the COVID-19 Pandemic.

This research used a deductive method of research approaches. The data to test the hypotheses developed after the literature review was gathered through questionnaires from consumers and the industries.

3.5 RESEARCH STRATEGY

The choice of research strategy depends upon the research questions and objectives, the amount of knowledge, time and resources available and the philosophical underpinnings of the researcher. The research strategies revealed in figure 3.1 are an experiment, survey, case study, action research, grounded theory, and ethnography.

An experiment is a part of research indebted much to natural science, even though it features much in social science research. An investigation tends to be used in exploratory and explanatory analysis to study the impact of change on one variable. Survey strategy is usually associated with the deductive approach. Therefore, it is used for exploratory and descriptive analysis. Surveys are a common strategy for business and management research because they allow large amounts of data to be collected from a large population cost-effectively. In addition, the survey strategy is evident by the people in general as authoritative and relatively easy to explain and understand. Data collected using a survey strategy can suggest possible reasons for specific relationships between variables and build models of these relationships.

Robson (2002) describes a case study as a strategy to conduct research involving an empirical examination of a particular contemporary phenomenon in its real-life context using multiple sources of evidence. The case study is the opposite of the experimental strategy, where the research is conducted within a highly controlled context. The case study is often used in explanatory and exploratory research. The data for the case study may be collected through interviews, observation, documentary analysis and questionnaires.

Although management researchers used the term action research in various ways, Lewin used this term for the first time in 1946. In action research, focuses are on the purpose of the study; involvement of practitioners and researchers, fact-finding and analysis, is undertaken to enable action planning and a decision about the actions to be taken and implications beyond the immediate projects. Thus, action research differs from the other research strategies because of its explicit focus on action, promoting change within the organization.

According to Goulding (2002), grounded theory is helpful for research to predict and explain behaviour, with an emphasis on developing and building ideas. Grounded theory is often considered the best example of the inductive approach, in which data collection starts without forming the initial theoretical framework. The data generated by a series of observations leads to the generation of predictions confirmed in further observations that may assure, or otherwise, the predictions. The frequent reference to data to develop and test the theory is Collis and Hussey (2003) call foundation theory, an inductive/deductive approach; The theory is based on the constant context of data. Ethnography originates from the field of anthropology rooted firmly in the inductive approach. It is a very time-consuming research strategy over an extended period. The researcher needs to immerse himself as much as possible in the social world studied. The research process should be flexible and amenable to change as the researcher develops new thought patterns. Ethnography strategies are realistic as the researchers research the phenomenon within its context and do not use data collection techniques that generalize the complexities of everyday life.

This research used the survey method as a research strategy. Surveys enable us to obtain data about practices, situations or views at one point in time through questionnaires or interviews. Quantitative and qualitative analytical techniques are then used to draw

inferences from this data regarding existing relationships. A fundamental weakness of the survey method is that it is tough to realize insights relating to the causes of processes involved in the phenomena measured. In addition, several prejudices like the self-selecting nature of respondents and the researcher himself through the survey's design.

3.6 CHOICES OF DATA COLLECTION TECHNIQUES

Data collection can be quantitative or qualitative, but in research design, unique qualitative or quantitative techniques and procedures do not exist in isolation. The quantitative data collection technique is the collection of data in numeric form through a questionnaire. The qualitative data collection technique is the collection of data through interviews in non-numerical form. In research methods, either a single data collection technique and corresponding data analysis procedures called the mono method or multiple methods using more than one data collection technique are used to answer the research questions. When quantitative and qualitative data collection techniques and data analysis procedures are used in research design, it is known as the mixed method. In mixed-method research, quantitative and qualitative data collection techniques and analysis procedures are simultaneously or one after the other. This means in a mixed-method, although the study uses both a quantitative and a qualitative world approach, numerical data is analyzed quantitatively, and qualitative data are analyzed qualitatively. Tashakkori and Teddlie (2003) argue for multiple methods to answer research questions better. In this research, mixed model research techniques are used. The data collected are qualitative and converted into numerical code for statistical analysis.

3.7 TIME HORIZONS

Time horizons are independent of research design or choice of methods. It is of two types, i.e., cross-sectional and longitudinal. The cross-sectional studies often used survey

strategies (Robson, 2003; Esterby-Smith et al., 2008; Saunders, 2011). These studies may describe the incidence of a specific phenomenon or explain the connections of factors within an organization. However, they may also use qualitative methods. For example, many case studies are based on interviews conducted within a short period. The researcher must observe an event or phenomenon over time for longitudinal studies. According to Adams and Schvaneveldt (1991), watching people over time enables a researcher to maintain some control over the variables studied, as long as the process of collecting data doesn't affect the variables. Data from the industry is gathered using cross-sectional studies in this study.

3.8 DATA COLLECTION

This research is based on primary source data collected by questionnaire survey method. A questionnaire-based survey was conducted to attain the various research objectives of this research related to consumer issues and their purchase intentions for green products, obstacles to green manufacturing practices in Indian SMEs, and understanding of the impact of green manufacturing practices on organizational performance. The questionnaire was designed after discussion with the experts and available literature. The questionnaire survey method has been used to incorporate the perception of green manufacturing practices; however, response rates in the questionnaire survey have not been excellent as the respondents are reluctant to spare time to respond. The questionnaire was designed as close-ended so that lesser time and effort are needed to fill the questionnaire. The questions were framed on five Point Likert scales.

A research report's trustworthiness lies at the core of what is commonly known as validity and reliability. Using conventional criteria definitions and delineating research tactics, this study uses the approach proposed by Yin (1994) to eliminate, or at least reduce,

possible criticism to prove the study's trustworthiness. Two types of validity tests were conducted on the questionnaire: content validity and construct validity.

Content validity represents the adequacy of a specified domain sampled (Nunally, 1978). Its determination is subjective and judgmental and cannot be determined numerically. The instruments developed in this study demonstrate content validity by selecting measurement items based on an exhaustive literature review and evaluation by academicians and industry experts during pre-testing. The content validity was also tested during the pilot survey as per guidelines provided by Forza (2002). A few questions were deleted from the questionnaire as per the responses received from the respondents.

Construct validity was conducted through exploratory factor analysis. Factor analysis was conducted to test the unidimensionality of the multi-item perceptual measures. The indicator's reliability can be checked from its outer loading, and it should be more than 0.7. However, the indicator's loading between 0.4 to 0.7 can be deleted to improve the composite reliability and AVE (Parvadavardini et al., 2016). The internal consistency can be measured through composite reliability with the help of Cronbach's alpha which asses the reliability based on the inter-correlation of the indicators. Cronbach's α should be 0.6 to 0.9 (Bagozzi and Yi, 1988). The value of α less than 0.6 shows a lack of internal consistency reliability. Accordingly, in our study, the indicators whose outer loading was less than 0.7 have been deleted to improve the overall reliability of the construct.

Validity can be checked through convergent validity and discriminant validity. The convergent validity indicates the extent to which the indicators positively correlate with alternative indicators of the same construct and can be established through Average Variance Extracted (AVE), whose value should be more than 0.5 (Bagozzi and Yi, 1988). Discriminant validity checks the uniqueness of the construct and should not capture the phenomena represented by others. The Discriminant validity can be checked through cross-

loading methods, Heterotrait -Monotrait Ratio (HTMT), and Fornell and Larcker method. In a cross-loading method, Fornell and Larcker (1981) suggested that the "**square root**" of the AVE of each latent variable should be greater than the correlations among the latent variables to test the discriminant validity. In a cross-loading and Fornell and Larker, the value can be changed when adding additional constructs in the model, whereas the value of HTMT does not change. The value of HTMT should be less than 0.85 for favourable results.

3.9 CONCLUSION

This chapter has covered the research process, the reason for adopting a particular philosophical approach and the strategy to deliver the research. After selecting the research topic, comprehensive literature reviews were carried out to identify the research gaps. The research objectives were established based on the research gap analysis. This research adopted the pragmatism philosophy, arguing that the most critical determinant is the appropriate research question to answer particular problems. This research used the survey method as a research strategy. Surveys enable us to obtain data about practices, situations or views at one point in time through questionnaires or interviews. A questionnaire-based survey was conducted to attain the various research objectives of this research. The hypotheses development and questionnaire administration are discussed in Chapter 4.

CHAPTER 4

HYPOTHESES DEVELOPMENT AND QUESTIONNAIRE ADMINISTRATION

4.1 INTRODUCTION

This chapter contains the result of the questionnaire-based assessment. A survey was conducted with the electrical, electronic, and automobile SMEs and individual consumers. The study aimed to examine the impact on the business organization's performance in adopting green manufacturing practices in their industry and consumers' intentions towards green products and consequently test the hypothesis formulated in this research. This chapter also deals with other aspects like questionnaire development and its administration.

4.2 DEVELOPMENT OF A CONCEPTUAL FRAMEWORK AND HYPOTHESES FORMULATION

Consumer behaviour is one of the most influencing reasons to motivate the company manager to produce green products. Suki (2016) defined a consumer's green purchase intention as a purchase of a product that is less harmful to the environment. Most researchers exploited the factors like attitude, knowledge, and value to affect consumer behaviour. Chen et al. (2018) have already observed the positive effects of social influence and monetary value on the consumer intention to purchase green products. Consumers are strongly influenced by sentimental factors like word of mouth from other people. Their habits and consumer preferences are inconsistent, changing with time and situation depending on the information received (Chowdhury and Samuel, 2014). The researcher observed that consumers' intentions of buying green products depend upon many factors,

such as environmental involvement and the type of products (Cleveland et al., 2005). Uddin and Khan (2016) observed that many aspects like ecological sensitiveness and eco-consciousness influence the green buying intentions of young urban consumers. Vazifehdousta (2013) stated that the consumer's green purchase intentions are significantly biased by his attitude and the product's green value. But based on public opinion, Ginsberg and Bloom (2004) observed that if other factors remain the same, consumers prefer green products over less environmentally friendly products.

D'Souza et al. (2006) observed that consumers are price-sensitive in buying green products and are unwilling to pay higher prices for green products. Price, convenience, and value are consumers' most critical buying criteria when making choices. These criteria have been commonly ignored (Roberts, 1996). Most consumers are expected to buy green products if the price of the environmentally safe product is not too high or it does not make any drastic change in lifestyle (Mayekar and Sankaranarayanan, 2014). More demand for green products helps to reduce the costs of production. Hence, the consumer should be promoted and made aware of green product utilization to increase the production of green products. Any product's production rate/volume is directly related to consumption.

A general list of factors influencing consumer behaviour was developed with the help of previous literature, industrial experts and academics. Based on their suggestions and after some amendments, it appears that purchase intention (PI) and consumer behaviour (CB) are the most influential factors in the production of green products (GP). The product's perceived quality (PQ) and brand loyalty (BL) also influence consumers' purchase intentions toward green products and, ultimately, green production. So, to verify the emerging thoughts, hypotheses have been developed. Fig 4.1 shows the pictorial view of hypotheses representing the relationship between various factors and the production of green products as a conceptual framework.

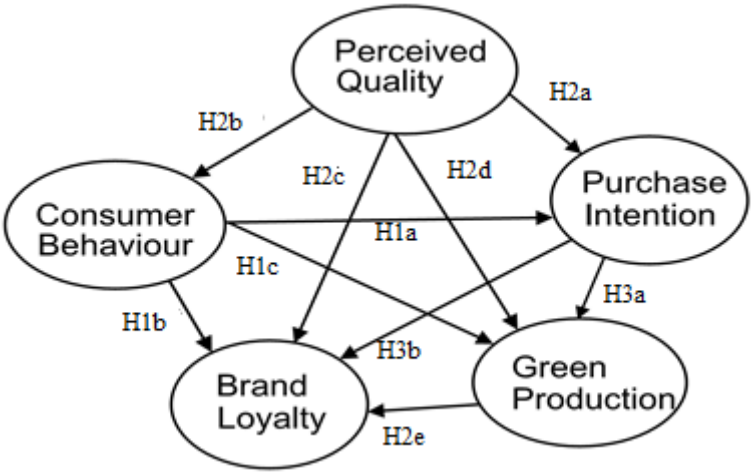

Figure 4.1: Conceptual framework showing the relationship between various factors of the green production

4.2.1 HYPOTHESES FOR CONSUMER BEHAVIOUR

From the perspective of sustainable development, the attempts to identify the factors affecting environmentally friendly behaviour, especially green purchase behaviour, have risen many folds over the last few years (do Paço et al., 2019). Many studies explained consumer behaviour towards green products. Communication advancement, social media, and increasing consumer awareness also create a need to understand consumer behaviour towards green buying (Groning et al., 2018). Consumer behaviour towards green products results from environmental consciousness influenced by many factors. Environmentally conscious consumers buy products that do not harm nature. An environmentally-conscious consumer, also known as a green consumer, avoids harmful products to health. Consumers believe green product ingredients require exceptional preservation and production methods, increasing production costs. Green consumerism catalyzes organizations to be more socially responsible. Consumer choice theory explains the economic influences on consumers. Bennett and Williams (2011) estimated that green products are 16 to 100 % costlier than conventional products.

Consumer preferences depend upon their budget and intentions against the fundamental principle (He et al., 2016). The consumption value theory states that consumer behaviour is a function of multiple consumption value that varies considerably, and the values are independent of each other (Sheth et al., 1991). The theory of reasoned action effectively explained the psychological and cognitive process of consumer decision-making and willingness to purchase green products or adopt green practices (Paul et al., 2016). In contrast, the theory of purchasing behaviour links an individual's beliefs and behaviours. However, despite all these advances, developing a suitable model to understand green consumer behaviour has continued to be complicated.

The consumer intentions to buy green products depend upon the quality, reliability, performance, income level to afford the products, awareness regarding the product delivery, ability to protect the environment, green initiatives, and corporate social responsibility. Many individuals do not have adequate knowledge of the ecological issue to act sensibly toward the environment. Environmental knowledge substantially influences the individual's intentions to purchase green products (Khan et al., 2020). The behaviour also inspired consumers' opinions about the product. The environmentally friendly attitude and intention often change the actual green consumption behaviour (Nguyen et al., 2019). The general consumer is motivated with immediate benefit from the products, whereas the environmentally-conscious consumer observes the use for society (Rejikumar, 2016). The brands can alter consumer behaviour for the green product, as influential green positions require brand distinction. There is a less commercial success for the products that do not replicate green attributes (Shabbir et al., 2020). Social influence, willingness to pay more and government initiation are essential factors that alter consumers' purchase intentions of green products. Social effects like family, friends, colleagues and strangers can influence a consumer's purchase decision. The consumer of the developing countries is the price-

sensitive customer. Consumers should be motivated to pay more for environmentally friendly products and services that inspire business organizations to produce and promote green products and services. Government participation in solving environmental issues can make people change their conduct and become more concerned about the environment (Rajadurai et al., 2021). Understanding consumer behaviour can be beneficial for business organizations in formulating their marketing strategies to improve consumer purchase intentions and increase the production of green products (Kripa and Vinod, 2021). The hypotheses formulated from reviewing the literature are:

H_{1a}: Consumer behaviour for utilization of green products positively influences their purchase intention.

H_{1b}: Consumer behaviour for utilization of green products positively impacts brand loyalty.

H_{1c}: Consumer behaviour for utilization of green products positively affects green production.

4.2.2 HYPOTHESES FOR PERCEIVED QUALITY AND BRAND LOYALTY

Loyalty is the consumer's emotion about a brand. Loyal customers also refer it to their friends and consociates neighbours. Loyal customers buy the products through multiple channels improving total consumption and reducing the cost of doing business (Duffy, 2003). Developing customers' brand loyalty is a strategic objective as new customer acquisition alone does not ensure long-term success. Customer retention and new customer development should be balanced in the long run. Hseih & Li (2008) stated that higher brand loyalty of customers leads to a higher market share and helps demand relatively higher prices compared to competitors. In addition, loyal customers raise positive

word-of-mouth promotion, defy competitors' strategies, and generate higher corporate profits, promoting the green product further. Dabija et al. (2018) felt that customer brand loyalty helps companies overcome competitors. At the same time, Chen et al. (2018) stated that brand loyalty positively enhances environmental consumerism and helps maintain ecological sustainability.

Moisescu (2018) implied that consumer re-purchase behaviour alone could not define his loyalty. Garcia et al. (2019) observed that brand loyalty is directly related to the emotional attachments of the consumer to the brands. Loyalty is the tendency to purchase a product or service of the same brand. It measures the consumer's commitment to the brand or company. Keeping loyal is a primary objective for the companies as it generates a noticeable advantage for the organization and helps them maintain competitiveness. The better services and products perceived quality help generate loyalty to the brand. The loyal customer also helps in improving the profitability of the company. Goriparthi and Tallapally (2017) found that consumers can protect the environment by using green products which can be recycled and reused to reduce the environmental impact. Although the consumers are aware of the sustainability issue and want to purchase green products, green products also have only 1-3% of the market share. Many studies found a gap between consumers' thinking and action toward buying green products, especially in the age group of 18-30 years, who are the potential consumers to increase attention for green products. When a company offers products of high perceived quality than the competitors, the company achieves an advantage of building reputation and loyalty amongst consumers (Hazen et al., 2011).

Chen and Chang (2012) felt that the customer does not rely on the brands if a company launches a product by misleading him about green claims. According to Chen et al. (2015), the perceived quality of the products may be the decisive factor for the

consumer's first time purchasing the products. Tsiotsou (2006) defined perceived quality as a customer's apprehension about a product's overall performance. Some researchers found a direct relationship between perceived quality and purchase intentions, whereas others did not find any relation between them. Ariffin et al. (2016) define perceived quality as consumers' perception of the superiority of the products over the same products available in the market by other brands. Perceived quality means the customer's overall perception of the quality or excellence of the product or service regarding the intended purpose. Customers have a good perception of the brands if it meets customers' expectations. Perceived quality affects consumers' decision to buy a product or use a brand's service if the brand meets consumer expectations (Sivaram et al., 2019). Perceived quality initiates satisfaction and behavioural intentions that lead to purchase decisions (Wang et al., 2020; Nekmahmud and Fekete-Farkas, 2020). Perceived quality is a component of consumer perceived value, the positive perspective for consuming the products, and influencing consumers' buying decisions (Alamsyah et al., 2021). The evident difference is a compilation of attitudes relating to a brand's insight that can generate a word-of-mouth effect, decreasing the cost of customer handling, increasing procurement amounts, and rising premium prices. The consumer may notice that green product superiority is the most volatile verdict about any offers. (Wasaya et al., 2021).

Service satisfaction, reliability, financial performance, dependability, environmental excellence, and ease of use measure the product's perceived quality. Perceived quality of products helps in increasing purchase intentions of the products. The perceived quality of the products also assists in building brand loyalty. On the other hand, when a consumer perceives good about the product quality, it helps build brand loyalty, which helps enhance green consumerism. The hypotheses formulated from reviewing the literature are:

H_{2a}: Perceived quality of the green product positively influences consumers' purchase intention.

H_{2b}: Perceived quality of the green product positively affects consumer behaviour.

H_{2c}: Perceived quality of the green product positively affects brand loyalty.

H_{2d}: Perceived quality of the green product positively affects green production.

H_{2e}: Green production has a positive impact on brand loyalty.

4.2.3 HYPOTHESES FOR PURCHASE INTENTIONS

More than 83% of the world population comprises developing countries (World Bank, 2016) which could lead to high pollution from their consumption. Consumer action has a remarkable negative effect on the environment. Global industrialization and a rapidly growing economy have further improved persons' consumption-ability causing further deterioration (Sun and Wang, 2019). Raising environmental consciousness leads to lifestyle changes and influences consumption patterns and purchase behaviour (Saleem et al., 2018 a, b). Trust is a concept supported by dependability, generosity, and validity. When these three entities occur in any business deal, they improve consumers' purchase intentions with the progression of the environmental era, and environmental consciousness developed in the customer, guided companies to realize the ecological importance (Wasaya et al., 2021). The advertisement plays a significant role in building the customers' trust. The endorsement of a product convinces the customer about the product's trustworthiness or services.

A product develops its trust when it fulfils the consumer's expectations. Purchase intentions show the possibilities, will, or plan to buy a product or service in the future. The increase in purchase intentions means an increase in a purchase opportunity. Purchase intentions are a part of consumer behaviour and are often used to forecast sales of existing products and services. Therefore, business organizations need to identify the choices of

consumers for which they want to buy a product. Thus, exploring the probability of consumption of green products in developing countries would solve environmental problems, increase the production of green products, and promote sustainable development (Nguyen and Dekhili, 2019). Many factors like social lifestyle, industrialization, and globalization, impact consumer purchase behaviour and their assessment of the products. Purchasing behaviour is a judgmental process that shows people's actions in buying and using products (Sivaram et al., 2019). The willingness to purchase depends on customers' positive and negative perceived value. A consumer with a high positive perceived value of natural products is highly interested in buying, whereas a negatively perceived value demotivates the consumer to buy the product (Nekmahmud and Fekete-Farkas, 2020). The products are evaluated by the consumer influence and purchase intention; if the perceived value outweighs the sacrifice to obtain it, the chance to purchase a product becomes higher (Satriawan and Setiawan, 2020).

Chen and Chang (2012) observed that consumers assess the product based on their experience to minimize the perceived risk. It becomes more challenging to buy a product when accurate information about that product or service is not available. If a seller acts dishonestly in the absence of precise data, it develops distrust and ultimately affects the perceived value of the products. This distrust makes consumers unwilling to buy the products (Gregg and Walczak, 2008). Trang et al. (2019) implied that a positive perception about a product develops ~~a~~ good feeling about the product. Since consumer judgment is often based on asymmetric information, product perceived value positively influences purchase intentions. Brand awareness plays a substantial role in influencing and intensifying the consumer attitude. The green packaging considerably inspired the attitudes, environmental awareness, willingness to pay, and consumers' purchase intentions (Praksh and Pathak, 2017; Walia et al., 2020).

Increasing the use of social media, business organizations also realized the importance of social media and increased their investments in green marketing to promote green products. But consumers do not purchase the products immediately after receiving information from social media. Usually, the cognitive factor also works with social media to influence consumers' purchase intentions. The theory of planned behaviour explains the mental aspect of consumers' green behaviour (Gao et al., 2017). The theory of planned behaviour analyzes the antecedents of buying behaviour based on an individual's perception of the possible consequences of the purchase (Parkinson et al., 2018; Costa et al., 2021) and explains that a person makes the purchase decision wisely based on his knowledge about the product (Sun and Wang, 2019).

The individual's behaviour is motivated by intentions, and a person with highly specified behaviour performs according to the situation. The individual attitude and experience can affect his perception of the product's attribute, and according to the consumption situation, the moment can guide the purchase intentions. Attitude can improve the individual's ability to evaluate product characteristics, boosting or reducing his interest and shaping his general feelings to buy the product (Chen and Wang, 2016; Costa et al., 2021). At the same time, the experience can be used as past information about the social and psychological consequences of the previous decision-making process for buying the product (Zhang et al., 2020; Costa et al., 2021).

Greenwashing can also influence consumers' purchase intention, creating negative brand perceptions. Greenwashing is misleading consumers by providing false information about the product's eco-friendliness. Because of the increasing demand for natural resources, electronics product manufacturers create the most significant ecological footprint by releasing massive industrial waste into the environment. Consequently, the greenwashing of the electronics manufacturing process can damage the products through

the false perception created in consumers' psychology (Nguyen et al., 2021). Consumers' psychological changes are non-negligible and play an essential part in decision-making. Some consumers feel happy to purchase green products as they perceive them to help the environment. The product attribute associated with environmental welfare strongly relates to utilitarian and hedonic attitudes. The practical value is associated with the functional significance of consumption, while the hedonic perspective pertains to emotional gratification (Qi and Ploeger, 2021). The hypotheses formulated from reviewing the literature are:

H_{3a}: Purchase intention positively enhances brand loyalty.

H_{3b}: Green purchase intention has a positive effect on green production.

4.2.4 HYPOTHESES FOR ORGANIZATIONAL PERFORMANCE

Ambec and Lanoie (2008) felt that sustainable development had become one of the most critical issues in the world. Carter et al. (2000) deduced that the firms slowly appreciate the significance of environmental proactivity and take the required steps to implement green approaches to preserve the environment. Nonetheless, purchase managers think that adopting green programs is expensive and hence scared to adopt green purchasing programs. According to Jayaraman et al. (2012), the initial expenses cause profit growth, whereas expenses to prevent contamination and improve processes offended the profit growth. Some researchers observed that social accountability is expensive and negatively influences the firm's financial performance. At the same time, some of them found that corporate social responsibility (CSR) improves economic performance. At the same time, some researchers also observed that CSR is not related to a firm's performance. Social awareness is positively associated with the firm's stock market performance. Socially meticulous actions can help improve a firm's relationships with stakeholders like banks,

investors, and government agencies, resulting in economic benefits and increased investment levels.

The environmental consideration is expensive for the organizations that freely use ecological resources. In reality, ecological consciousness distracts the firms from their primary goals of maximizing profit. Ambec and Lanoie (2008) found that the business firms compensate for the expenditures in reducing pollution partly or entirely by gains made elsewhere. Green Jr et al. (2012) conclude that environmental rules were increasing the cost of implementation of environmental sustainability guidelines damage competitiveness.

Zhu and Sarkis (2004) found an encouraging connection between implementing green supply chain practices and environmental and financial performance increases. Çankaya and Sezen (2018) found that all the green supply chain management dimensions are related to at least one performance, i.e., economic performance, social performance, and environmental performance. Gharde and Ahmed (2020) also studied the impact of financial and environmental performance on green supply chain management and found a positive relationship.

Aguilera and Mandojana (2013) found that green invention brings technological improvement to save energy, prevent toxic waste, or enable waste recycling. This innovation positively affects the firm's financial, social, and environmental outcomes and brings business sustainability. However, the national preferences in which firms develop their activities influenced the specific effect of green innovation. Some studies state that green innovation did not contribute much to firm innovation portfolios (Hull and Rothenberg, 2008). Some barriers like the knowledge gap, antipathy to risk in capital markets, and insufficient government support, so green innovation may not be adequately done (Runhaar et al., 2008). These barriers have also brought difficulties for managers to

attain environmental and competitive improvements at the firm level (Hull and Rothenberg, 2008). With increasing environmental problems, the business organization must take responsibility for environmental protection to bring together the concept of sustainable performance. Economic performance is a goal, and emphasis is placed on attaining social and ecological performance (Bombiak and Marciniuk-Kluska, 2018). Many manufacturing organizations generate waste and pollution and endanger life on the earth. From this point of view, encouraging sustainable practice to respond to global challenges is of the utmost importance in manufacturing firms. Green intellectual capital is an indefinable resource in achieving the firms' sustainable performance and competitive advantages. Green intellectual capital is the knowledge organizations use in environmental management to gain competitive advantages (Yusliza et al., 2019). Operational competitiveness shows the performance of a firm's supply chain and operation. Better operational competitiveness reflects the ability of an organization to meet customer expectations by delivering quality products on time, reducing waste in the production process, and operating flexibility (Feng et al., 2018). A firm reputation depends upon the customer's overall assessment based on direct experience with the firm. Firms with a good reputation get several benefits like more investment, skilled employees, and environmentally friendly customers (Morales-Raya et al., 2019).

Sustainable performance helps the firm measure its effort, improve environmental and social issues, and create shareholder value (Çankaya and Sezen, 2018). Economic performance is associated with operational and financial outcomes of the firms, like decreasing purchase input cost, waste, and energy consumption. Environmental performance is related to minimizing solid and water waste, carbon emission, hazardous material, environmental accidents, and reducing the overall environmental impact of the firm's activity (Centobelli et al., 2019; Çankaya and Sezen, 2018). Social performance is

assessed by employee health, safety, training, improvement in quality of life of the community, etc. (Wang and Dai, 2018). According to Afum et al. (2020), green manufacturing practices have a considerable impact on the sustainable performance of firms. The firm reputation and operational competitiveness do not significantly affect a firm's economic performance.

In contrast, social performance facilitates the relationship between firm financial performance and green manufacturing practices. The firm's financial performance can be measured by return on investment, return on sales, profit margin, and net profit. Green procurement and innovation provide better consumer products and the environment and significantly impact the firm's performance by improving these factors (Acquah et al., 2021). Blockchain technology ensures many potential business operations improvements and plays a significant positive role in the circular economy. Green practices positively impact environmental and financial performance and boost organizational performance (Khan et al., 2021).

Various researchers argue that unrestricted reforms in environmental performance often provide a financial benefit. But the prevailing research could not reply whether it pays to be green or whether it pays to operate in green industries. The hypotheses formulated from reviewing the literature are:

H_{4a}: Green manufacturing positively affects the company's financial performance.

H_{4b}: Green manufacturing positively affects the company's social performance.

H_{4c}: Green manufacturing positively affects the company's environmental performance.

The conceptual proposed hypothetical model for hypotheses H_{4a}, H_{4b} and H_{4c} are shown in Figure 4.2.

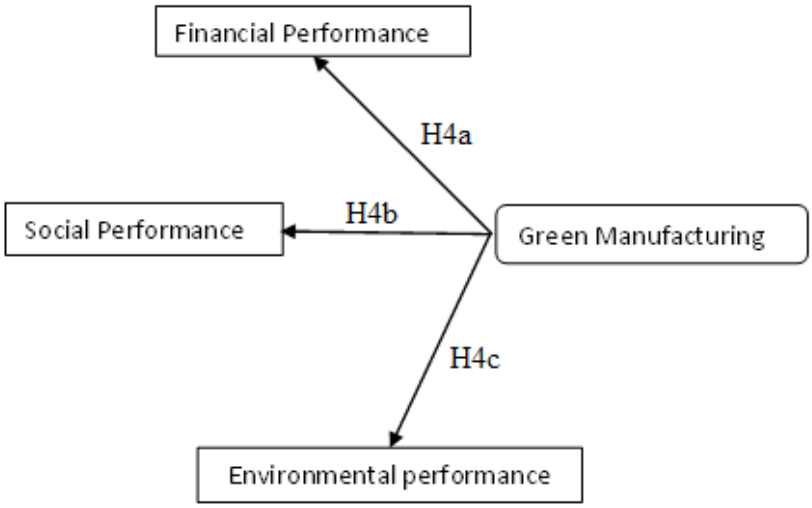

Figure 4.2: A proposed hypothetical model for hypotheses H_{4a}, H_{4b} and H_{4c}

4.3 QUESTIONNAIRE DEVELOPMENT

The consumers are not fully aware of the manufacturing processes, design, packaging materials, etc. In this situation, it is challenging to find the impact of consumer behaviour on producing such products that are not directly concerned with consumer use. The production of any product depends upon the market demand. The market demand is generated based on the request from the consumer. Indirectly production depends on consumer behaviour and purchase intentions for a particular product. More use of green products promotes the production of green products.

Further, the increasing environmental pollution compels the organization to adopt green manufacturing. But the global competition creates a fear of financial loss amongst the manufacturing organization, especially for Indian SMEs with many financial obstacles. Attempts have been made through this study to find the impact of green manufacturing on the organization's financial, social, and environmental performance. A questionnaire was framed with the help of industry experts and a literature review to know the consumer's favourable behaviour issues regarding green consumption. A survey was conducted to collect the individual response on a 5-points Likert scale. The reaction to the survey was

not very good as many respondents were unaware of green products, and few were very reluctant to spare time for the same. The questionnaire contains two sections. Section I dealt with the consumer's profile, while section II dealt with the issue related to behaviour and purchase intentions of consumers towards green products.

The quantitative research methodology approach is used to study the adoption of green manufacturing practices on organizational performance. The quantitative approach is a less time-consuming and independent technique, and results calculated from the data can be generalized to the whole population. From reviewing the literature and discussing with the experts, a questionnaire was framed to collect the data from the manufacturing firms involved in green manufacturing. The responses were collected through a questionnaire using 5 points Likert scale ranging from 1 (strongly disagree) to 5 (Strongly agree).

Statistical and multi-criteria decision-making methods have been used to identify and prioritize the obstacles to implementing green practices in Indian SMEs. The statistical approach segregates different blocks as they create barriers to implementing green manufacturing practices and the multi-criteria decision-making methods used to rank them. The responses were collected via a questionnaire containing 5 points Likert scale (1 (strongly disagree) to 5 (Strongly agree)).

Some of the significant factors related to green manufacturing were identified through the literature review to develop a framework to measure the green performance of Indian SMEs. Using the Graph Theory Matrix Approach (GTMA), the permanent matrix of all the factors developed the green index. The responses relating to the influence of the various elements on the implementation of green manufacturing practices have been collected via a questionnaire containing 5 points Likert scale (1 (strongly disagree) to 5 (Strongly agree)). The questionnaire contains six sections. Section I dealt with the profile of the participants, section II contains the consumer behaviour for green consumption-related

questions, section III contains the questions related to the impact of adopting green manufacturing practices on organizational performance, section IV contains the categorization of different obstacles into primary groups. Section V contains the question of deciding best to other and worst to other obstacles. Section VI deals with the issue related to developing a framework and index to assess the performance of green manufacturing organisations. The questionnaire is annexed as Appendix 'A'.

4.4 CONTENT VALIDATION OF A QUESTIONNAIRE

The questionnaire can be tested through content validity and construct validity. Content validity shows the adequacy of the samples collected from the specified domain (Nunally, 1978). Content validity indicates to which extent elements of an evaluation instrument are significant to and representative of the targeted construct for a specific evaluation purpose. The content validity is subjective and judgmental as it varies from person to person; it cannot be concluded numerically. This research measures the contents exhaustively through literature review and consultation from academicians and experts. The content validity involves the development stage, judgment and measuring step, and revising and reconstruction stage. The content validity is further evaluated as per guidelines provided by Almanasreh et al. (2018). After the survey, a few questions were deleted as suggested by the respondents.

The validity of the constructs is checked by analyzing a measurement model and calculating the composite reliability of each indicator loading, the average variance extracted (AVE), Cronbach's alpha, and the discriminant validity of the reflective constructs. The outer loading, the value of AVE and the value of Cronbach alpha should be more than 0.7, 0.5 and more than 0.6, respectively (Bagozzi and Yi, 1998).

4.5 QUESTIONNAIRE ADMINISTRATION

The economy of India is the sixth-largest economy by GDP and third-largest by purchasing power parity. The manufacturing sector accounts for 17% of India's GDP and employs around 27.3 million Indians in FY 2020-21 (Business standard report, May 7, 2021). The automobile, electrical, and electronics industries are the most growing industrial sectors selected for questionnaire administration. India's leading industrial sectors are the auto, electrical, and electronics industries. The automobile sector contributes 7.1 % to the Indian GDP. In contrast, India's electronics production grew at a compound annual growth rate of 25% in the last four years compared to 5.5% in 2014-15. The electronics production in India rose in 2018-19 to Rs 4.58 trillion; global electronics production was $ 2.1 trillion and covered 3.3% of the worldwide market share. The automobile sector contributes 49% of the manufacturing GDP with an annual turnover of Rs. 7.5 lakh crores and export of Rs. 3.5 lakh crores (Business standard report, 2021). These two sectors are highly diversified and represent the manufacturing industry's representative sector.

This research used WhatsApp, email, and personal visits as a survey method. Three hundred fifty (350) questionnaires were distributed amongst different ages, incomes, qualifications, and professional groups to study green product consumer behaviour and purchase intentions. Three hundred twenty (320) questionnaires were distributed to analyze the impact of the adoption of green manufacturing practices on the manufacturing organization. The company was selected carefully from the private sector, public sector, and government companies registered in the Confederation of Indian Industry (CII), Society of Indian Automobile Manufacturers (SIAM), and Public Sector Undertakings (PSUs), trade fairs, etc.

4.6 SURVEY RESPONSE AND RESPONDENT PROFILE

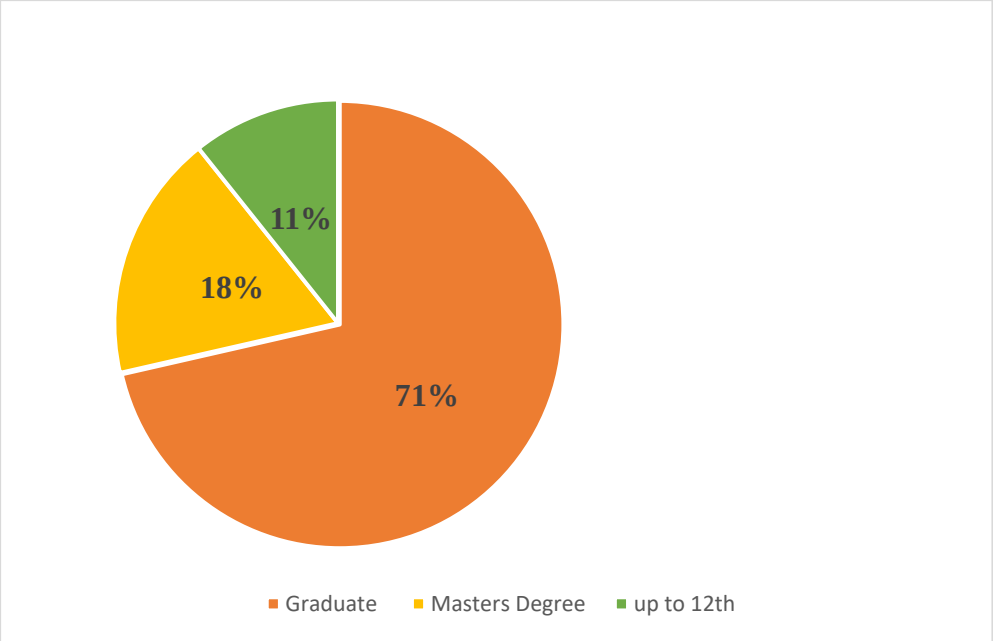

Figure 4.3: Qualification of respondents

Three hundred fifty questionnaires (350) were distributed amongst different ages, incomes, qualifications, and professional groups using personal contact and email to study consumer behaviour and purchase intentions, out of which 131 responses were received back. Out of these 131 responses, 19 were either incomplete or not very useful for the analysis; therefore, only 112 functional responses were available. The overall response rate is 32 %, with more than 20% responses as Malhotra and Grover (1998) recommended. The respondent's profile is given in Figures 4.3-4.5. As shown in Figure 4.3, out of 112 respondents, 71% had graduate/bachelor's degrees, 18% had master's degrees, and 11% had up to (10+2) level education. In terms of age-wise, as shown in Figure 4.4, 36% of the respondents were of age group 18-21 years, 44% of the respondents were of age group 22-35 years, 11% of the respondents were of age group 36-50 years, and 9% of the respondents were amongst above 50 years age group.

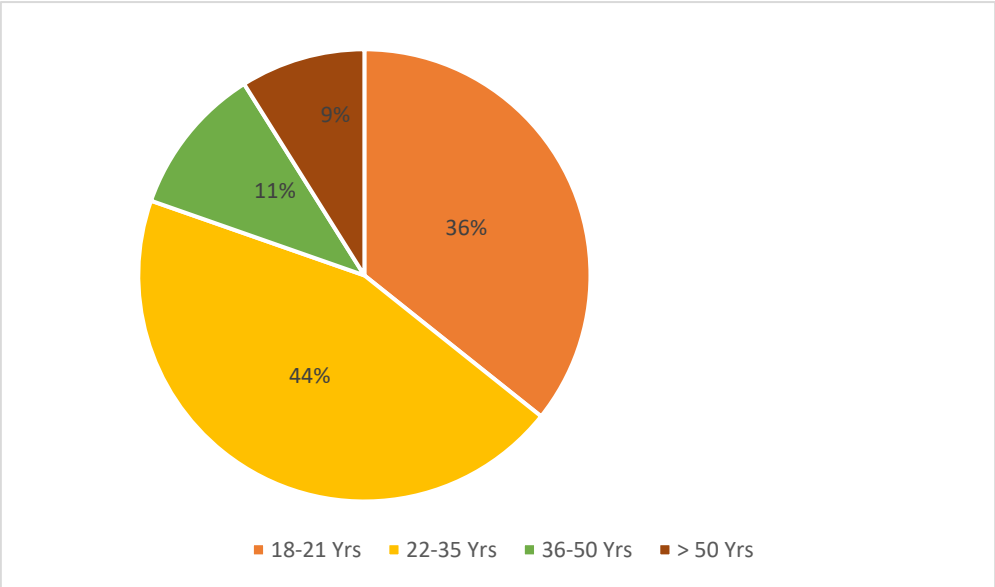

Figure 4.4: Age of respondents in years

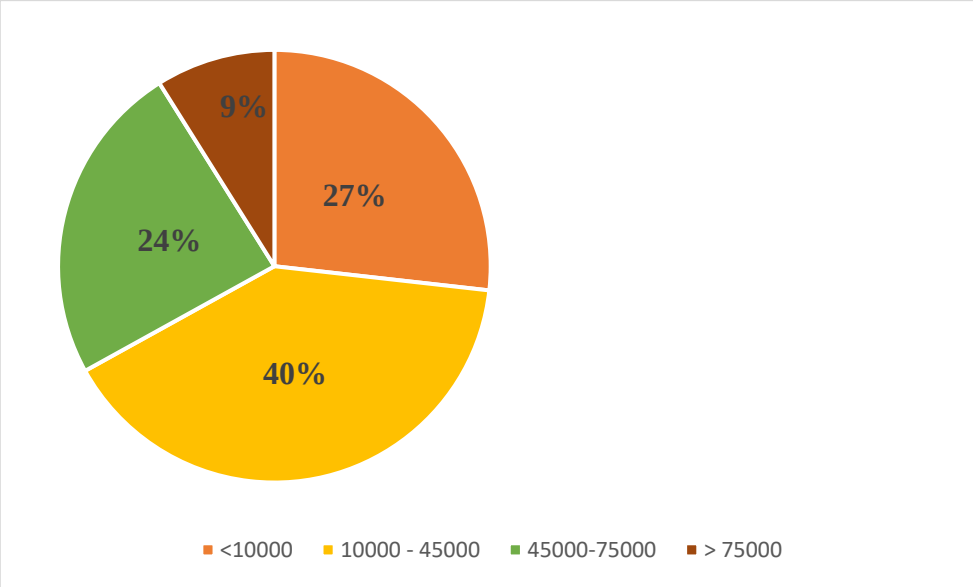

Figure 4.5: Income of respondents in rupees/month

In terms of income, as shown in Figure 4.5, 27% of the respondents had Income less than 10000 rupees, 40% of the respondents had an income range of 10000- 45000 rupees, 24% of the respondents had an Income of 45000-75000 rupees, whereas 9% of the respondents had Income more than 75000 rupees.

Three hundred twenty (320) questionnaires were distributed to study the impact of the adoption of green manufacturing practices on the manufacturing organizations, out of which 90 responses were received, which is about 28% and more than the recommended value (Malhotra and Grover, 1998). The quantitative approach is a less time-consuming and independent technique, and results calculated from the data can be generalized to the whole population. The responses were collected through a questionnaire using 5 points Likert scale ranging from 1 (strongly disagree) to 5 (Strongly agree). The description of the respondents is given in Table 4.1.

Table 4.1: Description of the respondents

Job Description	**No. of participants**	**% age of participants**
Manager	20	22.23
Supervisor	70	77.77
Experience	**No. of participants**	**% age of participants**
Less than 2 years	10	11
2-5 years	50	55.56
5-10 years	20	22.22
More than 10 years	10	11
Type of Industry	**No. of participants**	**%age of participants**
Auto component manufacturing	60	66.67
Electrical component manufacturing	20	22.22
Mobile	10	11

4.6.1 RELIABILITY OF QUESTIONNAIRE SURVEY

Reliability of the questions can be checked from the internal consistency of the person replying to a particular question. The internal consistency can be measured through composite reliability with the help of Cronbach's α, which should be 0.6 to 0.9 (Bagozzi and Yi, 1988). A value of Cronbach's α less than 0.6 shows a lack of internal consistency reliability. Mathematically,

Cronbach's α = $\left(\frac{R}{R-1}\right)\left(1-\frac{\sum_{i=1}^{R} S_i^2}{S_i^2}\right)$, where s_i^2 shows the variance of the '*I*' indicators of specific constructs measured by R indicators (I = 1, ---------, R).

In this study, the value of Cronbach's α is more than 0.6, which confirms the reliability of the questions. The value of Cronbach's α is given in Table 4.2.

Table 4.2: Value of Cronbach's α coefficients

Questions pertaining to	**Cronbach's α**	**No. of Indicators**
Purchase Intentions	0.695	4
Perceived Quality	0.845	5
Consumer Behavior	0.852	5
Brand Loyalty	0.833	5
Green Production	0.855	6
Financial performance	0.701	2
Social performance	0.889	4
Environmental performance	0.836	4
Green Manufacturing	0.788	3

4.7 DESCRIPTIVE STATISTICS

The mean and standard deviation of the responses collected for the research are presented in a bar chart for analysis.

4.7.1 IMPORTANT DIMENSIONS OF PURCHASE INTENTIONS

The respondents were asked to assign the value to the items of purchase intentions that may satisfy the consumer's purchase intentions for green products. From the Figure

4.6, it reveals that the need fulfilment (Mean = 4.05, Std. deviation = 0.733) is the most important parameter to define purchase intentions, followed by post-sales service (Mean = 3.92, Std. deviation = 0.82), personal attention (Mean = 3.91, Std. deviation = 0.82) and environmental consciousness (Mean = 3.76, Std. deviation = 0.74).

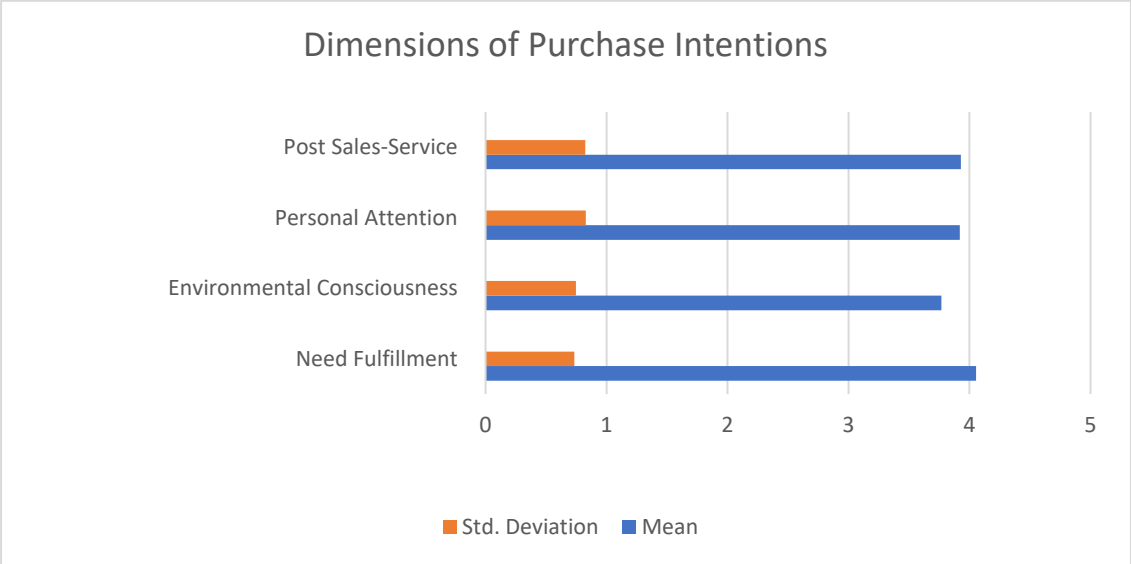

Figure 4.6: Dimensions of purchase intentions

The majority of Indian consumers prefer the fulfilment of needs and post-sales service.

4.7.2 IMPORTANT DIMENSIONS OF PERCEIVED QUALITY

The respondents were asked to assign value to the items of perceived quality that may satisfy the perceived quality to attract consumers to buy green products. From the Figure 4.7, it reveals that the empathy (Mean = 4.00, Std. deviation = 0.81) is the most important parameter to define perceived quality followed by assurance (Mean = 3.99, Std. deviation = 0.799), responsiveness (Mean = 3.98, Std. deviation = 0.734), consumer-producer relationship (Mean = 3.875, Std. deviation = 0.67) and reliability (Mean = 3.81, Std. deviation = 0.8).

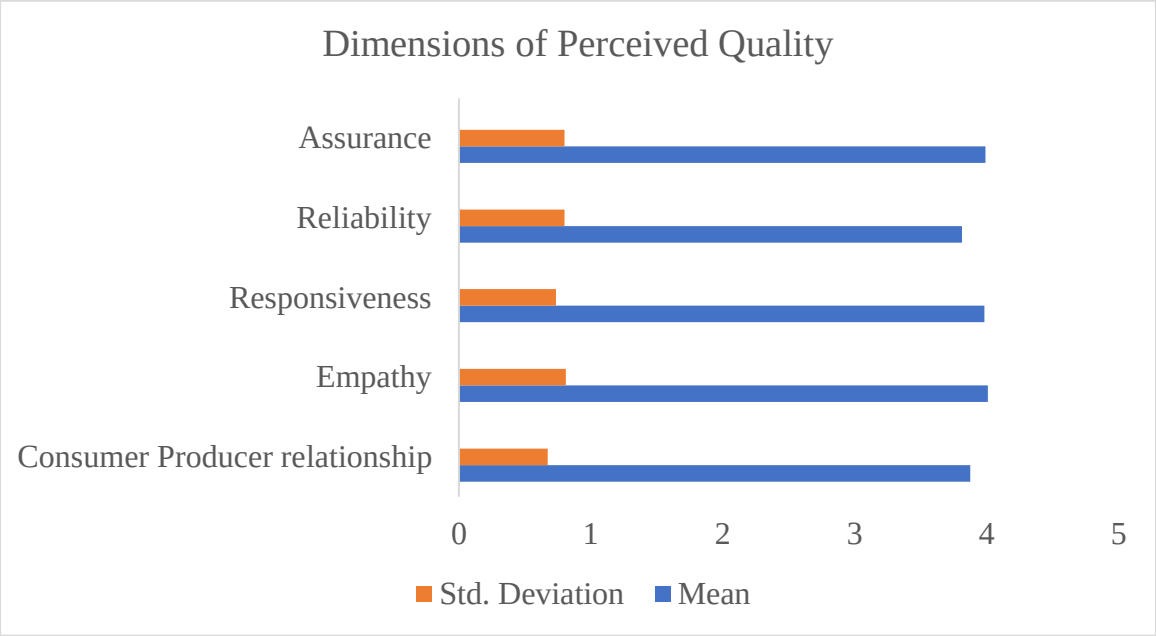

Figure 4.7: Dimensions of perceived quality

Reliability is the ability to accomplish the promised service consistently with accuracy. Responsiveness is how quickly and promptly the service is being provided. Assurance is employees' knowledge and manners and ability to express confidence with sureness. Empathy is the personal attention given by firms to resolve issues. All these factors improve the consumer-producer relationship. The result shows that the Indian consumers are giving more weightage to the personal attention firms provide to consumers.

4.7.3 IMPORTANT DIMENSIONS OF CONSUMER BEHAVIOUR

The respondents were asked to assign the value to the items of consumer behaviour that may motivate them to buy green products. From the Figure 4.8, it reveals that the income level (Mean = 4.06, Std. deviation = 0.726) is the most important parameter to to attract consumer to buy green products followed by addressing social issues (Mean = 4.00, Std. deviation = 0.716), product quality (Mean = 3.98, Std. deviation = 0.82), product cost

(Mean = 3.90, Std. deviation = 0.80) and green initiatives (Mean = 3.76, Std. deviation = 0.722).

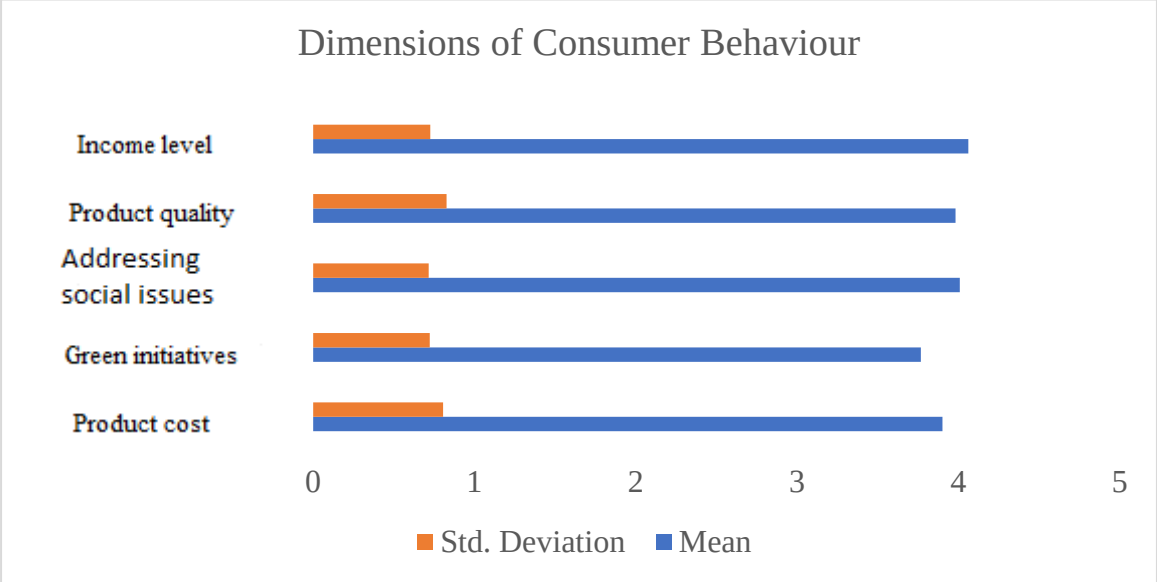

Figure 4.8: Dimensions of consumer behaviour

Indian consumers are price-sensitive, and their income level is the most motivating factor to buy green products. The consumers also give weightage to the company involved in corporate social responsibility.

4.7.4 IMPORTANT DIMENSIONS OF BRAND LOYALTY

The respondents were asked to assign the value to the items of brand loyalty that may motivate them to buy green products. From the Figure 4.9, it reveals that the transparency with consumers (Mean = 3.94, Std. deviation = 0.80) is the most important parameter to attract consumer to buy green products followed by organizational commitment (Mean = 3.93, Std. deviation = 0.76), respect for rule of law (Mean = 3.90,

Std. deviation = 0.79), consumer expectations (Mean = 3.84, Std. deviation = 0.81) and advertising and promotions (Mean = 3.81, Std. deviation = 0.77).

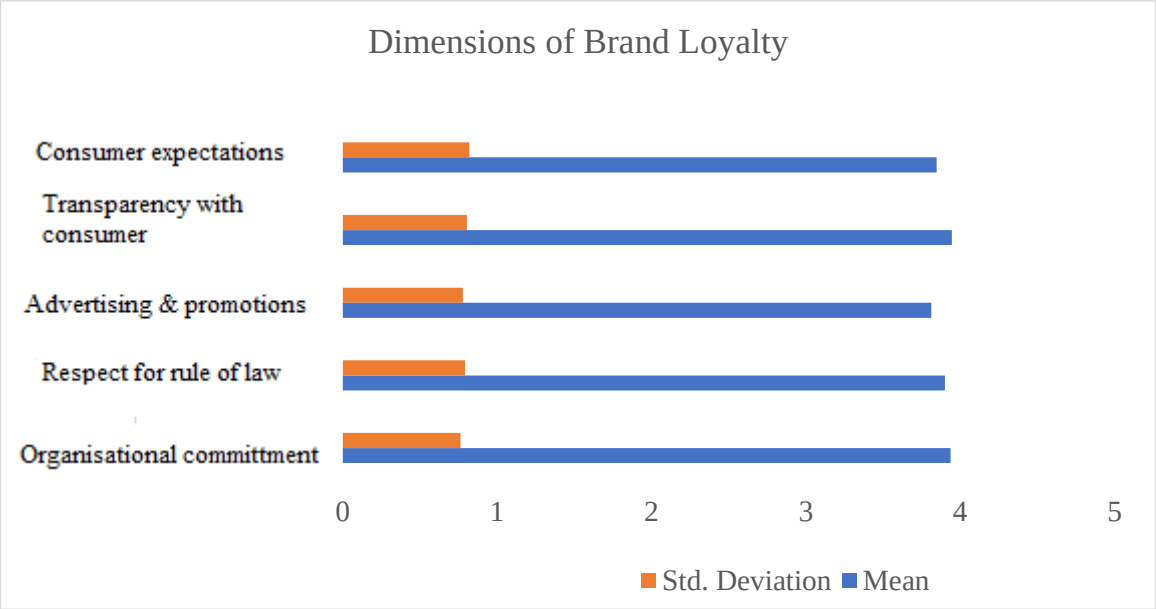

Figure 4.9: Dimensions of brand loyalty

Greenwashing lowers brand loyalty. Consumers give preferences to those companies who are transparent with consumers, take care of their expectations from the product, respect the rules of law, and are committed to the environment and society.

4.7.5 IMPORTANT DIMENSIONS OF GREEN PRODUCTION

The respondents were asked to assign the value to the items of green products that may motivate the organisations to produce green products. From the Figure 4.10, it reveals that the production cost (Mean = 3.91, Std. deviation = 0.54) is the most important parameter to produce green products followed by waste management (Mean = 3.848, Std. deviation = 0.673), use of alternative materials (Mean = 3.839, Std. deviation = 0.665), green packaging (Mean = 3.839, Std. deviation = 0.54), improvement in life expectancy

(Mean = 3.821, Std. deviation = 0.60) and energy conservations (Mean = 3.75, Std. deviation = 0.677).

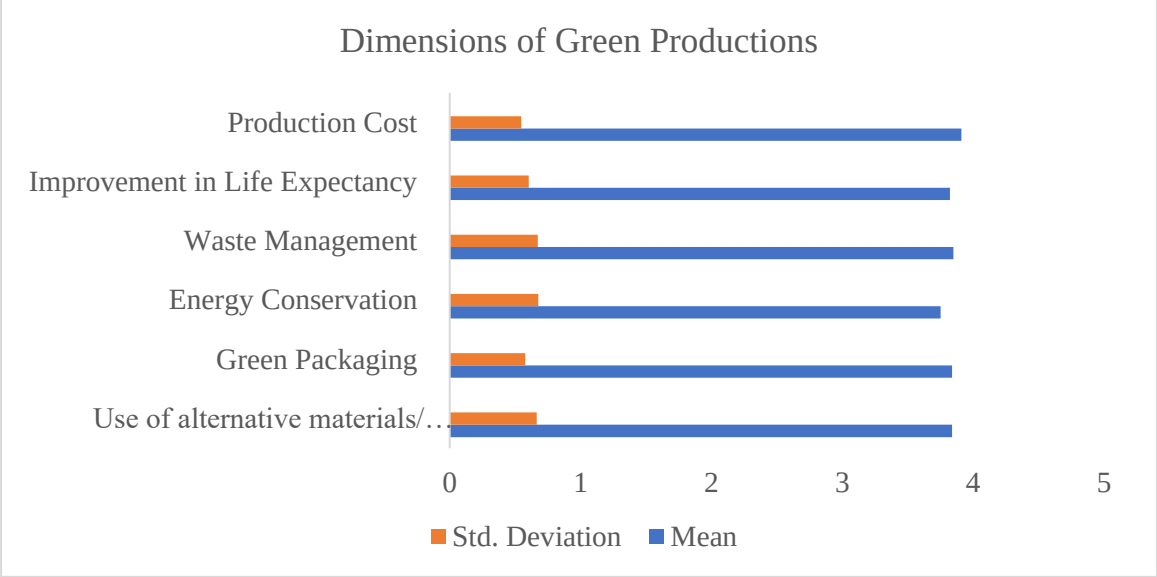

Figure 4.10: Dimensions of green production

The production cost is the critical parameter influencing manufacturers to produce green products. Other than production cost, the waste management of hazardous waste, availability and cost of alternate materials, green packaging, and improvement in the product's life are the factors that influence the production of green products.

4.7.6 IMPORTANT DIMENSIONS OF FINANCIAL PERFORMANCE OF THE ORGANIZATIONS

There are hesitations amongst organizations to adopt green manufacturing practices. The respondents from the organizations were asked to assign the value to the items of financial performances that may create hurdles in adopting green manufacturing

practices. Five items described financial performances, but the indicator loading of two items was less than 0.7; hence, it dropped to ascertain reliability. Figure 4.11 reveals that the increase in market share (Mean = 3.90, Std. deviation = 0.70) is the most critical parameter for the financial performance of the organizations, followed by profit increase (Mean = 3.65, Std. deviation = 0.736).

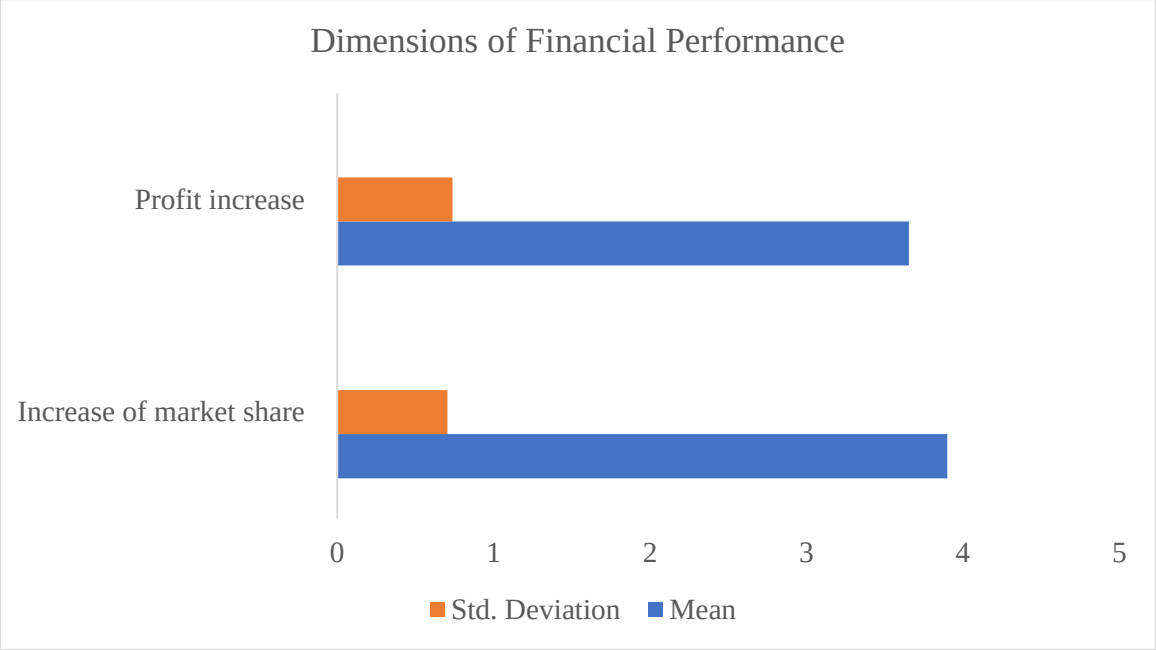

Figure 4.11: Dimensions of financial performances

The increase in market share and profit after adopting the green manufacturing practices are the essential factors that improve the organizations' financial performance.

4.7.7 IMPORTANT DIMENSIONS OF SOCIAL PERFORMANCE OF THE ORGANIZATIONS

There are hesitations amongst organizations to adopt green manufacturing practices. The respondents from the organizations were asked to assign value to the items of social performances that may influence the adoption of green manufacturing practices. From the Figure 4.12, it reveals that the job creation (Mean = 4.01, Std. deviation = 0.741)

is the most important parameter for the social performance of the organisations following ethical behaviour (Mean = 3.98, Std. deviation = 0.71), respect for rules of law (Mean = 3.86, Std. deviation = 0.83) and corporate reputations (Mean = 3.77, Std. deviation = 0.79).

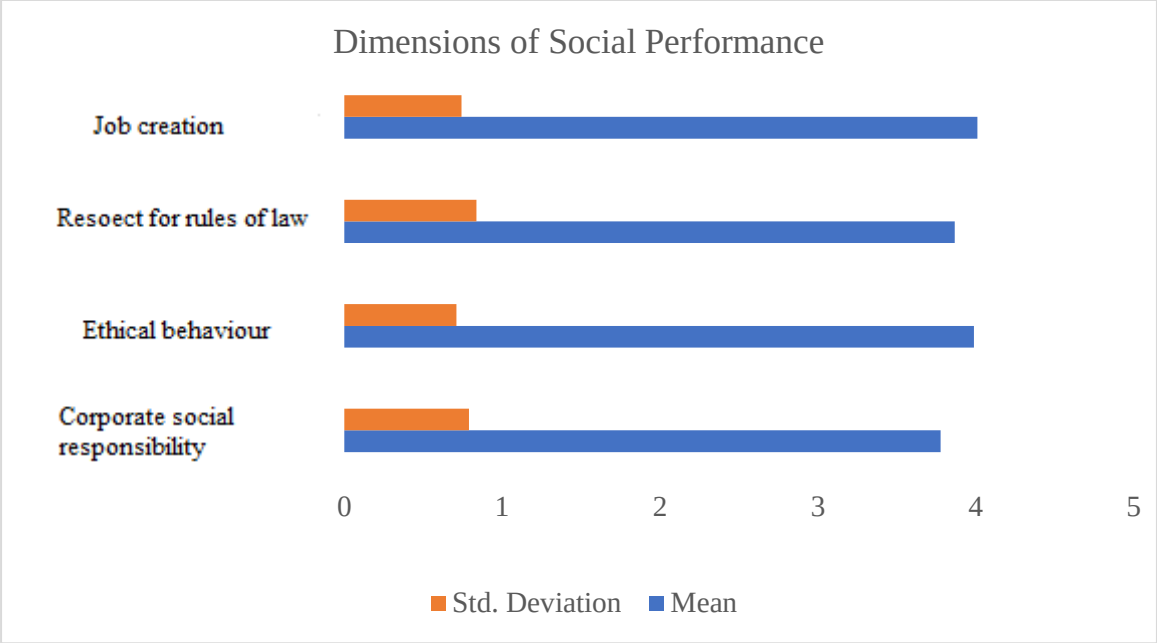

Figure 4.12: Dimensions of social performances

The organizations that create more jobs behave ethically and respect the rules of law, performing their social responsibility and having good social performance.

4.7.8 IMPORTANT DIMENSIONS OF ENVIRONMENTAL PERFORMANCE OF THE ORGANIZATIONS

There are hesitations amongst organizations to adopt green manufacturing practices. The respondents from the organizations were asked to assign the value to the items of environmental performances that may influence the adoption of green manufacturing practices. From the Figure 4.13, it reveals that the global warming (Mean = 3.92, Std. deviation = 0.81) and greenhouse gas emissions (Mean = 3.92, Std. deviation = 0.737) is the most important parameter for the environmental performance of the

organisations followed use of non-hazardous materials (Mean = 3.85, Std. deviation = 0.679), and optimal utilization of resources (Mean = 3.8, Std. deviation = 0.796).

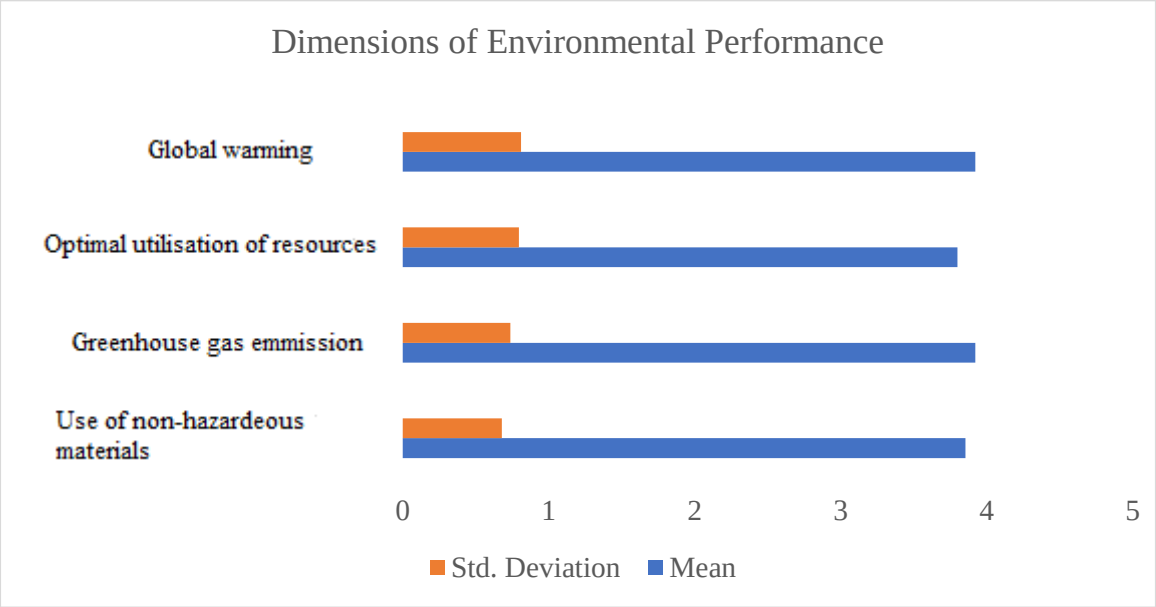

Figure 4.13: Dimensions of environmental performances

The more sensible organisations for global warming and greenhouse gas emissions have good environmental performance.

4.7.9 IMPORTANT DIMENSIONS OF GREEN MANUFACTURING PRACTICES ADOPTED BY THE ORGANIZATIONS

There are hesitations amongst organizations to adopt green manufacturing practices. The respondents from the organizations were asked to assign the value to the items of green manufacturing practices that may influence the adoption of green manufacturing practices. From the Figure 4.14, it reveals that the renewable energy sources (Mean = 3.92, Std. deviation = 0.767) followed by use of cleaner technology (Mean = 3.83, Std. deviation = 0.782), and green packaging (Mean = 3.78, Std. deviation = 0.71).

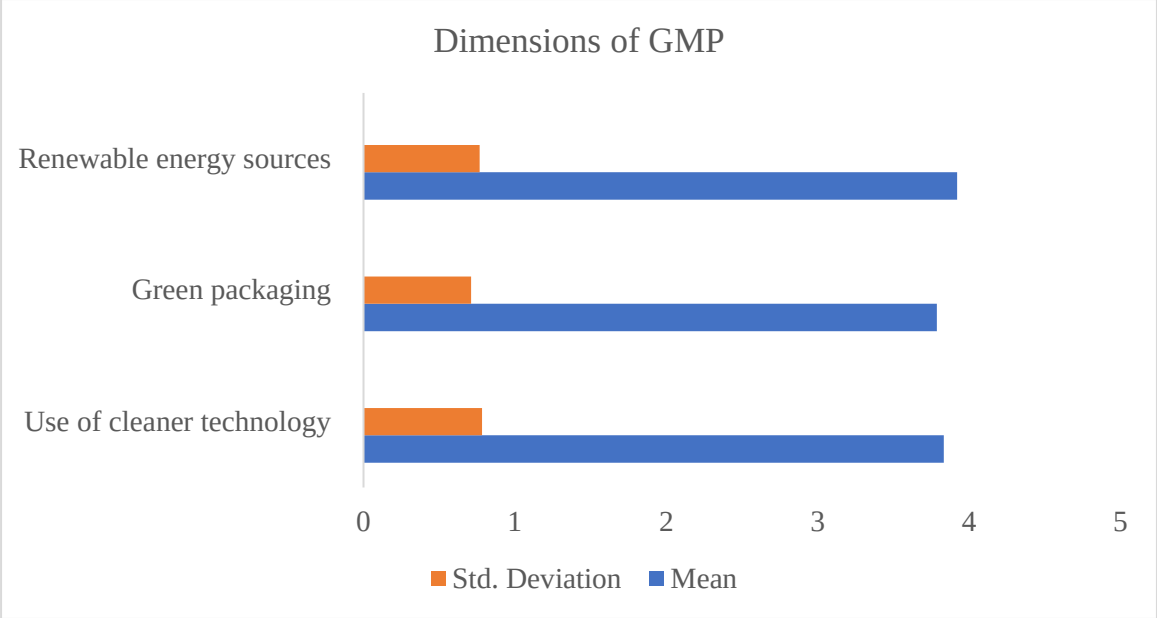

Figure 4.14: Dimensions of green manufacturing practices

The availability of renewable energy sources, cleaner technology and green packaging materials may motivate the adoption of green manufacturing practices.

4.8 CONCLUSION

This chapter consists of hypotheses formulation and descriptive statistics. An attempt has been made to study consumer behaviour and purchase intentions for green products. Green products help improve environmental conditions, whereas the firms' adoption of green manufacturing practices helps improve organizational performance, environmental performance, and competitive advantages, which leads to an increase in profit and market share. A questionnaire-based descriptive study of the survey presented in this chapter aims to understand the issue of green manufacturing practices in Indian SMEs. The hypothesis is tested statistically and represented in Chapter 5.

CHAPTER 5

STRUCTURAL EQUATION MODELLING: A PARTIAL LEAST SQUARE PATH MODELING APPROACH

5.1 INTRODUCTION

Testing the validity of the hypothesis is presented in this chapter. The hypotheses developed in the previous chapter are tested in this chapter in two sets. The first set concerns consumer behaviour towards purchasing environmentally friendly products and finding the impact of consumer behaviour on producing environmentally friendly products. The second set concerns the effect of adopting green manufacturing practices on the performance of Indian SMEs. The partial least square–path modelling (PLS-PM) technique of structural equation modelling (SEM) is used to test the hypotheses. The PLS-PM approach is used to know the causal relationship among the various factors. PLS-PM can be used for small data, as normalization of the data is not required in this process. The result shows that the perceived quality and cost of the product influence consumer behaviour and purchase intention towards green consumption. Besides these two factors, green initiatives, advertising and promotion, and social welfare also significantly influence consumers to use green products.

5.2 STRUCTURAL EQUATION MODELING

Structural Equation Modeling (SEM) is a second-generation multivariate data analysis technique employed to assess the factors in the analysis phase. PLS-PM is a variance-based structural equation modelling used for exploratory research. PM is the

diagrammatic representation of the relationship of hypotheses with variables containing two elements, namely

1) The structural model, also called the inner model, shows the relationship between the constructs and the
2) The measurement model also called the outer model, describes constructs' relationships and indicators (Sanchez G., 2013). Different approaches of SEM that have been in use are shown in Table 5.1.

Table 5.1: Distinct approaches of SEM

S.No	SEM Approaches	Software Application	Uses
1.	Covariance-based SEM (CB-SEM)	AMOS, EQS, LISREL, and Mplus	Primarily used in social science research when customarily distributed data are available.
2.	Partial Least Squares-Path Model (PLS-PM)	PLS-Graph, VisualPLS, SmartPLS, and WarpPLS	Predictive accuracy is the prime requirement, and exact model specification cannot be ensured; used for a small sample size. Normalization of data is not required.
3.	Generalized Structured Component Analysis (GSCA)	VisualGSCA, GeSCA	GSCA may be better than PLS if an overall model fit is required for non-linear latent variables.
4.	Nonlinear Universal Structural Relational Modeling (NEUSREL)	NEUSREL's Causal Analytics software	For non-linear data sets that demonstrate significant moderation effects among variables

5.2.1 MEASUREMENT MODEL

The measurement model shows the relationship between constructs and indicators. The latent variables/constructs are decided based on the hypotheses formulated in this research. The latent variables can be measured indirectly with the help of the indicators or manifest variables. There are two ways of measuring latent variables; i.e. one is a reflective

measurement in which latent constructs are causing the indicators. The second is the formative measurement, in which the indicators are the effect of latent variables.

PLS-PM technique deploys both reflective measurement models and formative measurement models. The reflective measurement models can be judged by checking the following factors: internal consistency reliability, indicator reliability, convergent validity, and discriminant validity. The reliability of constructs shows the ability to measure the same phenomenon accurately and repeatedly. The indicator's reliability can be checked from its outer loading, which should be more than 0.7. However, the indicator's loading between 0.4 to 0.7 can be deleted to improve the composite reliability and average variance extracted (AVE) (Parvadavardini et al., 2016). The internal consistency can be measured through composite reliability with the help of Cronbach's α, which asses the reliability based on the inter-correlation of the indicators.

Mathematically,

Cronbach's $\alpha = \left(\frac{R}{R-1}\right)\left(1-\frac{\sum_{i=1}^{R} S_i^2}{S_i^2}\right)$, where s_i^2 shows the variance of the '*I*' indicators of specific constructs measured by R indicators (I = 1, ---------, R).

Cronbach's α should be 0.6 to 0.9 (Bagozzi and Yi, 1988). The value of 'α' less than 0.6 shows a lack of internal consistency reliability. Accordingly, in this study, the indicators whose outer loading was less than 0.7 have been deleted to improve the overall reliability of the construct. Validity can be checked through convergent validity and discriminant validity. The convergent validity indicates the extent to which the indicators positively correlate with alternative indicators of the same construct and can be established through Average Variance Extracted (AVE), whose value should be more than 0.5 (Bagozzi and Yi, 1988).

Mathematically,

$$\text{AVE} = \left(\frac{\sum_{i=1}^{R} l_i^2}{R} \right).$$

The construct should be unique, not capture the phenomena represented by others, and can be established from Discriminant validity. The Discriminant validity can be checked through cross-loading methods, Heterotrait -Monotrait Ratio (HTMT), and Fornell and Larcker method. In a cross-loading method, the loading of the constructs should be higher than its cross-loadings. Fornell and Larcker (1981) suggested that the "**square root**" of the AVE of each latent variable should be greater than the correlations among the latent variables to test the discriminant validity. In a cross-loading, Fornell and Larker, the value can be changed when some additional constructs are added to the model, whereas the value of HTMT does not change. The value of HTMT should be less than 0.85 for favourable results.

In the formative measurement models, the construct convergent validity can be examined using reflective measures through its correlation with an alternative measure of the constructs. The correlation between the constructs should be equal to 0.7 or more. In the case of formative measurement, if the value of outer loading is ≥ 0.5, the indicator should be retained; otherwise, the formative indicator should be removed from the models. Collinearity is a phenomenon in which one predictor (indicator) can be predicted from the others with considerable accuracy. The variance inflation factor (VIF) can check indicators' collinearity. VIF shows the degree to which the standard error has been increased due to collinearity.

Mathematically,

$VIF_{np} = 1/TOL_{np}$**.**

Tolerance for indicator (TOL_{np}) = 1- R^2_{np}, whereas R^2_{np} is the indicator's variance. The value of VIF should be < 5, but there is always the issue of collinearity when the VIF value is 3-5. Ideally, the value of VIF should be < 3.

5.2.2 STRUCTURAL MODEL

It is the path relationship between the constructs. The left-side constructs are independent variables, whereas the right-side constructs are dependent variables. The independent variables are exogenous constructs with a single-headed arrow coming from them. The constructs that act as dependent or independent are endogenous constructs and a single-headed arrow, either coming into it or both coming and going out from it. Mathematically, it can be written as (Vinzi et al.,2010):

Suppose PLS-PM aims to estimate unobservable constructs among N (n = 1, ……., N). Let us assume X variables *(x = 1…., X)* observed on P units *(p = 1….., P)*. The path model can be written as:

$$Y_j = \beta_{0j} + \sum_{nY_a \to Y_j} \beta_{nj} Y_n + \zeta_j$$

Y_j ($j = 1, \ldots, J$) is the generic endogenous latent variable, β_{nj} is the generic path coefficient interrelating the n^{th} exogenous latent variable to the j^{th} endogenous one, ζ_j is the error in the inner relation. The measurement model can be reflective or formative depending on the relationship between latent and manifest variables. In a reflective model, indicators are related to the construct by a simple regression model i.e.

$W_{xn} = \lambda_{x0} + \lambda_{xn} Y_n + \varepsilon_{xn}$

Where $\lambda_{xn}$is the loading of x^{th} indicators in the n^{th} block and the error term ε_{xn} represents the inaccuracy in the measurement process.

5.3 HYPOTHESES TESTING

The hypotheses have been tested with PLS-PM on Smart PLS software version 3.0 due to its easy availability and accuracy for fewer data. For quick reference, the hypotheses are reproduced before their validation.

5.3.1 CONSUMER BEHAVIOUR AND ITS IMPACT ON HIS PURCHASE INTENTION AND MANUFACTURING OF GREEN PRODUCTS

The hypotheses are:

H_{1a}: Consumer behaviour for utilization of green products positively influences their purchase intention.

H_{1b}: Consumer behaviour for utilization of green products positively impacts brand loyalty.

H_{1c}: Consumer behaviour for utilization of green products positively affects green production.

H_{2a}: Perceived quality of the green product positively influences consumers' purchase intention.

H_{2b}: Perceived quality of the green product positively affects consumer behaviour for utilization of green products.

H_{2c}: Perceived quality of the green product positively affects brand loyalty.

H_{2d}: Perceived quality of the green product positively affects green production.

H_{2e}: Green production has a positive impact on brand loyalty.

H_{3a}: Green purchase intention positively enhances brand loyalty.

H_{3b}: Green purchase intention has a positive effect on green production.

5.3.1.1 RESULTS AND DISCUSSION

In this study, formative and reflective measurement models have been used, as shown in Figure 5.5. The structural model is concerned with consumer behaviour towards purchasing environmentally friendly products and finding the impact of consumer behaviour on producing environmentally friendly products. The perceived quality (PQ), consumer behaviour (CB), purchase intentions (PI), and brand loyalty (BL) have a formative loading, whereas green production (GP) has reflective loadings. Table 5.2 shows the internal Consistency measurement details.

Table 5.2: Internal consistency reliability

Constructs	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
BL	-	-	-
CB	-	-	-
GP	0.862	0.862	0.511
PI	-	-	-
PQ	-	-	-

We use a convergent validity test to check the correlation of one measure with other measures of the same construct using different indicators. The redundancy analysis is being done to check whether formative measured constructs are highly correlated with reflective measures of the same constructs or not. Figure 5.1 to 5.4 shows the redundancy analysis of formative constructs.

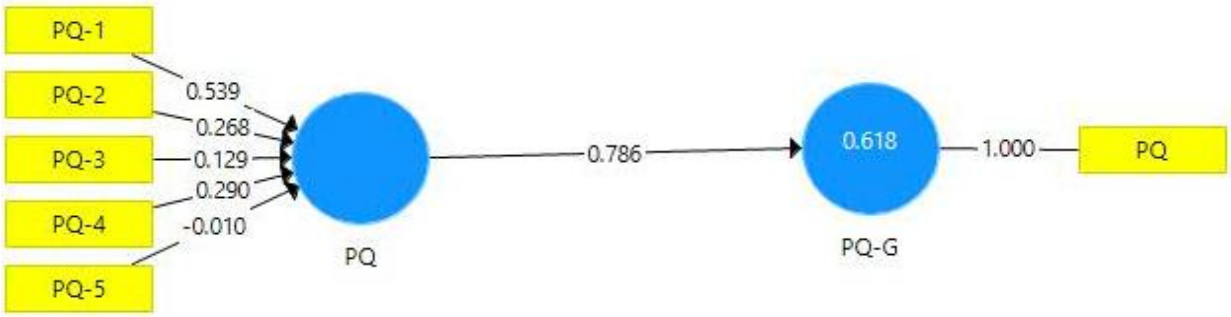

Figure 5.1: Convergent validity of the constructs PQ

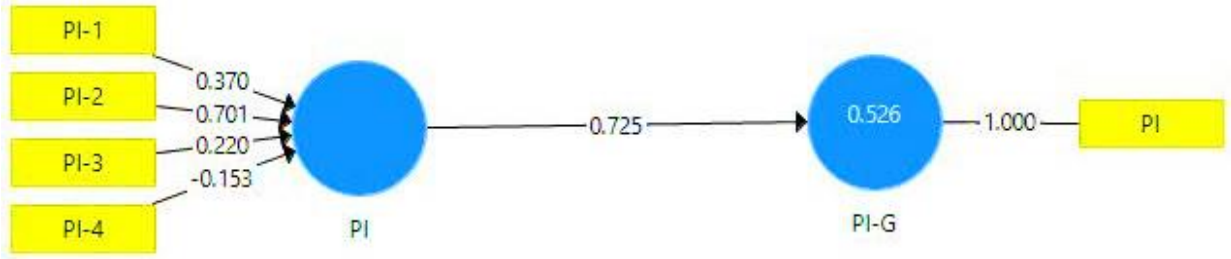

Figure 5.2: Convergent validity of the constructs PI

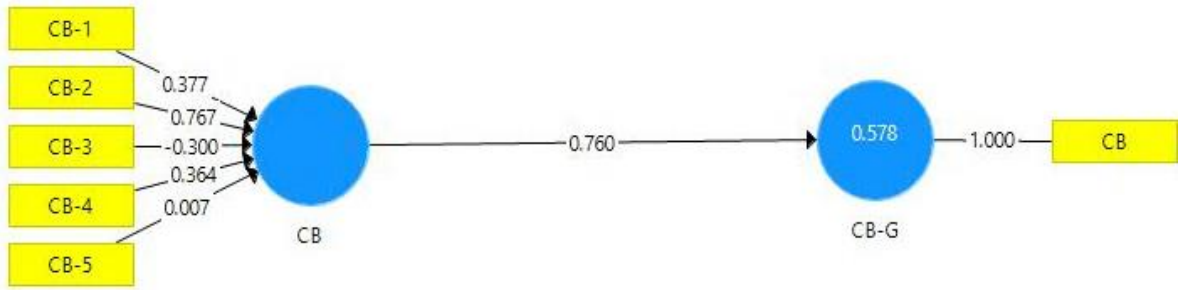

Figure 5.3: Convergent validity of the constructs CB

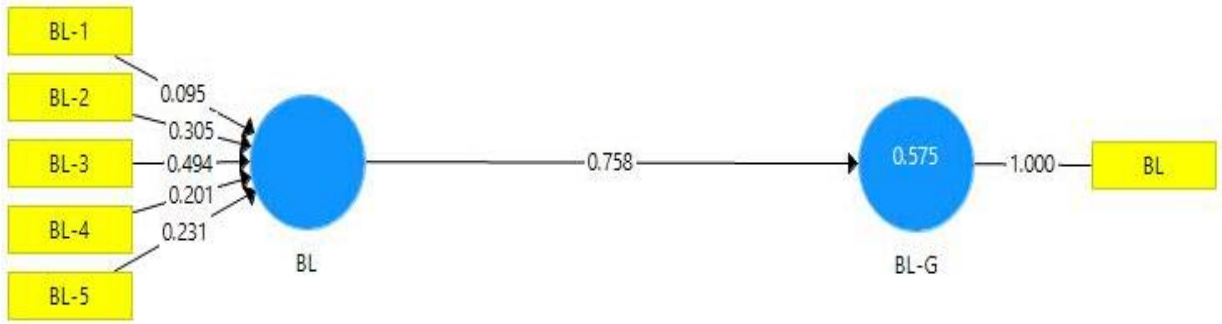

Figure 5.4: Convergent validity of the constructs BL

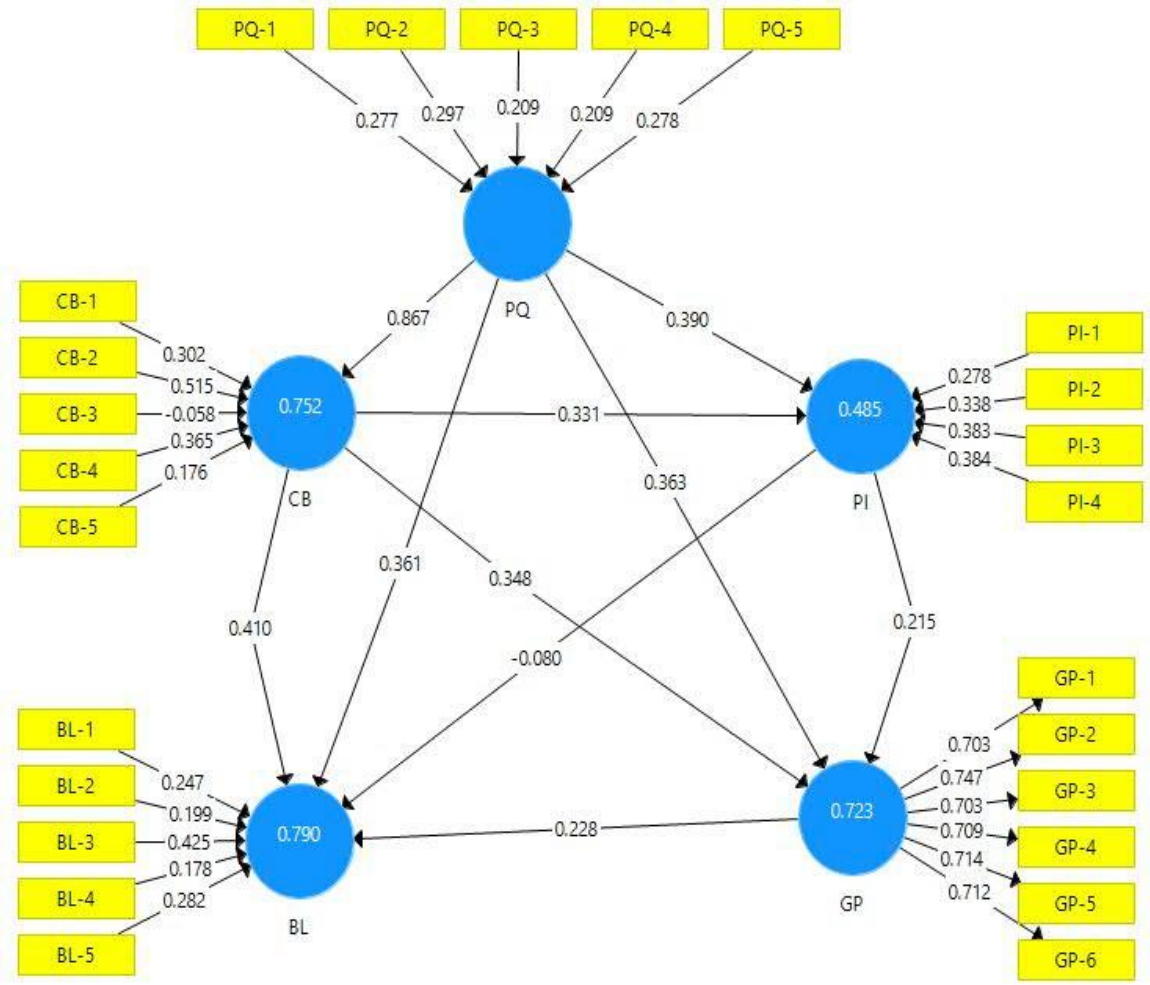

Figure 5.5: The structural model of consumer behaviour and its impact

The original formative construct is shown as PQ, PI, CB, and BL, and the assessment of the factors using a single indicator is shown as PQ-G, PI-G, CB-G, and BL-G. This analysis yields a path coefficient of 0.786, 0.725. 0.760 and 0.758which are more than the recommended threshold of 0.7, thus supporting the convergent validity of formative constructs. The collinearity of the indicators has also been checked through the formative indicator's VIF value. From the results mentioned in Table 5.3, it is observed that the maximum VIF value is 2.90, which is below the threshold value of 5, and collinearity is not an issue for the estimation of PLS-PM as it is much below the critical value. Their outer

weight checks the relevance and significance of the formative indicators resulting from multiple construct and indicator regression (Hair et al., 2011). The outer weight shows the relative contribution to forming the construct. If indicators are not correlated, the maximum possible outer weight becomes $1/\sqrt{n}$, where 'n' is the number of indicators. When outer loading is more than 0.50, the indicator would generally be retained despite the non-significant outer weight. The significance of the outer weight is checked through the bootstrapping process. In this study, outer weight/loading is shown in Table 5.3.

Table 5.3: Measurement of collinearity issue and significance of indicators

S. No.	Constructs	Indicators	Outer weight/Outer Loadings	Cronbach's α	VIF
1.	Purchase Intentions (PI)	Need fulfillment (PI-1)	0.278/ 0.720	0.695	1.546
		Environmental consciousness (PI-2)	0.338/0.709		1.470
		Personal attention (PI-3)	0.383/0.731		1.291
		Post-Sales-Service (PI-4)	0.384/0.730		1.278
2.	Perceived Quality (PQ)	Consumer producer relationship	0.277/0.756	0.845	2.775
		Empathy (PQ-2)	0.297/0.792		2.071
		Responsiveness (PQ-3)	0.209/0.806		2.164
		Reliability (PQ-4)	0.209/0.758		2.900
		Assurance (PQ-5)	0.278/0.819		2.300
3.	Consumer Behavior (CB)	Product cost (CB-1)	0.302/ 0.750	0.852	2.388
		Green initiatives (CB-2)	0.515/0.770		1.243
		Addressing social issues (CB-3)	-0.0580/		2.542
		Product quality (CB-4)	0.365/0.780		1.803
		Income level (CB-5)	0.176/0.762		2.705
4.	Brand Loyalty (BL)	Organizational commitment (BL-1)	0.247/0.790	0.833	2.070
		Respect for rule of law (BL-2)	0.199/0.758		2.079
		Advertising & promotions (BL-3)	0.425/0.718		1.199
		Transparency with consumer (BL-4)	0.1780.789		2.274
		Consumer expectations (BL-5)	0.2820.740		1.701
5.	Green Production (GP)	Use of alternative materials (GP-1)	0.213/0.703	0.855	1.318
		Green packaging (GP-2)	0.226/0.747		2.861
		Energy conservation (GP-3)	0.213/0.703		1.598
		Waste management (GP-4)	0.215/0.709		1.852
		Improvement in life expectancy (GP-5)	0.216/0.714		2.791
		Production cost (GP-6)	0.216/0.712		2.886

The structural model can be evaluated through the Coefficient of Determination (R^2), effect size (f^2), and the statistical significance of the structural path coefficients. R^2 measures the model's predictive accuracy. The value of R^2 equal to 0.75, 0.5, and 0.2 can be considered substantial, moderate, and weak in marketing research (Hair et al., 2011). The value of R^2 obtained in this study is shown below in Table 5.4.

Table 5.4: R^2 (Coefficient of determination)

Constructs	R Square	R Square Adjusted
BL	0.790	0.782
CB	0.752	0.750
GP	0.723	0.716
PI	0.485	0.475

The f^2 effect size measures the impact of omitted constructs due to a change in the value of R^2.

Mathematically,

$$f^2 = \frac{R^2_{included} - R^2_{excluded}}{1 - R^2_{included}}$$

R^2 included or excluded is the value of R^2 when exogenous constructs are included or excluded from the models. The f^2 value of 0.02, 0.15, and 0.35 represent small, medium, and large effects, respectively (Cohen, 1988). The f^2 is irrelevant in this study as no construct has been omitted. Bootstrapping is used to find the significance of path coefficients. The critical *'t'* value should be 1.65 (significance level 10%), 1.96 (significance level 5%) and 2.57 (significant level 1%) for two-tailed test and *'p'*-value should be less than 0.10 (significant level 10%), 0.05 (significance level 5%) and 0.01 (significant level 1%). A 5 % significance level has been taken in this study.

The product's perceived quality strongly affects changing consumer behaviour and purchase intentions. It explains 75.2% of the variance in consumer behaviour and 48.5% of the variance in purchase intentions of the consumer. The product's perceived quality, which improves consumer behaviour and purchase intentions, also has a significant role in enhancing the production of green products. Together, they explain 72.3 % of the variance in green production. In contrast, the perceived quality of the products and changing consumer behaviour and purchase intentions with green production also enormously help improve corporate brand loyalty. Together, they explain the 79 % variance in brand loyalty. The path coefficients, as shown in Table 5.5, the '*p*'-value and '*t*' value are significant at the 5% level, show that the perceived quality has the most substantial effect on consumer behaviour (0.867), followed by a price intention (0.390), green production (0.363), and brand loyalty (0.361). The path coefficient also shows that brand loyalty is enormously improved by consumer behaviour (0.410) rather than green production (0.228), whereas price intentions (-0.08) hurt brand loyalty. Consumer behaviour has a moderate impact on green production (0.348) and price intentions (0.331), and the effects of price intentions on green production (0.215) are also reasonable.

Table 5.5: Hypotheses testing results

Hypothesis	Relationship	Path coefficient	t- statistics	p-values	Result
H_{1a}	CB → PI	0.331	2.247	0.049	Accepted
H_{1b}	CB→ BL	0.410	3.350	0.000	Accepted
H_{1c}	CB→ GP	0.348	2.247	0.021	Accepted
H_{2a}	PQ→ PI	0.390	2.614	0.011	Accepted
H_{2b}	PQ→ CB	0.867	27.478	0.000	Accepted
H_{2c}	PQ→ BL	0.361	2.840	0.004	Accepted
H_{2d}	PQ→ GP	0.363	2.187	0.036	Accepted
H_{2e}	GP→ BL	0.228	1.732	0.109	**Rejected**
H_{3a}	PI→ BL	-0.080	0.881	0.370	**Rejected**
H_{3b}	PI→ GP	0.215	2.080	0.032	Accepted

The path coefficients and corresponding 'p' values show that consumer behaviour has a strong influence on the purchase intentions of the consumer (hypothesis H_{1a}), the brand loyalty to the firms (hypothesis H_{1b}), and the production of green products

(hypothesis H_{1c}). The perceived quality of the product also has a powerful impact on improving price intentions of the consumer (hypothesis H_{2a}), improving consumer behaviour toward green consumption (hypothesis H_{2b}), increasing brand loyalty (hypothesis H_{2c}), and finally raising green production (hypothesis H_{2d}) and hence accepted these hypotheses. This result also confirms the findings of D'Souza et al. (2006) that consumers do not tolerate lower quality with the higher price of products. The consumer's excellent purchase intentions also help to improve green production (hypothesis H_{3b}) and hence accepted the hypothesis. But the role of green productions and price intentions in strengthening brand loyalty has not been proved; therefore, the hypothesis H_{2e} and H_{3a} have been rejected.

5.3.2 THE HYPOTHESES CONCERNED WITH THE EFFECT OF IMPLEMENTATION OF GREEN MANUFACTURING PRACTICES ON THE PERFORMANCE OF THE INDIAN SMEs

The hypotheses are:

H_{4a}: Green manufacturing positively affects the company's financial performance.

H_{4b}: Green manufacturing positively affects the social performance of organizations.

H_{4c}: Green manufacturing positively affects the environmental performance of organizations.

5.3.2.1 RESULTS AND DISCUSSION

The validity of the constructs is checked by analyzing a measurement model and calculating the composite reliability of each indicator loading, the average variance extracted (AVE), Cronbach's α, and the discriminant validity of the reflective constructs. The outer loading should be more than 0.7 to improve the composite reliability and average

variance extracted (AVE). The value of AVE should be more than 0.5 to show that the indicators positively correlate with alternative indicators of the same construct, and the value of Cronbach's α should be more than 0.6 as the value less than 0.6 shows a lack of internal consistency reliability (Bagozzi and Yi, 1998). The Indicators F3 (increase in sales), F4 (return on investment), S2 (an increase of market share), and E2 (waste reduction) have been eliminated as their loading was less than 0.7. The uniqueness of the construct should be checked for discriminant validity. Variance inflation factor (VIF) is used to check the indicator's collinearity in the case of formative indicators, and its value should always be less than 5. Still, there might be a collinearity issue when the value lies between 3 and 5. However, the indicators should be retained if the outer loading is more than 0.5.

The Cronbach's α, AVE, and composite reliability values are more than recommended. The structural model can be evaluated through the Coefficient of Determination ($R^{2)}$, effect size (f^2), and the statistical significance of the structural path coefficients. R^2 measures the model's predictive accuracy. The value of R^2 equal to 0.75, 0.5, and 0.2 can be considered substantial, moderate, and weak in marketing research (Hair et al., 2011). The value of R^2 obtained in this study is shown in Table 5.6. The value of R^2 shows substantial relation with environmental performance, moderate with financial performance, and weak with social performance. Table 5.7 shows the validity of the constructs. Table 5.8 shows the discriminant validity using the Fornell-Larcker criterion, and Table 5.9 offers the model fit. In this study, reflective measurement models have been used, as shown in Figure 5.6, which shows the structural model to study the effect of green product development on the performance of Indian SMEs.

Table 5.6: R^2 (Coefficient of determination)

Constructs	**R square**	**R adjusted**
EP	0.706	0.703
FP	0.355	0.348
SP	0.216	0.207

Table 5.7: Construct's validity

S. No.	Constructs	Indicators	Outer Loadings	Cronbach's α	AVE	Composite reliability
1.	Financial Performance (FP)	Increase of market share (F1)	0.888	0.701	0.769	0.870
		Profit increase (F2)	0.866			
2.	Social Performance (SP)	Corporate social responsibility (S1)	0.837	0.889	0.751	0.923
		Ethical behaviour (S3)	0.927			
		Respect for rules of law (S4)	0.796			
		Job creation (S5)	0.901			
3.	Environmental Performance (EP)	Use of non-hazardous materials(E1)	0.876	0.836	0.715	0.888
		GHG emission (E3)	0.779			
		Optimal utilization of resources (E4)	0.893			
		Global warming (E5)	0.703			
4.	Green Manufacturing (GM)	Use of cleaner technology (G1)	0.847	0.788	0.703	0.876
		Green packaging (G2)	0.918			
		Renewable energy sources (G3)	0.741			

Table 5.8: Discriminant validity

(Fornell-Larcker criterion)

Constructs	EP	FP	GM	SP
EP	0.846			
FP	0.527	0.877		
GM	0.840	0.596	0.838	
SP	0.642	0.319	0.465	0.867

Table 5.9: Model fit

	Saturated Model	Estimated Model
SRMR	0.114	0.141
d_ULS	1.185	1.800
d_G	1.137	1.198
Chi-Square	407.484	420.087
NFI	0.592	0.579

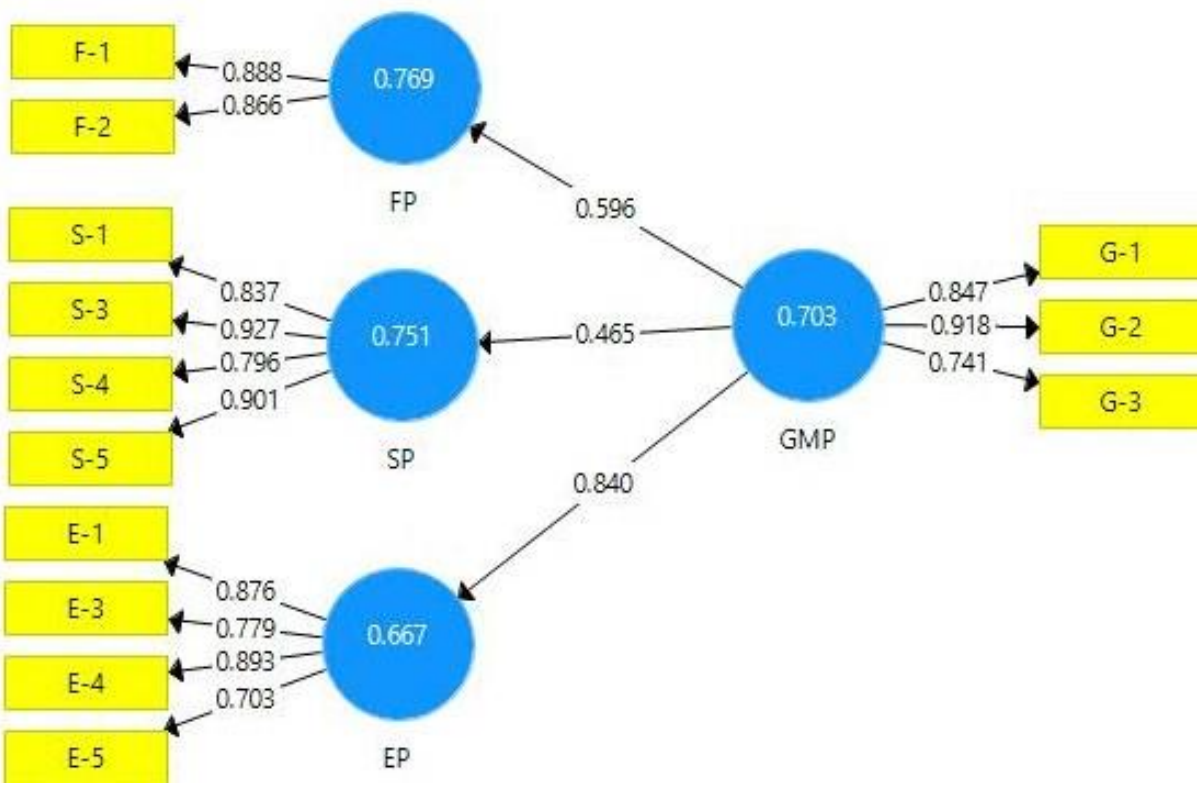

Figure 5.6: The structural model of organizational performances

After completion of measurement model validation, the structural model was tested to evaluate the PLS-PM results by assessing the Coefficient of Determination (R^2), the blindfolding-based cross-validated redundancy measure $Q^{2,}$ and the statistical significance of the various coefficients. Table 5.10 shows the details of path coefficients and their statistical significance, and Table 5.11 shows the cross-validated redundancy (Shmueli et al., 2016).

Table 5.10: Path coefficients and statistical significance

Hypothesis	Relationship	Path coefficients	t-statistics	P-value	Result
H4a	GM ⟶ FP	0.596	6.053	0.000	Accepted
H4b	GM ⟶ SP	0.465	5.302	0.000	Accepted
H4c	GM ⟶ EP	0.840	36.667	0.000	Accepted

Table 5.11: Constructs cross-validated redundancy

Constructs	SSO	SSE	Q^2 (=1-SSE/SSO)
EP	360.000	207.798	0.425
FP	180.000	136.532	0.241
GM	270.000	270.000	
SP	360.000	307.150	0.145

The value of R^2 lies between 0 – and 1, but the R^2 values of 0.75, 0.50, and 0.25 can be considered substantial, moderate, and weak. In this analysis, green manufacturing explains more excellent social performance and good financial and environmental performance. A higher Q^2 value defines higher predictive accuracy and should be more than zero. The Q^2 values 0, 0.25, and 0.5 show the model's small, medium, and large predictive relevance. The path coefficients show that with the increase of green manufacturing by 100%, 59.6% improvement in financial performance, 46.5% increase in

social performance, and 84% improvement in environmental performance, it is quite above the minimum value of 20% (Chin 1998a; 1998b).

Therefore, we can say that with the increase in green manufacturing practices, the organization's financial performance also improves. Hence, confirming hypothesis H_{4a}: Green manufacturing significantly affects the company's financial performance. Further, green manufacturing increases an organization's social performance, confirming hypothesis H_{4b}: Green manufacturing significantly affects the company's social performance. Furthermore, adopting green manufacturing practices also improves the organization's environmental performance, confirming hypothesis H_{4c}: Green manufacturing significantly affects the company's environmental performance.

5.4 CONCLUSION

The testing of hypotheses was completed with the help of the Smart PLS software 3.0 version. The hypotheses (H_{1a} to H_{3b}) are concerned with consumer behaviour towards purchasing environmentally friendly products and the impact of consumer behaviour on producing environmentally friendly products. The first three hypotheses show the influence of consumer behaviour on the consumer's purchase intentions for green products, the impact of consumer behaviour on brand loyalty, and the third hypothesis is concerned with the role of consumer behaviour in the production of green products. The path coefficients and corresponding 'p' values show that consumer behaviour has a strong influence on the purchase intentions of the consumer (H_{1a}), the brand loyalty to the firms (H_{1b}), and production of the green products (H_{1c}). Hypotheses H_{2a} to H_{2e} concern the firms' perceived quality and brand loyalty.

In contrast, hypothesis (H_{2d}) reflects the relation between the perceived quality of the green products to the production of the green products. The perceived quality of the

product also has a powerful impact on improving price intentions of the consumer (hypothesis H_{2a}), consumer behaviour toward green consumption (H_{2b}), increasing brand loyalty (hypothesis H_{2c}), raising green production (hypothesis H_{2d}) and hence the result show the acceptance of hypotheses. Hypothesis (H_{2e}) is related to the influence of green production on brand loyalty, and hypothesis (H_{3a}) shows the impact of consumer purchase intention on brand loyalty. The result shows no impact of green production or consumers' purchase intentions on the brand loyalty of the firms. Hypothesis (H_{3b}) shows that consumers' good purchase intentions also help improve green production.

Hypothesis H_{4a} to H_{4c} is related to the impact of the adoption of green manufacturing practices by the Indian SMEs on the organizational performance of the firms. The organizational performance integrates the firm's environmental, financial, and social performance. Hypothesis H_{4a} relates to the financial performance of the firms; hypothesis H_{4b} is concerned with the firm's social performance, whereas hypothesis H_{4c} reflects the environmental performance. The result shows that the organization's sustainable performance increases with green manufacturing practices, i.e., financial performance, social performance, and environmental performance improvement.

This chapter contains the testing of hypotheses concerned with consumer behaviour towards the purchase of environmentally friendly products and finding the impact of consumer behaviour on the production of environmentally friendly products and the effect of the implementation of GMP on the performance of the Indian SMEs. The hypotheses have been tested based on the response received from the Indian consumers and the data received from the Indian SMEs.

CHAPTER 6

RANKING OF OBSTACLES IN IMPLEMENTATION OF GREEN MANUFACTURING PRACTICES

6.1 INTRODUCTION

Manufacturing enterprises, especially SMEs, are the driving instruments for the growth of the Indian economy. About 42.50 million registered and unregistered SMEs employ about 106 million people, i.e., 40% of the Indian workforce (EVOMA, September 28, 2017). Any adverse impact on SME's performance influences other economic, social, and environmental activities. Chein et al. (2021) observed that SMEs are responsible for around 70% of industrial waste and environmental emissions. Manufacturing enterprises and the transportation sector create the most ecological pollution. In the era of globalization and a competitive environment, a shift towards next-generation manufacturing, i.e., green manufacturing, could be a decisive factor in addressing environmental pollution, particularly for SMEs, which are significant contributors to wealth and employment generation. The government often uses ecological policies to alleviate emissions enhanced by business organizations like SMEs (Mohsin et al., 2018; 2021). After increasing awareness, the government has imposed restrictions on SMEs to reduce environmental impact (Rasheed and Anser, 2017; Ahmad et al., 2020).

Kumar et al. (2012) and Xu et al. (2013) found that increasing environmental awareness also exerts pressure on industries to conserve the earth's resources and protect the environment. A good solution thus needs to address these twin issues. The policy can satisfy all environmental or social problems if it genuinely formulates a model. Hence, before searching for a solution and constructing any model, the green manufacturing

challenges related to technology, resources, etc., should be overcome. Noranarttakun and Pharino (2021) observed that green initiatives have unceasingly been encouraged in the last decades, causing the implementation of a green industrial policy.

Although the world is committed to implementing environmentally-friendly measures in manufacturing, the development of the same in Indian manufacturing enterprises is prolonged. Even though domestic companies progressively realize the benefits of sustainable practices, SMEs' performance is not up to the mark in many regions. It poses a risk for our society and hinders the sustainability of SMEs. Green manufacturing practices (GMP) are essential to decouple environmental pressure from economic growth. The manufacturing practices which do not harm the environment are known as GMP. According to Sindhwani et al. (2019), resource optimization with reducing emission and wastage for environmental conservation is the ultimate goal of GMP.

GMP implementation is facing many challenges. According to the United Nations Environment Program (UNEP, 2011), developing countries gross domestic product (GDP) nearly doubled during the last 15 years. This industrial production growth has also increased pressure on the environment. India's industrial and economic growth has come at the cost of growing greenhouse gas (GHG) emissions, rising demand for scarce resources, and increasing waste generation. India is the fifth largest GHG emitter globally and generates millions of tons of hazardous waste and e-waste, causing a significant threat to society. GMP economically substitutes clean energy and low carbon technologies, creates jobs, and reduces import dependencies.

According to Acharya et al. (2014), adopting GMP can also tackle poverty effectively. Hence, it has been gaining attention over recent decades (Younis et al., 2016). Shahria et al. (2019) stated that the government should persuade researchers and industrial communities about GMP. SMEs, the leading contributor to economic growth, are sceptical

about implementing green manufacturing practices. Many studies identify the reasons for scepticism creating obstacles in implementing GMP, even if identifying the reasons is insufficient. SMEs already lack infrastructure and financial resources. After the evolution of the term industry 4.0, it becomes more challenging to adopt green practices, especially for Indian SMEs, because of the market's increase in competitiveness. However, degrading the environmental quality and increasing market pressure force domestic companies to realize the benefits of sustainable practices. Therefore, especially after Industry 4.0 and technological advancement, an in-depth study is needed to classify the Indian SMEs' obstacles. Hence, the present study attempts to organize and ranks the hurdles in the current scenario to tackle the scepticism of SMEs about GMP.

To find out the most affecting obstacles, first, calculate each weight and then rank them based on their global ranking. Several methods can be used to calculate the significance of these obstacles, like DEMATEL, VIKOR, etc. (Gencer and Gürpinar, 2007; Thangchattu and Siripokapiram, 2010; Senthil et al., 2014; Awasthi and Kanan, 2016; Prakash and Barua, 2016). But all these techniques require pairwise comparison matrices, which often suffer consistency issues due to more data (Rezaei, 2015). To mitigate this issue, a new multi-criteria decision-making (MCDM) tool, which requires less amount of data and is more consistent, called the best-worst method (BWM), is used in this study.

6.2 GREEN MANUFACTURING OBSTACLES

The concept of green manufacturing emerged around the 1970s but did not gain momentum. Post and Altma (1994) found employee attitude, poor communications, and lack of top management leadership as organizational barriers and industry regulations, capital costs, and technical information as industrial barriers in green management. Walker et al. (2008) identified the cost and lack of legitimacy as internal barriers and regulation,

poor supplier commitment, and industry-specific barriers as external barriers. At different levels, Zhu and Geng (2013) found different motivators and barriers to adopting green technology. Compliance with environmental regulations enforces a cost on organizations, reducing firms' overall competitiveness (Darnall, 2009). However, if companies want to build a competitive advantage, they need to train their managers to deal with the internal obstacles of the manufacturing industry. Mudgal et al. (2010) found environmental sustainability one of the global community's biggest challenges.

Despite many obstacles in implementing GMP, they did not carry an equal impact (Pati et al., 2016). Jabbour et al. (2016) found that there still exists an opportunity to understand the barriers and motivators of green operational practices. Gupta and Barua (2018) realize that SMEs are on the back foot in implementing green procedures because of many obstacles to green innovation. Caldera et al. (2019) observed that due to the lack of financial resources, insufficient expertise workforce, the perception of having an indistinguishable position in the market, and the lack of environmental knowledge, SMEs are not adequately implementing lean and green practices. Xia et al. (2019) felt that identifying barriers to adopting green technology had become essential to successfully implementing green operations in the business. Knowing exact information about these barriers, managers can allocate their resources to maximize efficiency in the production process. Mittal and Sangwan (2014) stated that natural resource depletion and global warming forced manufacturing firms to implement GMP.

The Indian government desires to increase the manufacturing sector's contribution from 16% of the present level of GDP to 25 % and address the country's environmental worries (CII 2021). Besides minimizing waste generation, the manufacturing sector should also reduce energy and resource consumption by implementing GMP, which is now the country's need. Unnikrishnan et al. (2016) found that SMEs are less motivated to adopt

new technology to resolve environmental issues because of financial obstacles. Resistance to change and ignorance of praising environmental needs were other concerns. The study observed that dedicated funding for environmental management, education, and training is necessary to communicate environmental expectations to SMEs. All the obstacles responsible for creating obstacles in implementing GMP identified through the literature survey are given in succeeding paras.

6.2.1 FINANCIAL OBSTACLES

The financial requirements include the technologies procurement cost, innovation cost, disposable cost for hazardous wastes, green packaging cost, sustainability maintenance cost, etc. The prices of buying and implementing the latest technology are very high, and it also creates fear of a reduction in profit and market share (Dwyer, 2007). Investment in new machinery requires new capital. Albeit, in the long run, because of higher efficiency and better market reputation, green technologies can increase profit and market share. Still, higher initial capital cost discourages business organizations from implementing it (Shi et al., 2008).

Without financial motivation and investment in green technology, SMEs deliver poor-quality products. They violate environmental requirements, resulting in difficulties in maintaining sustainability in the production process (Bhandari et al., 2019). Mittal & Sangwan (2011) and Zhu & Geng (2013) observed that the initial investment cost of green technology adoption is a significant obstacle to GMP adoption. Some of the substantial challenges in the implementation of GMP in Indian SMEs are high initial financial requirements to implement GMP (Singh et al., 2021); limited financial resources (Caldera et al., 2019; Bhanot et al., 2017); green packaging costs; disposal waste disposal cost and lack of resources for green implementation, etc.

6.2.2 MANAGERIAL OBSTACLES

The barriers associated with the lack of commitment of the management to implement green technology and operational procedure are known as managerial obstacles. Singh et al. (2008) stated that most SMEs use outdated technology, unskilled labour, and traditional management practices causing inefficiency and poor quality. The management of SMEs due to lack of information and inadequate expertise, the management of SMEs is not acquainted with the action taken by other organizations to succeed (Wooi and Zailani, 2010). The benefits of implementing the GMP are often unknown to top management. According to Olugu et al. (2011), unless the top management decides to implement green initiatives as a strategy, it cannot succeed. Bhandari et al. (2019) found that the administration is most reluctant to change and prioritizes expanding and increasing their market share. For the successful implementation of green manufacturing practices, a long-term commitment from top management and a desire for continuous improvements (Karippaih et al., 2020) are essential. Lack of top management commitment to implement green manufacturing practices in their organizations (Singh et al., 2021), lack of supplier development and commitment, lack of information technologies, and lack of strategic planning are significant obstacles to adopting green manufacturing practices.

6.2.3 OPERATIONAL OBSTACLES

Globalization and changing business activity with increasing environmental awareness have forced organizations to adopt GMP proactively (Cherrafi et al., 2017; Garza-Reyes, 2015). Cherrafi et al. (2017) and Karuppiah et al. (2020) found that inadequate training and non-availability of proper educational facilities are key operational barriers to adopting GMP. The insufficient expertise and inherited fear of failure make them resistant to change. Because of the lack of proper training and education for the employee,

lack of infrastructure and awareness about global change, and lack of technological understanding, top management of SMEs may not understand the environmental impacts on their organizational activities. Also, improper internal communication and lack of exposure to the latest developments in technologies are other problems experienced by SMEs. Singh et al. (2012) observed that re-management of human resources is also an important barrier to adopting green manufacturing practices. Most human forces are not adequately skilled to be acquainted with the latest technology. According to Bhandari et al. (2019), top management is the critical behavioural factor controlling human barriers. Ahuja et al. (2019) felt a lack of trust and motivation between management and employee. The employees thought the management people were exploiting them and paid less attention to their problems, whereas the management was dissatisfied with their commitment.

6.2.4 TECHNOLOGICAL OBSTACLES

Good technological and theoretical knowledge is essential for proper green manufacturing practices. Singh et al. (2008) found that global competitive strategies are increasingly becoming technology-driven in the era of globalization and environmental awareness. The technological capabilities measure firm's business and manufacturing priorities. The technology helps maintain its position in a competitive market by providing better quality products and designs at a lower price with short delivery periods. The latest technologies allow SMEs to access international markets by introducing better quality products to these markets.

Singh et al. (2009) observed that the significant obstacles to the competitiveness of SMEs are the lack of adoption of the latest technology, causing failure to meet the demand effectively. The industries must acquaint themselves with the new technological development to implement green supply chain management (Govindan et al., 2014). SMEs

are usually slow in ameliorating environmentally friendly technology (Massoud et al., 2010). A lack of knowledge in the top management adversely affects employee training and involvement in green manufacturing implementation (Bhandari et al., 2019). Pati et al. (2016) stated that the managers should be properly acquainted with the skills and continuously upgrade their knowledge to maintain sustainability. The lack of new technology and expertise related to new technology are essential barriers to GMP (Kushwaha and Talib, 2020). Pathak et al. (2020) observed that it is challenging to adopt new technology because of a lack of finance and skilled workforce and the willingness of top management to adopt the latest technologies. The main obstacle to implementing green manufacturing is the lack of technology awareness, availability of advanced technology, poor management knowledge, and lack of incentives for green technology.

6.2.5 REGULATORY OBSTACLES

Because of the lower control limit of the ambient quality of life and the adoption of ineffective measures, the pollution regulation is feebler in developing countries (D'Souza and Peretiatko, 2002). In India, the Central Pollution Control Board (CPCB) sets environmental standards for all parts of India and coordinates the State Pollution Control Board (SPCBs) activities. The CPCB does not scrutinize the decentralized implementation of environmental laws, and just 7 % of Indian organizations obey pollution-control guidelines. Even after the government's persistent efforts, environmental problems exist due to the large population and limited natural resources. There is also a lack of general environmental guidelines describing priorities and ensuring compliance (Reich and Bowonder, 1992).

With taxation and expenditure, regulation is a critical lever government can use to promote green growth. Generally, SMEs do not have the proper competence to respond to

the stricter law. Tumpa et al. (2019) stated that the success of green initiatives in any manufacturing organization depends upon government regulations. Singh et al. (2021) felt that manufacturing enterprises should operate according to law and regulations (Mathiyazhagan et al., 2013) that motivate the adoption of green technologies. Pathak et al. (2020) observed no push-through rules for climatic control in India.

Further, due to uncertainty about forthcoming government policies, industries do not earnestly implement the sustainable work front. Although it is difficult for policymakers to address unsustainable development issues, stricter regulations are not helpful. Lack of clarity about sustainability standards, ineffective laws for reverse logistics, insufficient government support, and lack of efforts to implement rules and regulations create more obstacles to implementing green manufacturing practices.

6.2.6 ENVIRONMENTAL OBSTACLES

These barriers are related to the expertise of the industrial personnel in environments. Zhu et al. (2008) defined environmental performance as the ability of the organization to decrease the consumption of hazardous and toxic material along with the reduced frequency of ecological accidents. Environmental knowledge is positively related to environmental behaviour, but the contradiction is also available in the literature. According to Singh et al. (2021), some researchers found that ecological knowledge is insufficient for positive environmental behaviour (Sadik and Sadik, 2014). The importance of knowing facts and knowledge about actions, unlike factual knowledge, action-related knowledge is more likely to affect behaviour.

Perez-Valls (2015) stated that the enthusiasm and uncertainty of the current competitive business situation had forced organizations to create knowledge through strategic flexibility. As a result, new organizational support developed continuous

adaptation, reconfiguration, abilities and efficiency. Abdullah et al. (2016) stated that unskilled managers in environmental management put less effort into green initiatives because of less experience and short-term thinking. The lack of resources for the implementation of green practices, lack of alternative materials for product design and developments like proper knowledge about 3D printing, insufficient facilities for the management of end-life products like reuse, recycling and remanufacturing of the product, and lack of awareness about environmental impacts on businesses are the obstacles creating hindrance in the implementation of green manufacturing practices.

According to Sindhwani et al. (2019), it is not easy to implement GM in the industry because of financial and human resource obstacles, less knowledge of environmental aspects, government regulations, and its immediate impact on GDP.

During the literature review, it came to know that the obstacles identified by the earlier researchers are vague and not grouped according to their priority. There is a need to group and ranks them. The list of the obstacles to GMP identified through the literature survey is given in Table 6.1.

Table 6.1: The obstacles to the GMP identified through the literature survey

S. No.	Obstacles	References
1.	Technology procurement cost	Mittal and Sangwan (2014), Majumdar (2019)
2.	Green packaging cost	Gavrilescu et al. (2017); Jermsittiparsert et al. (2021).
3.	Waste disposable cost	Gavrilescu et al. (2017); Papadas et al. (2019); Handa et al. (2019).
4.	Insufficient resources	Gandhi et al. (2018); Moktadir et al. (2018); Karuppiah et al. (2020)
5.	Ineffective tax policy	Seth et al. (2018), Wang & Yu (2021)
6.	Lack of supplier development and commitment	Mathiyazhagan et al. (2013); Singh et al. (2020)

7.	Lack of top management commitment	Kaur et al. (2018); Gandhi et al. (2018).
8.	Lack of strategic planning	Gandhi et al. (2018); Majumdar (2019)
9.	Ineffective information technology	Chien et al. (2021)
10.	Poor availability of skilled labour	Gandhi et al. (2018); Gupta & Barua (2018); Majumdar (2019)
11.	Insufficient training and educational facilities	Gandhi et al. (2018); Karuppiah et al. (2020)
12.	Lack of mutual trust and motivation	Luo et al. (2018); Karuppiah et al. (2020); Chien et al. (2021.)
13.	Low investment in research and development (R & D)	Luo et al. (2018); Karuppiah et al. (2020); Chien et al. (2021.)
14.	Poor awareness	Mangla et al. (2017); Chien et al. (2021)
15.	Scarce advanced technology	Jabbour et al. (2016); Kaur et al. (2018); Singh et al. (2020)
16.	Poor organizational management	Karuppiah et al. (2020), Noranarttakun and Pharino (2021)
17.	Insufficient incentives for green technology	Chein et al. (2021), Zhu et al. (2012)
18.	Poor understanding of green standards	Mangla et al. (2017); Chien et al. (2021)
19.	Ineffective regulations for reverse logistics	Majumdar (2019); Karuppiah et al. (2020)
20.	Insufficient government support	Shi et al. (2008); Zhang et al. (2008); Singh et al. (2020)
21.	Ineffective implementation of rules and regulations	Mittal and Sangwan (2014); Majumdar (2019)
22.	Insufficient funds for the implementation of green practices	Moktadir et al. (2018); Karuppiah et al. (2020)
23.	Scarce green materials for product design and developments	Xiong et al. (2020)
24.	Insufficient facilities for the management of end-life products	Mathiyazhagan et al. (2013); Olah et al. (2020); Xiong et al. (2020)
25.	Poor knowledge about environmental impacts	Brave and Muduli (2012); Ghazilla et al. (2015); Singh et al. (2020)

These obstacle needs to rank in a group according to their priority. The ranking becomes more crucial for developing countries as they have limited resources and cannot

tackle them collectively. Further, the different researchers used different tools like decision-making trial and evaluation laboratory (DEMATEL) (Agayemang et al., 2018), Matrice d'impacts croisés multiplication appliquée á un classment (MICMAC) analysis (Barve and Mudulie, 2013), interpretive structural modelling (ISM) (Bhanot et al., 2017), etc. However, in this research best-worst method (BWM) has been used to rank different obstacles according to their impact on GMP by finding their weight through the BWM method.

6.3 METHODOLOGY

Twenty-five obstacles to GMP were identified based on the literature review and the opinion of industry experts, as shown in Table 6.1. The opinion of the experts collected on a Likert scale from 1 (strongly disagree) to 5 (strongly agree) to categorize them into a primary group of financial, operational, managerial, technological, regulatory, and environmental obstacles. Based on the weightage given by the experts, the factor analysis (FA) method is applied to categorize them. FA is a statistical approach used as an investigative technique to identify relationships among the variables. Communalities show the correlation of an item with other things, and higher communalities are preferable. The value of communalities for a sample size less than 100 should be greater than 0.6 (MacCallum et al., 1999); for sample sizes 100 to 200, it should be between 0.5 to 0.6, whereas, for more than 200 sample size, it should be ≥ 0.4 (Osborne, Costello, and Kellow, 2008). The Kaiser-Meyer-Oklin (KMO) measure of sampling adequacy determines the relationship's strength before the factor analysis (Hair et al., 1998). The value of KMO should be more than 0.5. The test result shows that the value of KMO in this research is 0.793, which is more than the suggested value for factor analysis. The obstacles grouped through factor analysis methods are given in Table 6.2.

Table 6.2: The obstacles grouped through factor analysis methods

S. No.	Factor analysis method (Rotated Component Matrix)						
.	**Sub-obstacles**	**Obstacles Category**					
		Financial (F)	Managerial (M)	Operational (O)	Technological (T)	Regulatory (R)	Environmental (E)
1.	Technology procurement cost (F1)	.812					
2.	Green packaging cost (F2)	.804					
3.	Waste disposable cost (F3)	.789					
4.	Insufficient resources (F4)	.724					
5.	Ineffective tax policy (F5)	.792					
6.	Lack of supplier development and commitment (M1)		.674				
7.	Lack of top management commitment (M2)		.907				
8.	Lack of strategic planning (M3)		.780				
9..	Ineffective information technology (M4)		.902				
10.	Poor availability of skilled labour (O1)			.767			
11.	Insufficient training and educational facilities (O2)			.788			
12.	Lack of mutual trust and motivation (O3)			.768			
13.	Low investment in research and development (R & D) (O4)			.757			
14.	Low awareness (T1)				.770		
15.	Scarce advanced technology (T2)				.803		
16.	Poor organizational management (T3)				.783		
17.	Insufficient incentives for green technology (T4)				.758		
18.	Poor understanding of green standards (R1)					.671	
19.	Ineffective regulations for reverse logistics (R2)					.789	
20.	Insufficient government support (R3)					.784	
21.	Ineffective implementation of rules and regulations (R4)					.761	
22.	Insufficient funds for the implementation of green practices (E1)						.698
23.	Scarce green materials for product design and developments (E2)						.624
24.	Insufficient facilities for the management of end-life products (E3)						.681
25.	Poor knowledge about environmental impacts (E4)						.662
	Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.						
	a. Rotation converged in 5 iterations.						

6.3.1 DATA COLLECTION AND QUESTIONNAIRE ADMINISTRATION

The authors utilized the internet source and personal contacts to get the data from the industry experts of electrical and electronic enterprises (SMEs) in Delhi NCR. A total of 1200 questionnaires have been sent, out of which 400 questionnaires were received back. Out of 400 questionnaires, 31 were incomplete. Hence, 369 questionnaires with a 30.75% response rate were found suitable for study, relatively more than 20%, as Malhotra and Grover (1998) recommended. The respondents who participated in the survey are Directors, Managers, Engineers, supervisors etc., with experience ranging from 5 to 25 years representing all categories of firms. The details of the respondents are given below in Figures 6.1 & 6. 2.

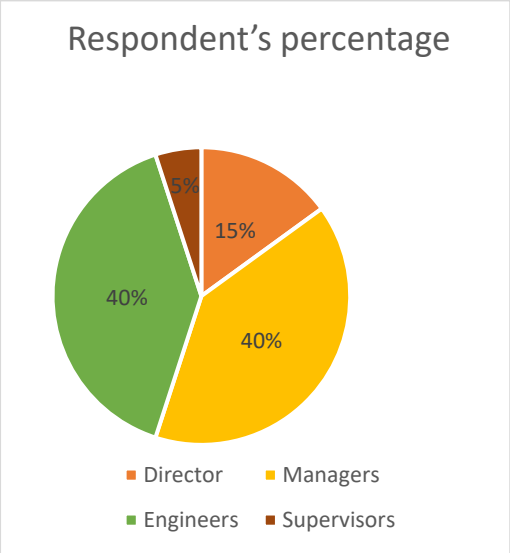

Figure 6.1: Positions of respondents

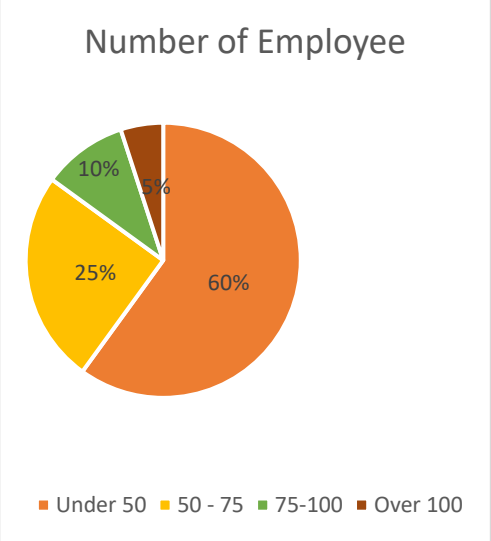

Figure 6.2: Number of employees

6.3.2 METHODS OF CALCULATION OF CRITERIA WEIGHT USING BWM

Multi-criteria decision-making (MCDM) techniques are used in complex problems to decide on the best among many alternatives. A new MCDM technique, known as BWM, developed by Rezaei (2015), is used to calculate the weight of the criteria. The different steps involved in BWM are:

Step 1: Recognize the set of decision criteria in the initial phase of the study.

Step 2: Recognize the best and worst criteria with the help of industry experts.

Step 3: Define the choice of the best criterion over another criterion on a 1-to-9 point ranking scale and construct V_B as shown in equation 1.

$$V_B = \{V_{B1}, V_{B2}, V_{B3}\ldots, V_{Bn}\} \quad (1)$$

Whereas V_{Bj} denotes the choice of the best criterion over criterion j. In this case $V_{Bj} = 1$.

Step 4: Similarly, define the choice of the other criterion over the worst criteria on a 1-to-9 point scale and construct V_W as shown in equation 2.

$$V_W = \{V_{1w}, V_{2w}, V_{3w}\ldots, V_{nw}\}^T \quad (2)$$

Whereas V_{jW} shows the choice of criterion j over the worst criterion W. Thus, $V_{WW} = 1$.

Step 5: In this step, we calculate the optimum weight $(W_1^*, W_2^*, \ldots, W_n^*)$ of each criterion. The fundamental purpose is to find out the maximum weights of the criteria, such that the optimal absolute difference for all 'j' is minimum for the set

$$\left|\frac{W_B}{W_j} - V_{Bj}\right|, \ \left|\frac{W_j}{W_W} - V_{jW}\right|.$$

The following minimax model can be formulated:

$$\min \max_j \left\{\left|\frac{W_B}{W_j} - V_{Bj}\right|, \left|\frac{W_j}{W_W} - V_{jW}\right|\right\} \quad (3)$$

$$subject\,to \sum_j W_j = 1, \ W_j \geq 0 \ for\,all \ j$$

Model 3 may be represented in the following form:

$$\min \xi^*$$

Subject to

$$\left|\frac{W_B}{W_j} - X_{Bj}\right| \leq \xi, \ for\,all \ j$$

$$\left|\frac{w_j}{w_B} - x_{jB}\right| \leq \xi, \text{ for all } j$$

$$\sum_j w_j = 1$$

$$w_j \geq 0 \text{ for all } j \qquad (4)$$

The maximum weight $(W_1^*, W_2^*, ..., W_n^*)$ and ξ^* is determined by solving the linear programming model as shown in equation (4) and using the consistency index (CI.). A value closer to 0 is required for consistency (Rezaei et al., 2016).

6.4 RESULTS AND DISCUSSION

Green manufacturing is essential for practitioners and researchers in the present scenario. Generally, the manufacturers are stimulated by the optimization of local factors. However, these days due to global pressure, industries have started to adopt green manufacturing practices, but it is in the initial stage, and still, some obstacles need to be eradicated. The barriers identified in this research are categorized according to their impacts on the manufacturing processes. To decide the most and least impacted obstacle, conclude the most impacted obstacle over all others and rank them over the least impacted barrier on a scale of 1 to 9. Consequently, the most impacted barriers to others' rating and others to the least impacted rating of the obstacles are given in Table 6.4.

Table 6.4 Pairwise comparison of main obstacles

Best to Others (BO)	Financial obstacles (F)	Managerial obstacles (M)	Operational obstacles (O)	Technological obstacles (T)	Regulatory obstacles (R)	Environmental obstacles (E)
Best criteria: F	1	5	9	2	3	4

Others to the Worst (OW)	Worst criteria: O
F	9
M	3
O	1
T	8
R	7
E	5

Similarly, the pairwise comparison of sub-criteria on a scale of 1 to 9 obtained after identifying their best and worst criteria is shown in Table 6.5- 6.10.

Table 6.5: Pairwise comparison of financial sub-obstacles

BO	F1	F2	F3	F4	F5
Best criteria: F1	1	4	3	7	2

OW	Worst criteria: F4
F1	9
F2	6
F3	7
F4	1
F5	8

Table 6.6: Pairwise comparison of managerial sub-obstacles

BO	M1	M2	M3	M4
Best criteria: M2	4	1	8	2

OW	Worst criteria: M3
M1	5
M2	8
M3	1
M4	7

Table 6.7: Pairwise comparison of operational sub-obstacles

BO	O1	O2	O3	O4
Best criteria: O2	2	1	9	4

OW	Worst criteria: O3
O1	7
O2	8
O3	1
O4	5

Table 6.8: Pairwise comparison of technological sub-obstacles

BO	T1	T2	T3	T4
Best criteria: T2	2	1	7	3

OW	Worst criteria: T3
T1	7
T2	8
T3	1
T4	5

Table 6.9: Pairwise comparison of regulatory sub-obstacles

BO	R1	R2	R3	R4
Best criteria: R3	2	9	1	3

OW	Worst criteria: R2
R1	6
R2	1
R3	8
R4	7

Table 6.10: Pairwise comparison of environmental sub-obstacles

BO	E1	E2	E3	E4
Best criteria: E4	2	3	7	1

OW	Worst criteria: E3
E1	6
E2	5
E3	1
E4	7

After calculating the weight of each main obstacle and sub-obstacles of green manufacturing practice, the rank of each sub-obstacles has been calculated based on their global ranking to find out the most impacted obstacles. The ranks of each sub-hurdles are shown in Table 6.11.

Table 6.11: Weight of main and sub-obstacles and their rankings

Main obstacle	Weights	Sub-obstacles	Weight of sub-obstacles	Global weights	Rankings
Financial obstacles (F)	0.3786	F1	0.4004	0.1516	1
		F2	0.1289	0.0488	8
		F3	0.1719	0.0651	5
		F4	0.0407	0.0154	16
		F5	0.2579	0.0976	3
Managerial obstacles (M)	0.0916	M1	0.15	0.0137	17
		M2	0.5	0.0458	7
		M3	0.05	0.0046	23
		M4	0.3	0.0275	13
Operational obstacles O)	0.0332	O1	0.3	0.01	19
		O2	0.5	0.0166	15
		O3	0.05	0.0017	24
		O4	0.15	0.005	22
Technological obstacles (T)	0.2291	T1	0.284	0.0651	5
		T2	0.4729	0.1083	2
		T3	0.0540	0.0124	18
		T4	0.1891	0.0433	10
Regulatory obstacles (R)	0.1547	R1	0.292	0.0452	9
		R2	0.0442	0.0068	20
		R3	0.4690	0.0726	4
		R4	0.1946	0.0301	12
Environmental obstacles (E)	0.1145	E1	0.282	0.0323	11
		E2	0.1878	0.0215	14
		E3	0.0552	0.0063	21
		E4	0.4751	0.0544	6

The result shows that finance is the primary constraint in green manufacturing practices, followed by technological limitations and regulatory and environmental obstacles. Low awareness about environmental impacts on business has the highest weightage, followed by poor availability of advanced technology, insufficient government support, technological procurement cost, absence of preferential tax policies, and insufficient incentives for green technology. To minute studies, the main obstacles to green manufacturing are further divided into sub-obstacles with the help of literature review and

the industry employee. These sub-obstacles are ranked based on global weight calculated through BWM. From the global weight, it has been observed that the technological procurement cost is the most influencing factor in implementing green manufacturing. Poor availability of advanced technology, ineffective tax policies, and insufficient government support are the other factors that create obstacles to implementing green manufacturing.

Majumdar (2019) found that financial obstacles are critical to implementing green manufacturing, which was further agreed upon by Singh et al. (2021). In the current study, it has been observed that insufficient government support and poor availability of technology are essential criteria that must be addressed first. Low awareness about environmental impacts on business has the highest weightage, followed by poor availability of advanced technology, insufficient government support, technological procurement cost, absence of preferential tax policies, and lack of incentives for green technology, which was agreed by Kaur et al., (2018) and Gupta and Barua (2018). According to Mathiyazhagan et al. (2013), lack of environmental awareness and top management commitment is essential obstacles in implementing green manufacturing. The global ranking is also shown graphically in Figure 6.3.

The study's outcome helps the business organizations concentrate their efforts to mitigate the obstacles of green manufacturing practices to obtain all the dimensions of environmental sustainability. The study also supports the management in making an operative action plan for sustainable manufacturing when the obstacles to green manufacturing are identified and prioritized.

The researchers/academicians may also be motivated to explore other green manufacturing practices' obstacles to obtaining sustainable dimensions. The ranking of the various obstacles helps the researchers/academicians to suggest strategies for the sustainable development of business organizations in the competitive environment.

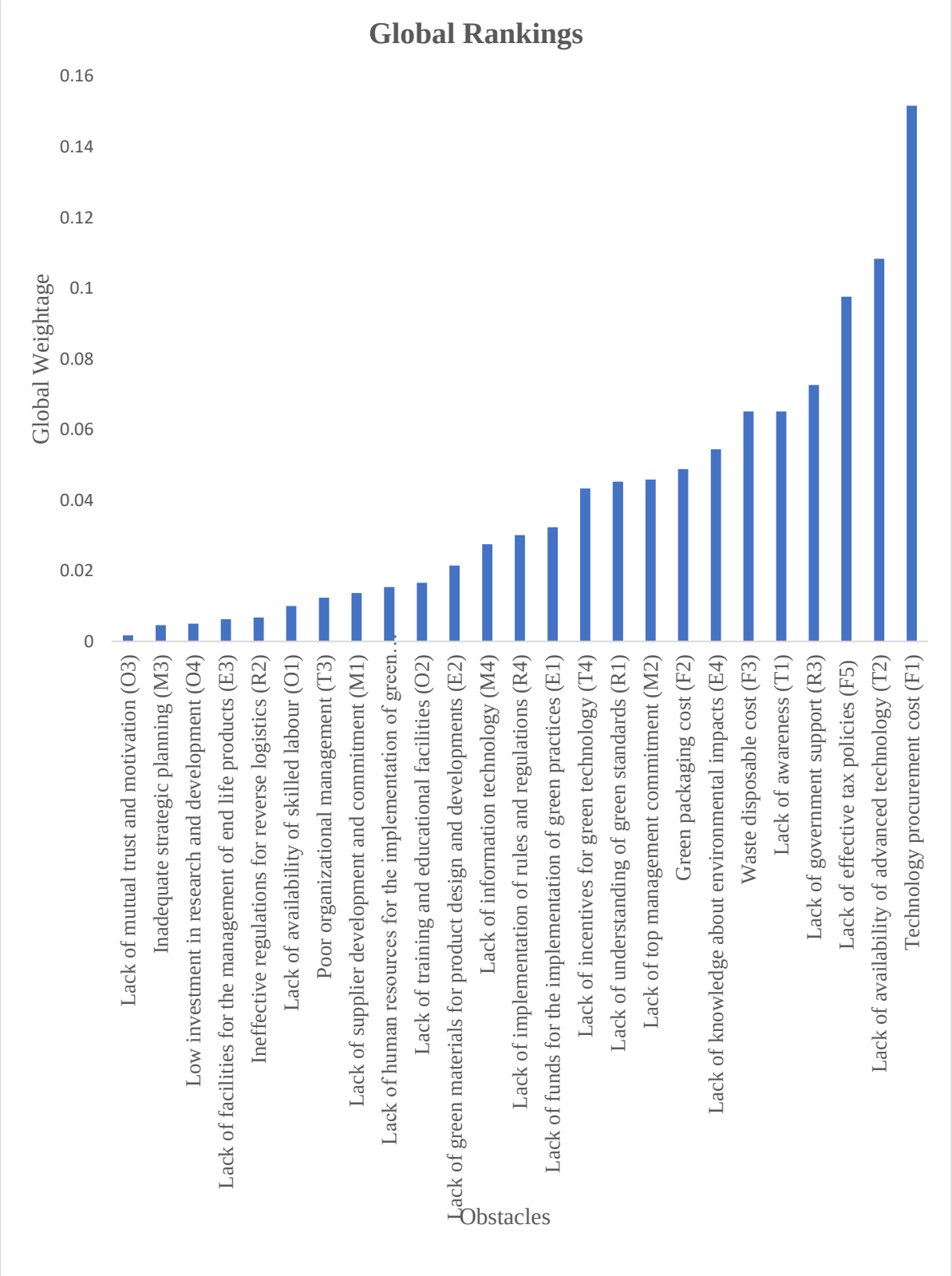

Figure 6.3: Global ranking chart

The role of government is essential in framing a policy for creating a sustainable environment. The study's findings may help developing countries like India formulate an

effective policy to promote sustainable manufacturing. The government may also provide incentives and tax rebates to adopt various technologies for manufacturing operations to create a sustainable environment and compete with the global market.

6.5 CONCLUSION

In this chapter, various obstacles experienced in implementing green manufacturing practices in Indian SMEs have been identified. The obstacles were categorized by the factor analysis method and then ranked using the best-worst method. Finally, twenty-five obstacles have been identified, classified as financial obstacles, managerial obstacles, operational obstacles, technological obstacles, regulatory obstacles, and environmental obstacles. The study confirms that SMEs can enhance green manufacturing practices by providing financial assistance and technical awareness. The stricter government regulations also create a fear of increasing costs and losing market share as it increases production costs. The SMEs should also be provided with land at a favourable location where many skilled workers may be available at lower wages and easily reach market facilities.

CHAPTER 7

FRAMEWORK FOR DEVELOPING GREEN INDEX

7.1 INTRODUCTION

Most of the attention towards green manufacturing/environmental concerns is focused on the large organizations/ original equipment manufacturers (OEMs). Many small and medium enterprises (SMEs) are engaged in auto components manufacturing in India. They are supplying the auto components to the local and multinational automobile manufacturers. SMEs represent more than 90% of the manufacturing organizations in number and play a critical role in this endeavour. SMEs play a crucial role in a country's economic growth. SMEs create more job opportunities for the workers and serve as suppliers of goods and services to large organizations. Many SMEs are working in an unorganized sector and employ rural workers. Green practices in SMEs must be integrated with all the processes to improve the environmental conditions and save scarce natural resources. Despite the availability of many research works on the role of large firms in ecological degradation, the role of SMEs remains relatively underexposed and unexplored (Perrini, 2006; Spence and Rutherford, 2003; Worthington and Patton, 2005).

The extensive manufacturing firms have a strategic relationship with multiple vendors as SMEs, and most components/parts, except those of strategic importance, are sourced from them. SMEs cannot justify the negligence of implementing green manufacturing practices as SMEs produce approximately two-thirds of the total pollution (Aragón -Correa et al., 2008). Considering the adverse impact on the environment due to nonstandard practices in SMEs, it is necessary to develop an understanding which may lead

the individual SME to adopt green practices. Generally, the policies are decided based on the insights from prominent firms, and it is assumed that SMEs may follow the customized/minor version of the corporate firms. It may be a misunderstanding by the policymakers (Aragón -Correa et al., 2008; Perrrini et al., 2007).

Nowadays, the manufacturing industry is under pressure to implement stringent environmental regulations. Conservation of natural resources and environmental protection is considered a significant issue in manufacturing. Increasing the consumer's environmental awareness is the main driving force that forces manufacturers to adopt green manufacturing practices. Green manufacturing practices use technology and processes that do not harm the environment, customers, stakeholders, or employees (Rehman et al., 2017). The drivers and barriers to implementing green manufacturing practices in SMEs differ from large enterprises. SMEs suffer from a lack of data, resources, technical expertise, lack of experience, etc., in implementing green initiatives (Ghazilla et al., 2015). Large enterprises are more influential and financially capable; therefore, they have more pressure to follow the rules and regulations related to environmental management than SMEs. Due to the reluctant attitude, many small firms are not ready to accept that their environmental impacts are significant. Most studies on SME environmental management are concerned with the companies' experience of greening the production facilities (Hillary, 2004). The role of SMEs in producing green products and services is to be explored. SMEs in developing countries like India struggle to adopt green manufacturing practices due to lacking internal abilities and strategies. The lack of research and development, absence of green design, and lack of certification is the most critical barrier for SMEs to adopt green manufacturing practices (Karuppiah et al., 2020).

Lean manufacturing practices combine tools to eliminate the activities that do not add value to the product. According to Singh et al. (2020), several Indian manufacturing

industries adopted lean practices to enhance their competitive capacity and business performance (Sharma et al., 2015). Increasing green innovation adoption increases the profit of business organizations by decreasing environmental deterioration. However, the crucial barriers are lack of enforcement of recycling policy, proper regulations, absence of government and ecological institutes association, and fear of failure to adopt green innovation (Ullah et al., 2021). Circular economy and cleaner production have attracted many researchers and practitioners for their valuable contributions to these research areas. A circular economy helps tackle the issues of environmental degradation and shortages of natural resources in an industrial context (Geng et al., 2009). Circular supply chain management may also help improve pollution problems, an unachievable pattern of production and consumption, climate change, etc., by reducing waste and environmental impacts (Mangla et al., 2018). A circular economy also helps in improving working conditions by reducing waste and energy use, increasing resource efficiency (Gupta et al., 2019), improving the supply chain (Jabbour et al., 2020), and developing green design by recycling, remanufacturing, repairing, and acting as an essential tool for sustainable development (Kazancoglu et al., 2021). According to Kazancoglu et al. (2021), many studies highlighted that government actions play an essential role in implementing and promoting a circular economy with required technological support (Govindan and Hasangic, 2018; Galvão et al., 2018; Jia et al., 2018; Manninen et al., 2018) and creating regulations, standards and green level (Prieto-Sandoval et al., 2018).

7.2 MAJOR FACTORS OF GREEN PRACTICES

In general, the management of SMEs is reluctant to follow the green practices due to capacity and resource obstacles, a small level of manufacturing activities, and the involvement of the relatively small workforce. They are also reluctant to implement the

Govt. legislation and environmental regulations. But due to the external pressure and competitive advantages of green practices, SMEs are forced to implement an environmental management system (EMS). Some factors, such as customers' awareness of green products, effective implementation of the Govt. legislation, top management commitment, and some more factors are discussed in detail in the following subsections and summarized in Figure 7.1. play a crucial role in green manufacturing.

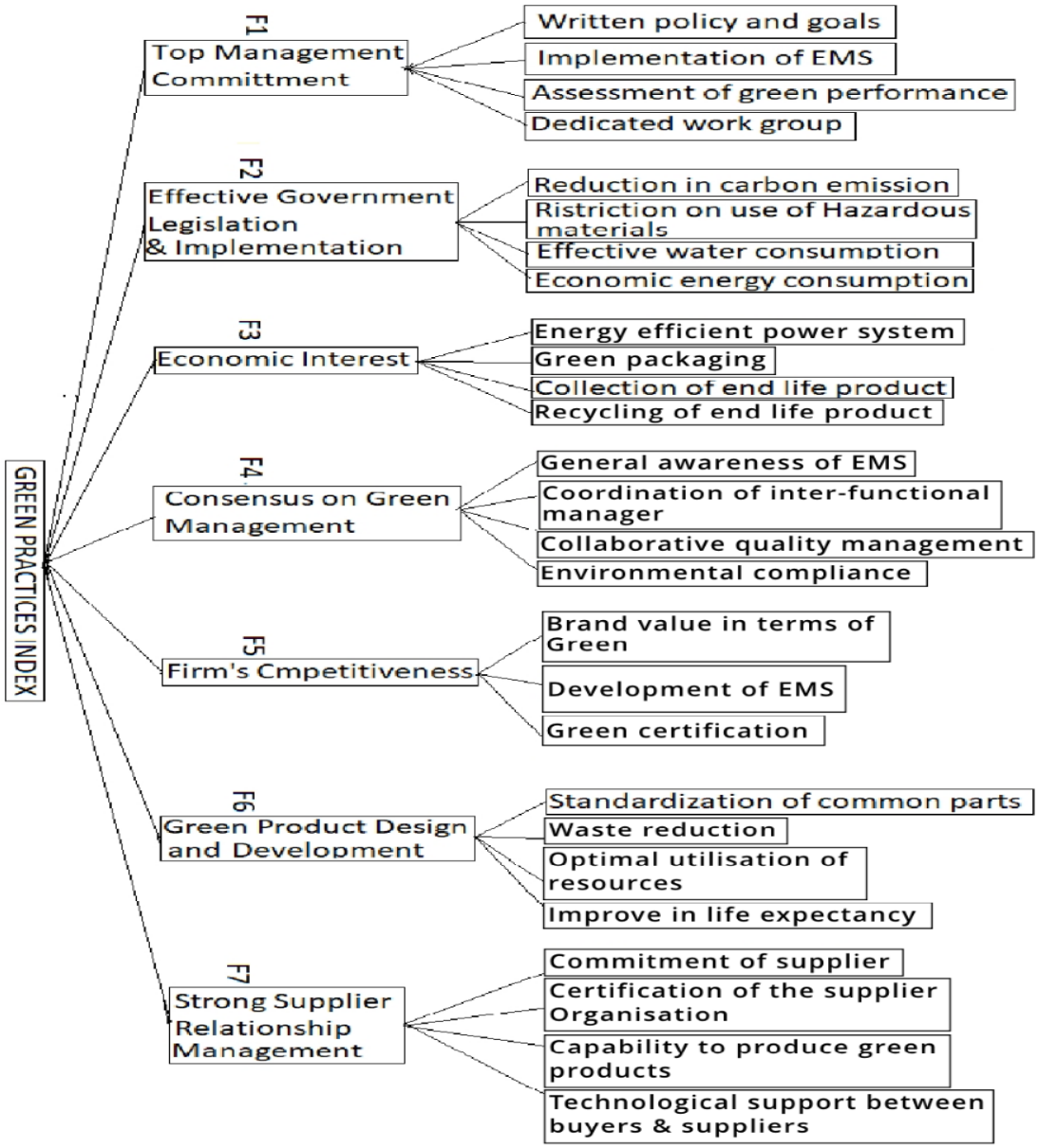

Figure 7.1: Variables of green practices in SMEs

Top management commitment: It refers to management's willingness to dedicate to green philosophy and collaborate with departments to adopt green practices (Olugu and Wong, 2011; Zailani et al., 2015). Lack of top management commitment is continuously listed as one of the significant barriers to implementing green practices. Dubey et al. (2017) felt that the belief of the top management plays a vital role in achieving green manufacturing practices through reconfigurable manufacturing systems. They can influence the policy, planning, and support for the green initiatives across the organization. Top management is the backbone of the planning and provides continuous support for green supply chain management in the strategic plans and action plans (Ravi and Shankar, 2005). According to Karuppiah et al. (2020), low-level commitment from top management is an inhibitor to implementing green management practices. The entrepreneurs of SMEs are often hesitant to take the risk of implementing green innovation practices and tend to work in the traditional way (Gupta and Barua, 2018). Singh et al. (2020) concluded that a competent leader with solid willpower and continuous motivation for the employee is needed to adopt green lean manufacturing practices. Green and lean practices can only be implemented in manufacturing industries if top management actively participates with sound commitment (Yusliza et al., 2019; Yadav et al., 2019). The top management continuously monitors all the factors to be accepted or discarded for proper implementation of green lean practices (Li et al., 2019). Jamwal et al. (2021) stated that the negligence shown by top-level management to alter the existing environment without communicating accurate information demotivates the middle-level management.

Effective government legislation and implementation: The government regulation implementation may encourage or discourage the organization's innovation by imposing specific terms and conditions on the industry (Scupola, 2003). For example, time-

consuming regulatory requirements, fees or levies, and taxes may discourage smaller firms. Environmental legislation and regulations are concerned with the sets of laws for protecting the natural environment and the health of the employee and communities, which must be implemented forcibly (Zakuan et al., 2012). Karuppiah et al. (2020) stated that the absence of proper guidelines prevents implementing green manufacturing practices. The rigorous and unclear procedure of government regulations and policies often impedes the implementation of green innovation practices and demotivates the organizations (Runhaar et al., 2008). The poor enforcement of environmental policies also prevents SMEs from adopting green practices (Gupta and Barua, 2018). According to Singh et al. (2020), legislation and regulation are required for the smooth functioning of any firm. Business organizations must operate as per the prevailing laws and regulations.

Economic interest: Kroll et al. (1999) observed that industries prefer low-cost strategies over quality or time-based strategies. Time-focussed processes, infrastructure, and inherent quality development are required for reprocessing and recycling the product materials and packaging materials. The radical technology change may require a drastic change in production processes, resulting in old investments. According to Ravi and Shankar (2005), lack of funding for environmental projects and high prices of green products have proven to be the leading financial barriers. Historically, the cost has been treated as one of the significant performance measures. AlKhidir and Zailani (2009) observed that a high investment is required initially for the technology concerned with green design, green manufacturing, and green packaging. For engaging environmental management, direct and indirect costs are a significant barrier. Therefore, the management must have an economic consideration and vision for the investment in green manufacturing. Manufacturing firms often face financial problems due to a lack of financial resources, and the high cost of innovation projects acts as a financial deterrent (Pinget et al., 2015). These economic

barriers prevent SMEs from implementing green innovation practices (Ghisetti et al., 2017). The general financial barriers which reduce SMEs' interest in the implementation of green innovation are less return compared to the investment, high disposing cost of hazardous waste (Govindan et al., 2014), less accessible government subsidies, incentives, and bank loans (Cecere et al., 2016; Hojnik and Ruzzier, 2016), high cost of change over from traditional manufacturing system to a green (Mudgal et al., 2010), lesser demand and non-availability of a proper market for SMEs to sell their green products (Gupta and Barua, 2018). Green lean practices require an initial investment for their implementation, and a lack of financial resources restrict the organizations from implementing new policies as they prioritize profit-making (Singh et al., 2020; Sindhwani et al., 2019; Caldera et al., 2019). Due to improved products and processes, increasing costs are the main issue for many Indian industries. Disproportionate distribution of funds and lower return on investment on sustainable projects makes it challenging for many SMEs to implement green projects (Jamwal et al., 2021).

Consensus on green management: Chen et al. (2006) stated that the demand from end-users is a driving force for implementing proactive environmental behaviours. Hence, the lack of awareness about the benefits of green products proves to be a significant barrier. According to Luthra et al. (2011), the customer awareness/demand for the green product may motivate and force the manufacturers toward innovative initiatives for green products. Ravi and Shankar (2005) stated that restriction in information flow across organizational hierarchy makes green management implementation unfeasible. Digalwar and Metri (2004) said that innovation and technology enhance corporate culture in which employees appreciate new ideas and solutions. It may reduce the resistance to change from the worker's side. The resistance to change may influence the adaptation of new technology. Thus, there should be a consensus among all the stakeholders for green manufacturing.

Green innovation requires skilled and knowledgeable employees with the correct information for green practices (Pinget et al., 2015). Lack of knowledge and information about the green practice and legislation, lack of ability to identify environmental opportunities and benefits of green products, and lack of technical details are SMEs' main barriers to consensus on the implementation of green practices (Gupta and Barua, 2018). Singh et al. (2020) observed that employees of organizations are reluctant to accept any change in their daily routine due to fear of unpredictable output (Sindhwani et al., 2019).

Firm's competitiveness: The SMEs are not interested in new initiatives due to a lack of expertise. The management of SMEs is facing a shortage of technical support and a lack of information on new technologies, processes, products, and materials. Therefore, lacking technical expertise created a significant barrier to green practices. One of the critical bottlenecks for ensuring an adequate workforce is the lack of proper training facilities. It can be both in quantity and technical knowledge. Training for skill and attitude is essential (Hillary, 2004). It helps in implementing green practices better. Employee empowerment and participation are required to fulfil the target of green manufacturing. Total Quality Management plays a significant role in continuous improvement, customer focus, employee empowerment, and innovation. Singh et al. (2020) stated that components of the supply chain and successful implementation of green and lean practices improve the competitiveness of the firms (Kumar et al., 2016).

Green product design and development: Zhou et al. (2008) suggested an evaluation system, procedure, and method to evaluate green product design. They have used a total of six factors covering thirty-seven indicators. These six factors are technology, resources, energy, environment, economies, and society. The product, process, and technology are also identified as three dimensions of green manufacturing (Sarkis and Rasheed, 1995).

Many authors recognized green product development as one of the main themes in sustainable supply chain management (Seuring and Müller, 2008; Kleindorfer et al., 2005; Ashby et al., 2012). Firms use tools such as life cycle analysis, design for the environment, and design for disassembling to reduce the negative impact of products on the environment (Faruk et al., 2001; Albino et al., 2009; Kara et al., 2014; Sarkis, 2001). Sustainable product design is one of the areas of research interest as it is closely related to the closed-loop supply chain (Kleindorfer et al., 2005; Guide and Wassenhove, 2009). From their material extraction stage to manufacturing, transportation, use, and disposal, the products impact all three aspects of sustainability (Tarne et al., 2017). Kulatunga et al. (2015) found that about 80% of sustainability impacts are due to the product's design. Hence, to address the issue of sustainability in the manufacturing sector, making strategies at the design and production level is more critical to attaining sustainability and cleaner production objectives (Ameli et al., 2016, Ahmad et al., 2018). According to Zhang and Li (2019), manufacturing organizations should apply green design principles to the product to explore the concepts of industrial ecology to meet customer needs within the context of market-oriented sustainability (Mean-Shen, 2011; Lemke and Luzio, 2014). But the idea of eco-design has not been adequately implemented in new product development due to the gap between eco-oriented and product-oriented design perspectives (Ng, 2018). Li et al. (2020) observed that many manufacturing organizations endeavour toward a circular economy by investing fair amounts of money in designing, manufacturing, and promoting green products to meet regulatory requirements and customer expectations. Due to the producer's green product design and initiatives, the wholesale price of the products increases, causing squeezed profit margin of the retailers, and thus retailers act adversely towards the manufacturers (Li et al., 2018). Therefore, to achieve sustainable supply chain performance, a manufacturer shall

consider the profit concerns of the retailers also while adding environmental features to the product.

Strong supplier relationship: Vendor-managed inventory and strong collaboration with the suppliers results in low inventory cost and higher accuracy (Sarkar and Mohapatra, 2006). A good supplier relationship also leads to a competitive advantage for the manufacturers. Hamner (2006) pointed out the importance of the supplier's contribution to the production of green products and said that without the supplier's support, it is tough to achieve the goal of environmental management. The sharing of knowledge, information, people's competencies, and skills is the primary purpose of collaboration, which helps in the efficient running of the supply chain. Supplier relationship management has become part of strategic procurement (Tangpong et al., 2008). The buying firms only focus on their core competencies, and all the other goods and services are sourced from the suppliers (Krause, 1997; Krause et al., 2000; Narasimhan and Das, 2001). It is not advisable to search the green suppliers and buy green products based on an arm's length relationship with suppliers. It is more important to make an environmental collaboration and supplier development, which enhances the supplier capabilities and the ability to meet the increasing challenges (Watts and Hahn, 1993; de Burgos and Lorente, 2001). Singh et al. (2020) stated that suppliers serve as an essential element to survive and grow in a competitive environment but do not actively participate in implementing lean and green (Yadav et al., 2019).

The hesitancy of suppliers to adopt green and lean initiatives is due to their traditional thinking (Srivastav and Gaur, 2015). The importance of supplier relationship management becomes critical due to the increasing outsourcing of production and administrative processes and plays a significant role in achieving sustainability. Sustainability is concerned with balancing the triple bottom line dimensions into supply

chain management, supplier selection, supplier development, and monitoring and evaluation (Adesanya et al., 2020). Green supplier development has appeared as a significant green supply chain management activity because the supplier's environmental performance is the most critical contributor to the ecological issue of manufacturing industries. Green supplier development creates “win-win” strategies for manufacturing organizations (Bai et al., 2016; Mudgal et al., 2013). Incorporating green supplier development within the traditional supplier is challenging for firms due to the absence of the greening measure, insufficient funds, and low green supplier participation. To successfully implement the green supplier development, the firms should support the government regulations and a good amount of commitment from the top management. The essential factors and sub-factors with reference are summarized in Table 7.1.

Table 7.1: Important factors identified for green manufacturing

Factors	Remarks/Concerned Sub factors	References
Top management commitment (F1)	• Written policy and goals of the organization • Implementation of Environment management systems • Regular assessment of the green performance • Dedicated workgroup for the environmental initiatives	Ravi and Shankar (2005); Mittal et al. (2013); Luthra et al. (2014); Ghazilla et al. (2015), Karuppiah et al. (2020), Baah et al. (2021), Bhatia and Kumar (2022)
Government legislation (F2)	• Reduction in carbon emission • Restriction on the use of hazardous materials • Effective water consumption • Reduced energy consumption and use of an alternative source of energy	Luthra et al. (2010, 2011); Qadri et al. (2011); Balasubramanian (2012), Li et al. (2020), Baah et al. (2021), Kuo et al. (2022)
Economic interest (F3)	• Energy-efficient power systems • Green packaging • Collection of end-life products from the consumer • Recycling of end-life products	Mudgal et al. (2009); Luthra et al. (2011), Prakash et al. (2019); Xiao et al. (2019)
Consensus on Green Management (F4)	• General awareness of environmental management program • Coordination of inter-functional managers • Collaborative quality management program	Mudgal et al. (2009); Reijonen (2011); Luthra et al. (2011), Baah et al. (2020)

	• Environmental compliance and auditing systems	
Firm's Competitiveness (F5)	• Brand value in terms of green • Development of Environmental management system • Green certification	Mudgal et al. (2009); Dheeraj and Vishal (2012); Lee et al. (2015), Afum et al. (2020), Baah et al. (2020)
Green Product Design and Development (F6)	• Standardization of common parts • Waste reduction • Optimal utilization of resources • Improvement in life expectancy	Jugend et al. (2017); Kamble et al. (2020); Stukalo & Simakhova (2019); Pandey et al. (2020)
Supplier relationship management (F7)	Commitment of supplier Certification of the supplier organization Capability to produce green products Technological support between buyers and suppliers	Ravi and Shankar (2005); Hasan et al. (2007); Luthra et al. (2014); Andiç et al. (2012), Li et al. (2020)

7.3 GRAPH THEORY AND MATRIX APPROACH

Graph theory is a logical and systematic approach. Graph theory is used to study graphs; mathematical structures model the pairwise relationship between objects. The first and foremost step in the graph theory and matrix approach is identifying the attributes or criteria and the alternatives involved in the decision-making problem. It helps analyze and understand the system by identifying it at the component level. It gives the best option from many alternatives available for a problem. The graph represents any physical situation to show the relationship between different objects (Geetha and Sekar, 2016). Graph theory has been used to solve various types of problems. Some of the significant usage addressed in the past literature is job scheduling (Xu and Li, 2007), selecting television channels for advertisement (Saha et al., 2007), comparing the machinability of work materials (Rao and Gandhi, 2002), tool life and its failure analysis (Rao and Gandhi, 2002), and quality measurement (Kulkarni, 2005). Many techniques for multi-attribute decision making (MADM) have been used in past research, such as Analytic Hierarchy Process (AHP), Graph-Theoretic Matrix Approach (GTMA), Weighted Sum Method (WSM), Technique

of Order Preference by Similarity to Ideal Solution (TOPSIS), Weighted Product Method (WPM), and Simple Attribute Weighting Method (SAW).

Most of these techniques are generally based on comparing one attribute with the other in one direction and finding the ranks of different decision-making units (DMUs). But in the Graph Theory matrix approach, the pairwise comparison of the attributes is mapped in both directions, as shown in Figure 7.2. For example, if we consider a 0 – 10 scale for mapping of factors' i' and 'j', the relative importance of 'i' over 'j' using f_{ij} =3, then the relative importance of 'j' over 'i' may be shown as f_{ji} =7; i.e. f_{ij} = 10-f_{ji}. It is the uniqueness of the method. An index is prepared using the digraph mapping of the factors and sub-factors with the help of the permanent matrix.

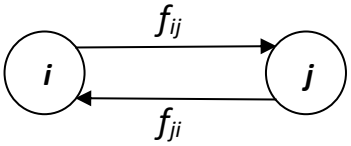

Figure 7.2: Digraph of the relative importance of factor' i' over 'j' and 'j' over 'i'

The current chapter attempts to produce an index based on which the different SMEs can compare their efforts to implement green practices using the Graph theory and matrix approach (GTMA).

7.3.1 METHODOLOGY: GRAPH THEORY AND MATRIX APPROACH

The graph-theoretic matrix approach helps fix the index benchmarking and meet the objective (Safari et al., 2013). Muduli et al. (2013) used this approach to produce an index to analyze barriers in green supply chain management in the Indian mining industry. Malhotra et al. (2012) also proposed this framework for creating an index for analyzing the obstacles in remanufacturing systems (RMS). This tool shows the interdependencies of one

factor over another. It is an effective tool for decision-making and has served as a modelling tool in network analysis, functional representation, conceptual modelling, diagnosis, etc. (Sabharwal and Garg, 2013). This method comprises the digraph technique, the matrix formulation, and the permanent function representation. The relationship between different variables is represented by a directional graph based on which a matrix is formed. Numerical values assign interdependencies among variables and their contribution to the system on some fixed scale, and an overall index is calculated. This index may be used for self-analysis or comparison between other similar systems. The digraph is drawn conceptually to visualize the interdependencies between two specific variables. The complete digraph produces a mathematical matrix form, and the permanent matrix represents the numerical index (Malhotra et al., 2012).

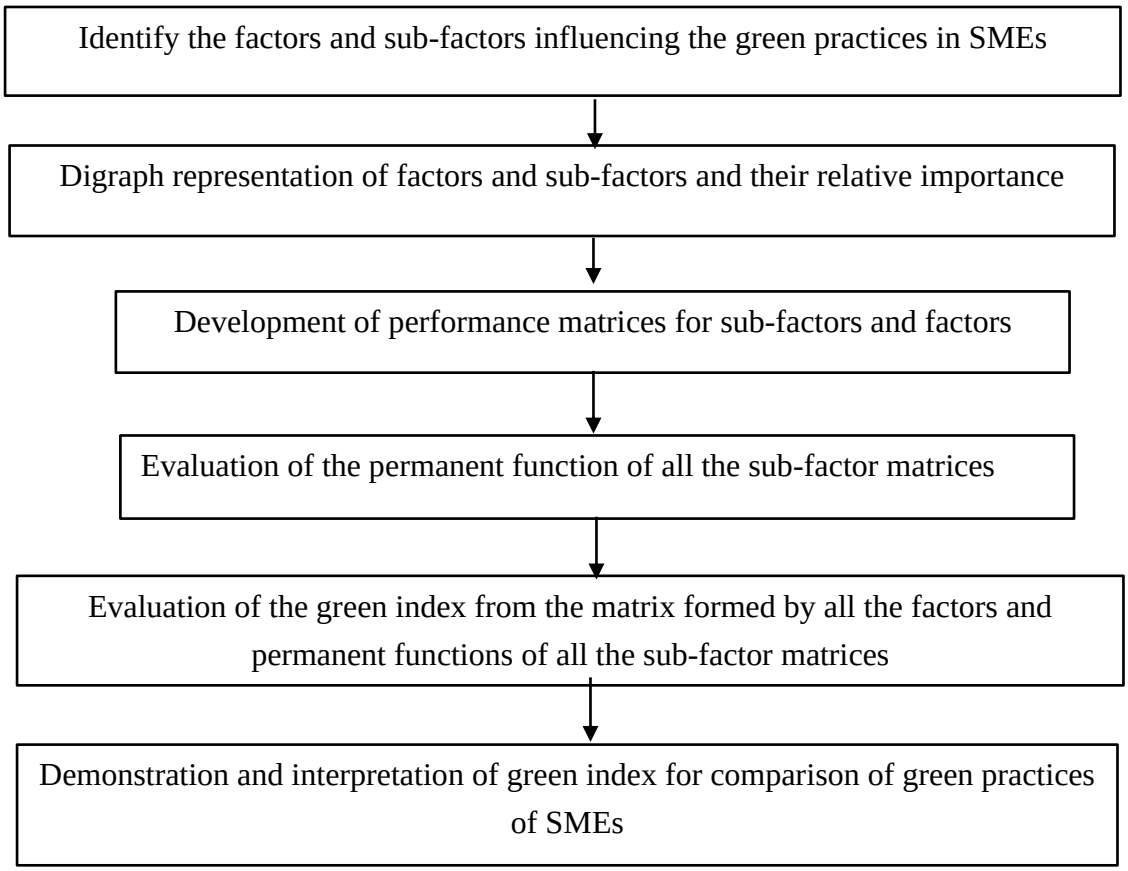

Figure 7.3: Flowchart for the graph theory and matrix model.

It is a systematic and logical approach to analyzing directed graphs to derive the index for the systems (Rao, 2007). In this study, the graph theory matrix model comprises factors influencing green practices and their sub-factors. It establishes the graphical relationships among them using the digraph technique, preparing matrices, and determining the permanent function matrices. Figure 7.3 is a self-explanatory flowchart for the graph theory and matrix model.

7.3.2 PERFORMANCE DIGRAPH

The digraph represents the interrelationships among the factors in terms of nodes and edges. Performance digraph consists of a set of nodes N={n_i}, I = 1,2, 3……n and a set of edges E={f_{ij}}. A node n_i shows the i^{th} factor, and edge f_{ij} shows the measure of interdependencies between the factors *i* and *j*. The total number of nodes, N, equals the number of performance factors. The importance of node '*i*' over node '*j*' is indicated by an edge f_{ij}, drawn from node '*i*' to node '*j*'.

Similarly, the importance of node *j* over node *i* is indicated by an edge f_{ji} drawn from node *j* to node *i*. For example, if three performance factors are considered, as shown in Figure 7.4. There are three nodes in the digraph. If factor 1 is more critical than nodes 2 and 3, directed edges may be drawn from node 1 to nodes 2 and 3. But, factor 2 may also be important then directed edges will be drawn from node 2 to both nodes 1 and 3.

Similarly, factor 3 may also be important then directed edges will be drawn from node 3 to nodes 1 and 2. The magnitude of the importance may be different from one factor to another, which may be used in the performance matrix. As the number of nodes and the edges representing the interrelationship increases, the graph becomes more complicated,

and drawing the digraph becomes difficult; therefore, a performance matrix is used to interpret the relationships (Rao, 2007).

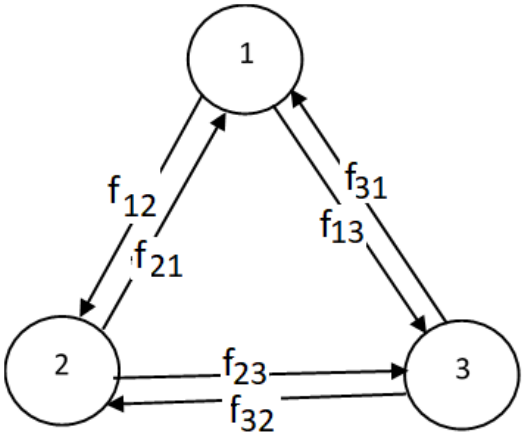

Figure 7.4: Performance factors digraph

7.3.3 MATRIX REPRESENTATION OF DIGRAPHS

A performance matrix consisting of all the factors (F_i) and the relative importance (f_{ij}) is the simplest way to represent the performance digraph. It is an $n \times n$ matrix, as shown in Equation (1). It is analogous to the Adjacency matrix in graph theory.

$$PM = F = \begin{bmatrix} F_i & f_{ij} & f_{ik} \\ f_{ji} & F_j & f_{jk} \\ f_{ki} & f_{kj} & F_k \end{bmatrix} = \begin{bmatrix} F_1 & f_{12} & f_{13} \\ f_{21} & F_2 & f_{23} \\ f_{31} & f_{32} & F_3 \end{bmatrix} \quad (1)$$

F_i is the value of the i^{th} factor shown by node n_i, and f_{ij} is the relative importance of the i^{th} factor over the j^{th} factor represented. According to Brualdi and Shader (1990), "the Permanent of a matrix is used to characterize configurations of a system or the structure of a graph and develop a unique representation independent of labelling". This matrix leads to a better appreciation without loss of information in evaluation (Rao and Gandhi, 2002; Jurkat and Ryser, 1966). The permanent matrix F can be calculated using Equation 2.

$$
\begin{aligned}
permF = \prod_{i=1}^{6} F_i &+ \sum_{i=1}^{5}\sum_{j=i+1}^{6}\sum_{k=1}^{3}\sum_{l=k+1}^{4}\sum_{m=l+1}^{5}\sum_{n=m+1}^{6}\left(f_{ij}\,f_{ji}\right)F_k F_l F_m F_n \\
&+\sum_{i=1}^{4}\sum_{j=i+1}^{5}\sum_{k=j+1}^{6}\sum_{l=1}^{4}\sum_{m=l+1}^{5}\sum_{n=m+1}^{6}\left(f_{ij}\,f_{jk}\,f_{ki}+f_{ik}\,f_{kj}\,f_{ji}\right)F_l F_m F_n \\
&+\left[\begin{array}{l}
\displaystyle\sum_{i=1}^{3}\sum_{j=i+1}^{6}\sum_{k=j+1}^{5}\sum_{l=i+2}^{6}\sum_{m=1}^{5}\sum_{n=m+1}^{6}\left(f_{ij}\,f_{jk}\right)\left(f_{kl}\,f_{lk}\right)_l F_m F_n \\
+\displaystyle\sum_{i=1}^{3}\sum_{j=i+1}^{5}\sum_{k=i+1}^{6}\sum_{l=j+1}^{6}\sum_{m=1}^{5}\sum_{n=m+1}^{6}\left(f_{ij}\,f_{jk}\,f_{kl}\,f_{li}+f_{il}\,f_{lk}\,f_{kj}\,f_{ji}\right)_l F_m F_n
\end{array}\right] \\
&+\left[\begin{array}{l}
\displaystyle\sum_{i=1}^{4}\sum_{j=i+1}^{5}\sum_{k=j+1}^{6}\sum_{l=1}^{5}\sum_{m=l+1}^{6}\sum_{n=1}^{6}\left(f_{ij}\,f_{jk}\,f_{ki}+f_{ik}\,f_{kj}\,f_{ji}\right)\left(f_{lm}\,f_{ml}\right)_l F_m \\
+\displaystyle\sum_{i=1}^{2}\sum_{j=i+1}^{5}\sum_{k=i+1}^{6}\sum_{l=i+1}^{6}\sum_{m=j+1}^{6}\sum_{n=1}^{6}\left(f_{ij}\,f_{jk}\,f_{kl}\,f_{lm}\,f_{mi}+f_{im}\,f_{ml}\,f_{lk}\,f_{kj}\,f_{ji}\right)F_n
\end{array}\right] \\
&+\left[\begin{array}{l}
\displaystyle\sum_{i=1}^{3}\sum_{j=i+1}^{5}\sum_{k=i+1}^{6}\sum_{l=i+1}^{6}\sum_{m=1}^{6}\sum_{n=m+1}^{6}\left(f_{ij}\,f_{jk}\,f_{kl}\,f_{li}+f_{il}\,f_{lk}\,f_{kj}\,f_{ji}\right)\left(f_{mn}\,f_{nm}\right) \\
+\displaystyle\sum_{i=1}^{1}\sum_{j=i+1}^{5}\sum_{k=j+1}^{6}\sum_{l=1}^{4}\sum_{m=l+1}^{5}\sum_{n=m+1}^{6}\left(f_{ij}\,f_{jk}\,f_{ki}+f_{ik}\,f_{kj}\,f_{ji}\right)\left(f_{lm}\,f_{mn}\,f_{nl}+f_{\ln}\,f_{nm}\,f_{ml}\right) \\
+\displaystyle\sum_{i=1}^{1}\sum_{j=i+1}^{6}\sum_{k=i+1}^{3}\sum_{l=i+2}^{6}\sum_{m=k+1}^{5}\sum_{n=k+2}^{6}\left(f_{ij}\,f_{ji}\right)\left(f_{kl}\,f_{lk}\right)\left(f_{mn}\,f_{nm}\right) \\
+\displaystyle\sum_{i=1}^{1}\sum_{j=i+1}^{5}\sum_{k=i+1}^{6}\sum_{l=i+1}^{6}\sum_{m=i+1}^{6}\sum_{n=j+1}^{6}\left(f_{ij}\,f_{jk}\,f_{kl}\,f_{lm}\,f_{mn}\,f_{ni}+f_{in}\,f_{nm}\,f_{ml}\,f_{lk}\,f_{kj}\,f_{ji}\right)
\end{array}\right]
\end{aligned}
\qquad \ldots(2)
$$

The calculation of the permanent matrix is derived from the Leibniz formula. This is very similar to the determinant of the matrix, but there is a basic difference between the determinant of a matrix and a permanent matrix. In the former case, the elements used in the matrix may be negative also, but in the case of the permanent matrix, all elements should be positive. The Equation for the determinant of a matrix and a permanent matrix is shown in equations (3) and (4). The detailed calculation of the permanent matrix of sizes 3×3 and 4×4 is explained in equations (5) and (6) for easy understanding.

$$
\det F = sign(\sigma)\sum_{\sigma\in F_n}\prod_{i=1}^{n} f_{i,\sigma(i)} \qquad (3)
$$

$$
permF = \sum_{\sigma\in F_n}\prod_{i=1}^{n} f_{i,\sigma(i)} \qquad (4)
$$

Let us consider a 3 × 3 matrix; the total number of terms will be equal to $\lfloor \underline{n}$ for n×n matrix.

Let us consider the 3×3 matrix:

$$A = \begin{vmatrix} a & b & c \\ d & e & f \\ g & h & i \end{vmatrix}$$

$$permA = aei + afh + idb + gec + gbf + chd \quad \textbf{(5)}$$

Similarly, for the 4×4 matrix:

$$A = \begin{vmatrix} a & b & c & d \\ e & f & g & h \\ i & j & k & l \\ m & n & o & p \end{vmatrix}$$

$$permA = a \times perm \begin{vmatrix} f & g & h \\ j & k & l \\ n & o & p \end{vmatrix} + e \times perm \begin{vmatrix} b & c & d \\ j & k & l \\ n & o & p \end{vmatrix} + i \times perm \begin{vmatrix} b & c & d \\ f & g & h \\ n & o & p \end{vmatrix} +$$

$$m \times perm \begin{vmatrix} b & c & d \\ f & g & h \\ j & k & l \end{vmatrix} \quad \textbf{(6)}$$

7.3.4 GREEN PERFORMANCE INDEX (GPI)

The permanent performance attributes matrix from Eq. (2) gives an Index. This study is named as green performance Index (GPI). To calculate the value of GPI, the values of R_i and f_{ij} are required. The value of R_i is a ranked value judgment on a scale of 0-10 (Rao, 2007). The value of relative importance of factor' I' over the factor *j* (f_{ij}) is also assigned on a scale of 0-10, as shown in Table 7.2 and Table 7.3

Table 7.2: Values of Performance factors

Qualitative measure of performance factors	**Assigned Value**
Exceptionally low	0
Extremely low	1
Very low	2
Below average	3
Average	4
Above average	5
Moderate	6
High	7
Very high	8
Extremely high	9
Exceptionally high	10

If f_{ij} represents the relative importance of the i^{th} factor over the j^{th} factor, then the relative importance of the j^{th} factor over the i^{th} factor will be $10 - f_{ij}$. The permanent functions are evaluated for each factor (as shown in Table 7.1), and finally, GPI is calculated using the permanent functions of all the factors incorporated in the final matrix.

Table 7.3: Relative importance of performance factors

Class description	**Relative importance of factors**	
	f_{ij}	$f_{ij} = 10 - f_{ji}$
Two factors are equally important	5	5
One factor is slightly more important over the other	6	4
One factor is strongly more important over the other	7	3
One factor is very strongly more important over the other	8	2
One factor is extremely important over the other	9	1
One factor is exceptionally more important over the other	10	0

7.4. CASE ILLUSTRATION

Delhi NCR is a hub of automobile manufacturers, and more than 30% of the total cars manufactured in India are produced in Delhi NCR. Two major car manufacturers are Suzuki Motor Limited (Maruti Udyog Limited) and Honda motors, located in Delhi NCR. A large number of SMEs are involved in the production of auto components. Also, air pollution is a significant issue in Delhi NCR. The industry is one of the significant contributors to air pollution through the transportation, vehicle, and burning of crop residues (Kumar et al., 2020). In this case study, SMEs related to auto component manufacturing have been considered for green performance measurement. The performance is measured using a dimensionless numerical value called the green performance index (GPI). GPI can be used to compare the performance of the case company with other auto component manufacturing companies. The observation is based on the executive's opinion regarding implementing green practices. The ratings of the factors and sub-factors have been taken on a 10-point rating scale with the help of the executives, as shown in Tables 7.2 and 7.3. The permanent matrix of the factor F_1 of four sub-factors can be represented as shown in Equation (7).

$$\mathrm{Per}\left(\mathrm{F}_1\right)=\begin{bmatrix} R_1 & f_{12}^1 & f_{13}^1 & f_{14}^1 \\ f_{21}^1 & R_2 & f_{23}^1 & f_{24}^1 \\ f_{31}^1 & f_{32}^1 & R_3 & f_{34}^1 \\ f_{41}^1 & f_{42}^1 & f_{43}^1 & R_4 \end{bmatrix} \tag{7}$$

In the above matrix, R1, R2, R3, and R4 are the four sub-factors of Factor F_1. The value of diagonal elements is measured on a 10-point rating scale, whereas f_{ij} shows the influence of the i^{th} factor on the j^{th} factor on the 10-point rating scale, e.g., suppose $f_{23} = 7$, then f_{32} will be 3. The behavioural digraph can be shown as given in Figure 6.5.

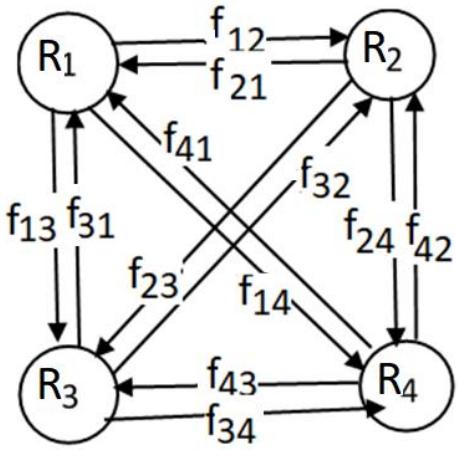

Figure 7.5: Behavioural digraph

7.5 DEVELOPMENT OF THE GREEN PERFORMANCE INDEX

Broadly, 7-factors are shortlisted from the literature review and considering the executives' opinions. These 7- factors have many sub-factors used to find the index for all the 7-factors; based on the indexing of these 7-factors (Equations. 8-14), the final Green Performance Index is calculated using a Permanent matrix (Equation 15). All these factors are already discussed in detail, and a table for the subfactors and factors with references is also produced in the literature review section.

The different factors with their sub-factors influencing green practices are discussed below:

F_1: Top management commitment

(a) Written policy and goals of the organization

(b) Implementation of Environment management systems

(c) Regular assessment of the green performance

(d) Dedicated workgroup for the environmental initiatives

Top management commitment is an essential factor that shows the intention and mission. The concern of top management regarding green manufacturing is following the

rules and regulation, documentation, and regular assessment to achieve the target of green manufacturing and helps to produce green products. The green practice starts at the top of the organization. The operational level management follows the direction and willingness of top-level management.

F_2: Effective govt. legislation and implementation

(a) Reduction in carbon emission

(b) Restriction on the use of hazardous materials

(c) Effective water consumption

(d) Reduced energy consumption and use of an alternative source of energy

Each country has legislation to maintain a clean environment and follow green manufacturing, but its effectiveness depends on the practical implementation. The primary legislation is related to the level of carbon emission in the various forms, use of hazardous materials, utilization of the water resources, and conservation of energy in the different forms. For the sustainable development of a country, green manufacturing is one of the essential parts of the triple bottom line (environmental, social, and economic sustainability) Kumar et al., 2017; Kumar et al., 2018).

F_3: Economic interest

(a) Energy-efficient power systems

(b) Green packaging

(c) Collection of end-life products from the consumer

(d) Recycling of end-life products

Nowadays, quality has become an essential parameter for the manufacturing and marketing of a product. Quality is preferred over cost due to increasing general awareness of the customer regarding the comparative values of the alternative products available in

the market. Information technology plays a vital role in educating the customer about the product. The customer is more concerned with the environmental effect of the products, the packaging materials, and recycling of the products at the end of their life, i.e. whether the manufacturer is providing the reverse logistics service to collect the end-life products.

F_4 : Consensus on green management

(a) General awareness of environmental management program

(b) Coordination of inter-functional managers

(c) Collaborative quality management program

(d) Environmental compliance and auditing systems

All stakeholders must have a consensus and support to successfully implement green practices in the organization. All supply chain partners need support to make the awareness program and produce green products. The employees must be motivated and innovative to solve problems and be involved in decision-making. It is the collaborative effort of the departments.

F_5: Firm competitiveness

(a) Brand values in terms of green

(b) Development of environment management system

(c) Green certification

The firm's competitiveness is a self-motivating factor that forces the manager to implement green practices. There should be a complete consensus on green management so that advanced technology can be used to follow the green practices in all the activities. Full employee participation is expected to solve the problems related to green management. Reverse logistics should also be used to reprocess and reuse the materials obtained from the end-life product.

F_6: Green product design and development

(a) Standardization of common parts

(b) Waste reduction

(c) Optimal utilization of resources

(d) Improvement in life expectancy

The major environment-related issues can be addressed at the design and development level of the product. The product's design must follow the simplification and standardization principles so that the time to design and develop the product can be minimized with fewer product varieties, and the waste can be minimized. It is also concerned with the selection of materials for the product. The materials must be environment-friendly so that during and after use, they can be easily reprocessed at the end of their lives. The packaging materials must be biodegradable or recyclable.

F_7: Strong supplier relationship management

(a) Commitment of supplier

(b) Certification of supplier organizations

(c) Capability to produce green products

(d) Technological support between buyers and suppliers

Suppliers play a crucial role in the success of any organization. Suppliers help manufacturing firms with product design and development and technical support. Therefore, suppliers should follow green practices in the development of materials and components development. The supplier must have the capability to produce green products. The strong relationship enhances both the supplier's and buyer's technical, financial, and marketing capability.

The permanent of the matrix for the top-level management can be calculated as shown in Equation. (8). The maximum value of the permanent matrix size 4 × 4 is

calculated as 15000, considering each value (balanced) in the matrix as 5 on a 10-point rating scale. The rating is based on the preference given to one sub-factor or variable on the 10-point scale compared to another. Similarly, the permanent of the matrix for all the other factors F2, …, F7, are calculated using Equation (2) and shown below:

$$\mathrm{Per}(\mathrm{F}_1)=\begin{bmatrix}4&5&3&2\\5&4&4&3\\7&6&5&4\\8&7&6&5\end{bmatrix}=11048 \qquad \textit{Maximum value of } \mathrm{Per}(\mathrm{F}_1)=15000 \tag{8}$$

$$\mathrm{Per}(\mathrm{F}_2)=\begin{bmatrix}7&3&6&4\\7&6&6&7\\4&4&4&5\\6&3&5&4\end{bmatrix}=14491 \qquad \textit{Maximum value of } \mathrm{Per}(\mathrm{F}_2)=15000 \tag{9}$$

$$\mathrm{Per}(\mathrm{F}_3)=\begin{bmatrix}4&4&4&5\\6&4&5&6\\6&5&6&5\\5&4&5&6\end{bmatrix}=14523 \qquad \textit{Maximum value of } \mathrm{Per}(\mathrm{F}_2)=15000 \tag{10}$$

$$\mathrm{Per}(\mathrm{F}_4)=\begin{bmatrix}4&4&3&3\\6&4&6&5\\7&4&5&4\\7&5&6&3\end{bmatrix}=11073 \qquad \textit{Maximum value of } \mathrm{Per}(\mathrm{F}_2)=15000 \tag{11}$$

$$\mathrm{Per}(\mathrm{F}_5)=\begin{bmatrix}7&7&4\\3&4&3\\6&7&5\end{bmatrix}=698 \qquad \textit{Maximum value of } \mathrm{Per}(\mathrm{F}_5)=750 \tag{12}$$

$$\mathrm{Per}(\mathrm{F}_6)=\begin{bmatrix}4&5&6&3\\5&4&5&4\\4&5&3&4\\7&6&6&5\end{bmatrix}=11630 \qquad \textit{Maximum value of } \mathrm{Per}(\mathrm{F}_6)=15000 \tag{13}$$

$$\mathrm{Per}\left(\mathrm{F}_7\right)=\begin{bmatrix}6 & 4 & 5 & 4\\ 6 & 4 & 7 & 5\\ 5 & 3 & 5 & 4\\ 6 & 5 & 6 & 4\end{bmatrix}=13289 \qquad \textit{Maximum value of } \mathrm{Per}\left(\mathrm{F}_6\right)=15000 \tag{14}$$

F: Green Performance Index

F1- Top management commitment to green production

F2- Effective government legislation and implementation

F3- Economic interest

F4- Consensus on green management

F5- Firm's competitiveness

F6- Initiatives for green product design and development

F7- Strong supplier relationship management

The final green index is based on the indices of all the factors from F1 to F7 and their mutual interactions. The mutual interactions between these factors are shown in Figure 7.6. The final green index can be calculated as shown in Equation. (15).

$$GPI = Per\left(F\right)=\begin{bmatrix}F_1 & f_{12} & f_{13} & f_{14} & f_{15} & f_{16} & f_{17}\\ f_{21} & F_2 & f_{23} & f_{24} & f_{25} & f_{26} & f_{26}\\ f_{31} & f_{32} & F_3 & f_{34} & f_{35} & f_{36} & f_{37}\\ f_{41} & f_{42} & f_{43} & F_4 & f_{45} & f_{46} & f_{47}\\ f_{51} & f_{52} & f_{53} & f_{54} & F_5 & f_{56} & f_{57}\\ f_{61} & f_{62} & f_{63} & f_{64} & f_{65} & F_6 & f_{67}\\ f_{71} & f_{72} & f_{73} & f_{74} & f_{75} & f_{76} & F_7\end{bmatrix} \tag{15}$$

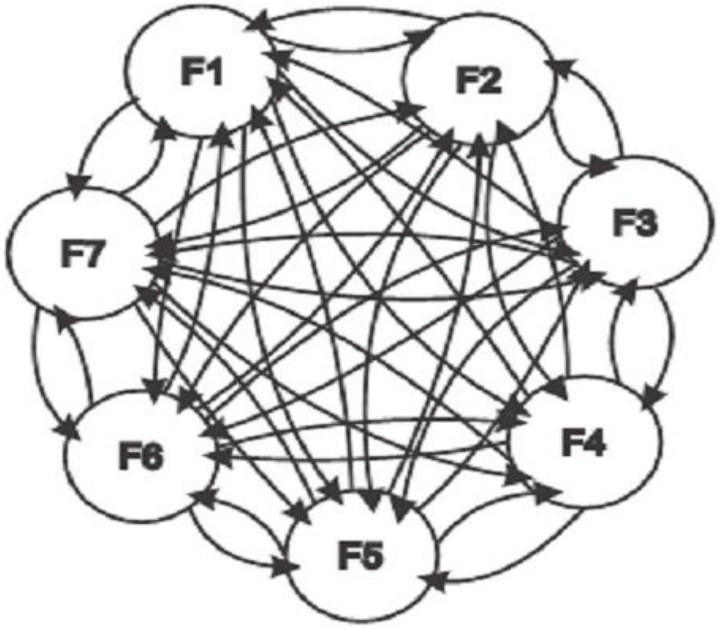

Figure 7.6: Mutual interactions among the factors of green practices

$$= \begin{bmatrix} 11048 & 4 & 7 & 6 & 5 & 5 & 4 \\ 6 & 14491 & 7 & 7 & 6 & 6 & 7 \\ 3 & 3 & 14523 & 4 & 4 & 3 & 5 \\ 4 & 3 & 6 & 11073 & 5 & 5 & 4 \\ 5 & 4 & 6 & 5 & 698 & 4 & 4 \\ 5 & 4 & 7 & 5 & 6 & 11630 & 6 \\ 6 & 3 & 5 & 6 & 6 & 4 & 13289 \end{bmatrix} = 27.77 \times 10^{26}$$

$$Maximum\, value\, of\ \mathrm{Per}(\mathrm{F}) = 58.68 \times 10^{26}$$

Diagonal values of all matrices shown in Equation (15) are taken from the permanent's matrix of all factors F_1 to F_7 from Equations (8-14). The green index calculated as 27.77×10^{26} is a scale that can be compared with the green index of the other companies. The maximum value of the green index was calculated as $58.68 \times 10^{26,}$ considering everything favourable. Thus, there is an opportunity to improve the company's green performance. Also, if we analyze the individual factors index with their maximum value, it is observed that the factors F1, F4, and F6 are to be improved. The permanent matrix value

for these factors is much less than the maximum value, i.e., 15000. The maximum value of the indices is calculated considering each value in the matrices as the maximum and balance value on the rating scale. The value of the green index may vary from company to company; it depends on the value of preference given by the company manager to the variable of green manufacturing on the 10-point rating scale. This method shows how qualitative things can be measured quantitatively to find the green performance. The variable may also vary from company to company and country to country. It is just a model produced to measure the green index.

7.6 CONCLUSION

In the current study, factors influencing green practices in SMEs have been outlined from past literature, and an index to assess green practices has been produced. The assessment of the implementation of green practices in a small organization needs a qualitative approach. A digraph is a method that can be applied to map the relationship among the different factors of green practices. These digraphs can be easily used as an input for the matrix to find the permanent of the matrix. The permanent matrix of all the seven factors incorporated in this study produces an index known as Green Index. The green index may vary from one organization to another because of the subjective judgment of decision-makers concerning interactions of factors and sub-factors. Due to this variation, the performance of different organizations regarding green products has been compared. Also, the maximum value of the green index shows a benchmark for an organization to achieve that level by suitable improvement. The individual factor's permanent matrix can also be compared with its maximum value for further improvement even without comparing it with any other organization.

Managerial implications: The manager of a company can evaluate the green performance index using a graph-theoretic matrix approach. The uniqueness of this analysis is that the inputs in this method are based on the opinion of practitioners, which is subjective and can be presented on a 10-point rating scale. This process requires less documentation. To make the activity-wise comparison, the manager may produce the green performance index for all the different activities at the micro/macro level. Also, this is a subjective analysis; one can analyze and observe the factors lagging or leading. Thus, the area required for further improvement can be easily found.

CHAPTER 8

SUMMARY, LIMITATIONS, AND FUTURE RESEARCH SCOPE

8.1 INTRODUCTION

Globalization, industrialization, urbanization, and increasing population forced manufacturing organizations to increase their production. Simultaneously, rapid industrialization also increases the exploitation of natural resources causing environmental threats to society. The growing awareness among the community and increasing ecological consciousness of the business firms forced them to adopt sustainability initiatives. The sustainability initiatives forced industries to redesign their product and processes to minimize the deterioration of natural resources and improve environmental conditions. Numerous business organizations saw promising opportunities for their businesses due to growing awareness of the environment in society. Some organizations adopt a strategic approach to gain competitive advantages from environmental practices. The strategic approach lessens the risk associated with environmental performance but does not create opportunities for profitability.

The green product should be popular amongst the people to increase sales volume. But due to significant initial investments in green manufacturing practices, the cost of green products is more than traditional products. The consumers of developing countries are price-conscious and hesitant to spend more on green products, despite being aware of environmental degradation. The higher price of green products is also due to the shortages of skilled human resources and accurate information regarding green manufacturing practices. SMEs already facing a financial crunch should be motivated by benefits offered

such as subsidies, bank loans, the latest technology, and training to generate a skilled workforce to promote green products in developing countries like India,

This study has tried to determine how consumers can be motivated to adopt green products as a part of their lives. Factors to motivate manufacturing organizations to adopt green manufacturing practices in their organizations have also been identified. The government agencies should also encourage manufacturing organizations to adopt green manufacturing practices. The government regulations should be environmentally friendly, and rules enforcement should also be proper. Adopting green manufacturing practices may help the organizations increase their profit by increasing sales volume and building a reputation as an environmentally friendly manufacturing organization.

8.2 SUMMARY OF WORK DONE

The research has tried to fill some of the gaps in contemporary research in adopting green manufacturing practices by Indian SMEs. In this section, the work done in fulfilling the research gap has been presented. The works done include the following:

- An extensive literature review has been conducted to identify the gaps and relevant research issues in implementing green manufacturing practices in Indian SMEs.
- A set of research hypotheses related to consumer behaviour and consumer purchase intentions for green products and the effect of green product development on the performance of the Indian SMEs has been formulated based on the literature review discussion with the academician and industrial experts.
- A questionnaire was designed to get the responses from the consumers and industry professionals. The consumers' responses helped to know the consumer's perception of green products. At the same time, the reactions from the industry professionals helped to understand the perception about the implementation of

green manufacturing practices in Indian SMEs. The questionnaire included various aspects of consumers like the perceived quality of the product, brand loyalty, production of green products, purchase intentions, and consumer behaviour, and various aspects concerned to performances of the organizations like environmental performance, social performance, organizational performance, operational performance, financial performance, factors related to green manufacturing practices and aspects about obstacles in the implementation of green manufacturing practices in Indian SMEs.

- The questionnaire responses were analyzed for reliability, discriminant validity, content and construct validity, internal consistency, etc.
- Various factors affecting the adoption of green manufacturing practices have been analyzed to calculate the green performance index.
- The various obstacles to implementing green manufacturing practices in Indian SMEs have been analyzed and ranked to prioritize dealing with those obstacles.
- The PLS-PM SEM has been used to analyze consumer behaviour and calculate organizational performance. In contrast, the BWM technique categorizes the obstacles according to priority, and the graph theory matrix calculates the green performance index.

8.3 MAJOR FINDINGS OF THE RESEARCH

All the research gaps have been appropriately addressed. The research gaps have been addressed using SEM, BWM, and GTMA. The conclusions of the analysis are given below:

- The first objective was to identify and rank the obstacles to implementing green practices in Indian SMEs. In chapter 6, twenty-five obstacles were identified. These twenty-five obstacles are categorized into financial, management, operational,

technological, regulatory, and environmental. The factor analysis method has been used to classify sub-obstacles to main category obstacles, and the best-worst method has been used for ranking these obstacles. The study confirms that SMEs can enhance green manufacturing practices by providing financial assistance and technological awareness. The stricter government regulations also create a fear of increasing costs and losing market share as it increases production costs. The SMEs should also be provided with land at a favourable location where many skilled workers may be available at a lower cost with easy reach to market facilities. The following recommendations are being made based on this study:

1. Financial assistance like a loan with less interest, lower tax rates, etc., should be provided to the SMEs.
2. A campaign should be made for the proper awareness about the latest technology support for green manufacturing.
3. Regulations should be practical and friendly so that SMEs can quickly implement them.
4. Land at subsidized rates with proper market facilities in the nearby area should be provided to the SMEs.

- The second objective was to study the consumer behaviour towards the purchase of environmentally friendly products and find the impact of consumer behaviour on producing environmentally friendly products. In chapter 5, the factors of consumer behaviour that influence the production of green products have been identified. Although green manufacturing is a very old practice, green production has not received the proper attention of the manufacturers. The main reason for the poor response of the consumers to the utilization of green products is the lack of popularization of green products. In this research, some important factors that need

to be addressed to improve the consumption patterns of green products have been identified. It has been observed that environmental problems cannot be solved only by sustainable production strategies. It also requires a change in consumer behaviour and price strategy. The study has proved that the perceived quality of the products has the highest impact on changing consumer behaviour for green utilization. The consumer of developing countries is very much price sensitive. It is observed in the study that the price intentions of the consumer also significantly impact green production. It has been observed that the consumer's need for fulfilment and environmental consciousness, personal attention is given by the manufacturer, and post-sales service have a significant role in improving the price intentions of the consumer. At the same time, the product cost, green initiatives, and product quality significantly impact changing consumer behaviour for green utilization. However, the consumer-producer relationship, empathy, responsiveness, reliability, and assurance are the main factors that help improve the product's perceived quality.

- The third objective was to correlate the effect of green product development on the performance of Indian SMEs. In chapter 5, the impact of green manufacturing practices has been studied, and a framework to measure the performance of the green manufacturing organizations has been developed. Green manufacturing practices are the demand of the current global scenario. But the manufacturers, especially Indian SMEs with many financial obstacles, are afraid to adopt green manufacturing because of the high investment in procuring tools and equipment for green manufacturing and hiring skilled personnel. Further, the loss of profits and market share is an essential fear for the manufacturing organization. The Indian consumers are price-conscious and compare the output of the products with

traditional products. Conventional products are readily available, and the manufacturing organization is afraid to lose its social reputation. This research has empirically investigated the effects of green manufacturing on organizations' financial, social, and environmental performance.

- The findings of this research show that the manufacturing organisation's financial performance is improved after adopting green manufacturing. Economic performance and the social and environmental performance of the organization also improve after adopting green manufacturing. The market share also improves along with the increase in profit share if the company goes green manufacturing. The result may motivate the manufacturing organizations to adopt green manufacturing, which helps reduce pollution and resource scarcity.

- The fourth objective was to develop a framework to measure the green performance of Indian SMEs. From past literature, factors of green manufacturing practices in SMEs have been explored to produce an index of these factors. The assessment of the implementation of green practices in a small organization needs a qualitative approach. The permanent matrix of all the seven elements incorporated in this study produces a Green Index. The green index may vary from one organization to another due to the subjective judgment of the decision-makers regarding the interactions of the factors and sub-factors. Due to this variation, we can compare the performance of different organizations regarding green production.

8.4 SIGNIFICANCE AND IMPLICATIONS OF THE RESEARCH

The findings of this research promote the literature on implementing green manufacturing practices in Indian SMEs. The questionnaire survey, case studies, PLS-PM, BWM, and graph theory and matrix approach have provided new insight into the green

manufacturing practices and could be helpful for academicians and managers of the industry.

8.4.1 ACADEMIC IMPLICATIONS

- The study is helpful for the researchers working in green manufacturing practices. The study offers a comprehensive literature review on hurdles of green manufacturing, consumer behaviour towards green products, and the green and financial performance of the organizations involved in green manufacturing.
- The various research methods used in this research, like PLS-PM, BWM, and GTMA, help the researchers for future research.
- The literature review and gaps identified in this research could be a reference for future research on the issue of green manufacturing practices in India and abroad.
- The questionnaire developed in this research can help future researchers conduct further realistic studies on green manufacturing practices.
- The BWM is used to rank the obstacles to implementing green manufacturing practices in Indian SMEs. It may provide valuable insight to the academics, which may help them build up a new framework for further research in this area.

8.4.2 MANEGERIAL IMPLICATIONS

Several managerial implications emerge in this research are:

- The company manager can evaluate the green performance index using a graph-theoretic matrix approach. The uniqueness of this analysis is that inputs are based on the opinion of practitioners, which is subjective and presented on a 10-point rating scale. This process requires less documentation. To make the activity-wise comparison, the manager may

produce the green performance index for all the different activities at the micro/macro level.

- This study influences consumer behaviour towards green consumption by several means such as social welfare, green initiatives, price reduction, quality improvement, use of alternative materials, etc. It also helps the manager link the various factors with the production of green products as presented in the structural equation modelling according to the path coefficient, factor loading, and different valid statistical values.
- This research may motivate the manufacturing organizations to adopt green manufacturing, which helps reduce pollution and resource scarcity.
- In this research, the ranking of the obstacles to implementing the green manufacturing practices in Indian SMEs has been done, which may help the managers to implement green manufacturing practices in Indian SMEs.
- This research helps the manager identify the factors improving green consumerism and ensures the production of green products accordingly.
- The factors influencing the consumer's perception of green products and the factors related to improving the consumers' purchase intentions for green products help the industry enhance the production of green products.
- The prioritization of GMP obstacles helps the industry deal with them according to their priority.
- The maximum green index value shows the benchmark for an organization and how much improvement is required to achieve that level.
- The findings may help to reduce the prices of green products.
- The adoption of GMP by organizations at a large scale may increase the availability of green products in the market and improves environmental sustainability.

8.5 LIMITATIONS AND FUTURE RESEARCH SCOPE

It is significant to recognize the limitation of this research. This study targeted limited sections of society and a few industries of different products and sizes. The data with high accuracy may be obtained by considering an extensive community section with different cultures, languages, and regions. Also, the industry of some other developing countries can be considered in future research to establish strong results. The factors considered in this research belong to the Indian perspective. Hence, for global applicability, the other developing countries' factors should also consider a wide variety of industry and public data. The data has been analyzed with statistical tools, and this research uses the graph theory matrices method.

It is essential to recognize the limitation of this research. This study targeted a few sections of society and a few different products and sizes industries. In future research, vast data is required for an extensive analysis of community sections with different cultures, languages, and regions of the industry of some other developing countries to analyze the results with different demographical conditions. The latest technologies emerge day by day in the market. The study with more obstacles to green manufacturing practices in the light of the latest technology should be performed for broader prospects.

8.6 CONCLUSION

The production of any product depends upon its consumption — the more popular the product, the more its consumption and, conversely, its production. Green manufacturing practices have not gained proper attention in developing countries because of poor responses from the consumers. The consumer's reaction depends upon the popularity and price of the product. The consumer of the developing countries is very much price sensitive.

The increase in production decreases the cost of the product also. The study reveals that the perceived quality of the products plays an essential role in popularization and rise in product consumption. The need fulfilment and fulfilment of environmental expectations, personal attention given by the manufacturer, and post-sales service also play a significant role in improving the price intentions of the consumer.

In the current commercial environment, when the technologies are growing fast, increasing awareness of customers about quality, customers are becoming impatient about the delivery of the products and want products at low costs with its greenness, forcing the business organizations to adopt sustainable manufacturing system. Various digitized technological methods are also available to make it easy for manufacturing to obtain sustainability. Organizations are also facing challenges in effectively integrating digital technologies (Singh et al., 2019; Bhandari et al., 2019). Finally, this study identified twenty-five obstacles categorized into financial, management, operational, technological, regulatory, and environmental obstacles with the help of the factor analysis method. It has been found that financial assistance, technical awareness, and stricter government regulations are the essential factors that need to be addressed. Further, SMEs should also be provided with land at a favourable location where a large number of skilled workers may be available at a lower cost with easy reach to market facilities can increase the possibility of adopting green manufacturing by the SMEs.

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APPENDIX – 'A'

QUESTIONNAIRE

Department of Mechanical Engineering

Delhi Technological University

Main Bawana Road, Shahabad Daulatpur, Delhi-110042

Subject: Issues in green manufacturing practices in Indian SMEs.

Dear Sir/Madam,

Deteriorating environmental conditions attracted the attention of researchers and industrialists and forced them to adopt green manufacturing practices. The industry uses minimum natural resources and fewer energy emissions in green manufacturing practices. The materials can be reused, recycled, and remanufactured for optimal use.

The current research is being conducted to know the factors influencing consumer behaviour for the purchase of environmentally friendly products and their impact on the production of green products, correlating the effect of green product development on the performance of the Indian SMEs, to identify and rank the obstacles faced by the Indian SMEs in implementing green manufacturing practices and to develop an index to assess the green practices of the Indian SMEs. Your feedback in this regard may give significant value to this study.

Hence, it is requested that to spare some time and respond to the enclosed questionnaire. The objective of this study is purely research and academic-oriented, and all responses will be kept confidential.

With regards,

Manoj Kumar Singh

Email: manojsinghavp@gmail.com

Research Supervisor

Dr Pravin Kumar
Associate Professor
(Department of Mechanical Engineering, DTU)

Dr Saurabh Agrawal
Associate Professor
(Delhi School of Management, DTU)

SECTION- I

Personal profile

1. Name –
2. Age-
3. Qualification –
4. Income –
5. Name of the organization –
6. Number of employees –
7. Designation -

SECTION -II

Please mark (√) on a scale of 1 to 5 (1- least agreed, 5- strongly agreed) the factors you feel most appropriate with your concerned behaviour/intentions.

A. Purchase intentions of the consumer

Purchase Intentions (PI) are influenced by	1	2	3	4	5
1. Need Fulfilment					
2. Environmental Consciousness					
3. Personal Attention					
4. Post-Sales-Service					

B. The Perceived Quality of the products depends upon

The Perceived Quality (PQ) of the products depends upon	1	2	3	4	5
1. Consumer Producer relationship					
2. Empathy					
3. Responsiveness					
4. Reliability					
5. Assurance					

C. Consumer Behaviour toward green products depends upon

Consumer Behaviour (CB) towards green products	1	2	3	4	5
1. Product Cost					
2. Green Initiatives					
3. (CSR)Social Welfare					
4. Product Quality					
5. Income Level					

D. Brand Loyalty of the firms improves from

Brand Loyalty (BL) improves from	1	2	3	4	5
1. Organizational Commitment					
2. Respect for Rule of Law					
3. Advertising & Promotions					
4. Transparency in dealing					
5. Expectations					

E. Production of a green product depends upon

Production of a green product depends upon (GP)	1	2	3	4	5
1. Use of alternative materials/ Green Design					
2. Green Packaging					
3. Energy Conservation					
4. Waste Management					
5. Improvement in Life Expectancy					
6. Production Cost					

SECTION -III

Please mark (√) on a scale of 1 to 5 (1- least agreed, 5- strongly agreed) the factors you feel most appropriate with your industrial experience.

A. The Financial Performance of the company depends upon

The Financial Performance (FP) of the company depends upon	1	2	3	4	5
1. Increase in market share					
2. Profit increase					
3. Increase in sales					
4. Return on investment					

B. The Social Performance of the company depends upon

The Social Performance (SP) of the company depends upon	1	2	3	4	5
1. Corporate reputation					
2. An increase in market share					
3. Ethical behaviour					
4. Respect for rules of law					
5. Job creation					

C. The Environmental Performance of the company depends upon

The Environmental Performance (EP)of the company depends upon	1	2	3	4	5
1. Use of non-hazardous materials					
2. Waste reduction					
3. GHG emission					
4. Optimum utilization of resources					
5. Amount of air pollutants discharged					

D. Green Manufacturing stands for

Green Manufacturing (GM) stands for	1	2	3	4	5
1. Use of cleaner technology					
2. Green packaging					

3. Renewable energy sources					

SECTION -IV

The questionnaire used for Delphi Study

Based on the literature review and opinion of research guides, the 25 obstacles to implementing green manufacturing practices in Indian SMEs are identified.

Obstacles
1. Technology procurement cost
2. Green packaging cost
3. Waste disposable cost
4. Insufficient resources
5. Ineffective tax policy
6. Lack of supplier development and commitment
7. Lack of top management commitment
8. Lack of strategic planning
9. Ineffective information technology
10. Poor availability of skilled labour
11. Insufficient training and educational facilities
12. Lack of mutual trust and motivation
13. Low investment in research and development (R & D)
14. Poor awareness
15. Scarce advanced technology
16. Poor organizational management
17. Insufficient incentives for green technology
18. Poor understanding of green standards
19. Ineffective regulations for reverse logistics
20. Insufficient government support
21. Ineffective implementation of rules and regulations
22. Insufficient funds for the implementation of green practices
23. Scarce green materials for product design and developments
24. Insufficient facilities for the management of end-life products
25. Poor knowledge about environmental impacts

After a brief introduction of the research plan and purpose of the study based on green manufacturing practices, the following questions should be replied to by the experts:

Q1. Please, go through the obstacles extracted from the literature review. Is it sufficient to describe the challenges in green manufacturing practices in the context of Indian SMEs? If No, what other practical obstacles can be included in describing the challenges?

Q2. Please mark (√) on a scale of 1 to 5 (1- least agreed, 5- strongly agreed) all the 25 obstacles mentioned above to classify all the obstacles into six different categories as

1. Financial obstacles 2. Managerial obstacles 3. Operational obstacles
4. Technological obstacles 5. Regulatory obstacles, and
6. Environmental obstacles

SECTION - V

I. Please select the Best (Most Challenging) and Worst (Least Challenging) obstacles among the six classes of obstacles/obstacles in GMP implementation.

1. Financial obstacles 2. Managerial obstacles 3. Operational obstacles
4. Technological obstacles 5. Regulatory obstacles, and
6. Environmental obstacles

I. Please, rate the Best barrier compared with other obstacles/obstacles on a 9-point rating scale

Best Barrier↓	Financial obstacles	Managerial obstacles	Operational obstacles	Technological obstacles	Regulatory obstacles	Environmental obstacles

II. Please, rate the other barriers compared with the worst obstacles/obstacles on a 9-point rating scale.

Worst Barrier→	
Financial obstacles	
Managerial obstacles	
Operational obstacles	
Technological obstacles	
Regulatory obstacles	
Environmental obstacles	

III. Please select the Best (Most Challenging) and Worst (Least Challenging) obstacles/ obstacles among the five Financial obstacles in GMP implementation.

1. Technologies procurement cost	
2. Green packaging cost	
3. Disposable cost for hazardous wastes	
4. Insufficient resources for the implementation of green technology	
5. Ineffective tax policies	

IV. Please, rate the Best obstacles/ obstacles among the five Financial obstacles in the implementation of GMP compared with other barriers on a 9-point rating scale

.**Best Barrier↓**	Technologies procurement cost	Green packaging cost	Disposable cost for hazardous wastes	Insufficient resources for the implementation of green technology	Ineffective tax policies

V. Please, rate the other obstacles/obstacles compared with the worst financial obstacles/ obstacles on a 9-point rating scale.

Worst Barrier→	
1. Technologies procurement cost	
2. Green packaging cost	
3. Disposable cost for hazardous wastes	
4. Insufficient resources for the implementation of green technology	
5. Ineffective tax policies	

VI. Please select the Best (Most Challenging) and Worst (Least Challenging) obstacles/ obstacles among the four managerial obstacles in GMP implementation.

1. Lack of supplier development and their commitment	
2. Lack of top management commitment	
3. Lack of strategic planning	
4. Insufficient information technologies	

VII. Please, rate the Best obstacles/ obstacles among the four managerial obstacles in the implementation of GMP compared with other barriers on a 9-point rating scale

.**Best Barrier ↓**	Lack of supplier development and their commitment	Lack of top management commitment	Lack of strategic planning	Insufficient information technologies

VIII. Please, rate the other obstacles/obstacles compared with the worst managerial obstacles/ obstacles on a 9-point rating scale.

Worst Barrier→	
1. Lack of supplier development and their commitment	
2. Lack of top management commitment	
3. Lack of strategic planning	
4. Insufficient information technologies	

IX. Please select the Best (Most Challenging) and Worst (Least Challenging) obstacles/ obstacles among the four operational obstacles in GMP implementation.

1. Poor availability of skilled labour	
2. Insufficient training and educational facilities	
3. Lack of mutual trust and motivation	
4. Low investment in Research and Development	

X. Please, rate the Best obstacles/ obstacles among the four operational obstacles in the implementation of GMP compared with other barriers on a 9-point rating scale

Best Barrier ↓	Poor availability of skilled labour	Insufficient training and educational facilities	Lack of mutual trust and motivation	Low investment in Research and Development

XI. Please, rate the other obstacles/obstacles compared with the worst operational obstacles/ obstacles on a 9-point rating scale.

Worst Barrier→	
1. Poor availability of skilled labour	
2. Insufficient training and educational facilities	
3. Lack of mutual trust and motivation	
4. Low investment in Research and Development	

XII. Please select the Best (Most Challenging) and Worst (Least Challenging) obstacles/ obstacles among the four technological obstacles in GMP implementation.

1. Low awareness related to technology	
2. Scarce advanced technology	
3. Poor organizational management	
4. Insufficient incentives for green technology	

XIII. Please, rate the Best obstacles/ obstacles among the four technological obstacles in the implementation of GMP compared with other barriers on a 9-point rating scale

Best Barrier ↓	Low awareness related to technology	Scarce advanced technology	Poor organizational management	Insufficient incentives for green technology

XIV. Please, rate the other obstacles/obstacles compared with the worst technological obstacles/ obstacles on a 9-point rating scale.

	Worst Barrier→	
1.	Low awareness related to technology	
2.	Scarce advanced technology	
3.	Poor organizational management	
4.	Insufficient incentives for green technology	

XV. Please select the Best (Most Challenging) and Worst (Least Challenging) obstacles/ obstacles among the four regulatory obstacles in GMP implementation.

1.	Poor understanding of green standards	
2.	Ineffective regulations for reverse logistics	
3.	Insufficient government support	
4.	Ineffective implementation of rules and regulations	

XVI. Please, rate the Best obstacles/ obstacles among the four regulatory obstacles in the implementation of GMP compared with other barriers on a 9-point rating scale

Best Barrier ↓	Poor understanding of green standards	Ineffective regulations for reverse logistics	Insufficient government support	ineffective implementation of rules and regulations

XVII. Please, rate the other obstacles/obstacles compared with the worst regulatory obstacles/ obstacles on a 9-point rating scale.

	Worst Barrier→	
1.	Poor understanding of green standards	
2.	Ineffective regulations for reverse logistics	
3.	Insufficient government support	
4.	Ineffective implementation of rules and regulations	

XVIII. Please select the Best (Most Challenging) and Worst (Least Challenging) obstacles/ obstacles among the four environmental obstacles in GMP implementation.

1. Insufficient funds for the implementation of green practices	
2. Scarce green materials for product design and developments	
3. Insufficient facilities for the management of end-life products	
4. Poor knowledge about environmental impacts	

XIX. Please, rate the Best obstacles/ obstacles among the four environmental obstacles in the implementation of GMP compared with other barriers on a 9-point rating scale

.**Best Barrier ↓**	Insufficient funds for the implementation of green practices	Scarce green materials for product design and developments	Insufficient facilities for the management of end-life products	Poor knowledge about environmental impacts

XX. Please, rate the other obstacles/obstacles compared with the worst environmental obstacles/ obstacles on a 9-point rating scale.

Worst Barrier→	
1. Insufficient funds for the implementation of green practices	
2. Scarce green materials for product design and developments	
3. Insufficient facilities for the management of end-life products	
4. Poor knowledge about environmental impacts	

SECTION - VI

The questionnaire used for Delphi Study

After a brief introduction of the research agenda and purpose of the study based on green manufacturing practices, the following questions were asked from the experts: Based on

the literature review, the following 27 essential factors of green manufacturing practices in Indian SMEs are identified. These factors are:

1. Written policy and goals of the organization cost
2. Implementation of Environment management systems
3. Regular assessment of the green Performance
4. Dedicated workgroup for the environmental initiatives
5. Reduction in carbon emission
6. Restriction on the use of hazardous materials
7. Effective water consumption
8. Reduced energy consumption and use of an alternative source of energy
9. Energy-efficient lighting systems
10. Recycling of end life products
11. Collection of end life products from the consumer
12. Green packaging
13. General awareness of environmental management program
14. Support of inter-functional managers
15. Collaborative quality management program
16. Environmental compliance and auditing systems
17. Support of inter-functional managers
18. Collaborative quality management program
19. Environmental compliance
20. Standardization of common parts
21. Avoiding the use of hazardous materials
22. Use of green packaging
23. Use of recycled products
24. The willingness of the supplier to design and develop green products
25. ISO 14000 Certification
26. The ability of the supplier to follow green practices
27. Buyer's technological support to suppliers

Q1. Please review the factors of green manufacturing practices from the literature review. Is it sufficient to describe the green manufacturing practices in the Indian SMEs context? If No, what other practical factors can be included in describing the green manufacturing practices?

Q2. Please, classify all the factors of green manufacturing practices extracted from the literature review into seven different categories as

1. Top management commitment 2. Effective government legislation & implementation 3. Economic interest 4. Consensus on green management 5. Firm's competitiveness 6. Green product design & development, and 7. Strong supplier relationship management

Q3. Please assign a numerical value to the qualitative measure of performance factors as given below to determine the interdependence among the variables and their contribution to the system to calculate the overall index.

A qualitative measure of performance factors	**Assigned Value**
Exceptionally low influencing	0
Extremely low influencing	1
Very low influencing	2
Below average influencing	3
Average influencing	4
Above-average influencing	5
Moderate influencing	6
High influencing	7
Very high influencing	8
Extremely high influencing	9
Exceptionally high influencing	10

Q4. Please assign a numerical value to the relative importance of performance factors as given below to calculate the overall index.

Class description	Relative importance of factors	
	f_{ij}	$f_{ij} = 10 - f_{ji}$
Two factors are equally important	5	5
One factor is slightly more important over the other	6	4
One factor is strongly more important over the other	7	3
One factor is very strongly more important over the other	8	2
One factor is extremely important over the other	9	1
One factor is exceptionally more important over the other	10	0

LIST OF RESEARCH PUBLICATIONS FROM THE THESIS

List of papers published in SCI/SCIE Journals

- Manoj Kumar Singh, Pravin Kumar, and Saurabh Agrawal (2021). An assessment of green practices in Small and Medium-sized Enterprises (SMEs) using the Graph-Theoretic Matrix Approach. Accepted in Journal of Engineering and Research. Journal of Engg. Research ICARI Special Issue pp. 11-21, DOI: 10.36909/jer.ICARI.15289
- Pravin Kumar, Manoj Kumar Singh, and Saurabh Agrawal (2021). An analysis of customer's purchase intention towards the green products and its effect on manufacturing: A statistical approach. Accepted in Journal of Engineering and Research. Journal of Engg. Research ICARI Special Issue pp. 1-10, DOI: 10.36909/jer.ICARI.15279

List of papers presented at International Conferences

- Manoj Kumar Singh, Pravin Kumar, and Saurabh Agrawal (2017). A review of green practices in Indian Small and Medium Enterprises (SMEs): 2nd International Conference on Advanced Production and Industrial Engineering (ICAPIE-2017) organized by Center for Advanced Production and Industrial Engineering (CAPIER), Delhi Technological University, New Delhi, held on 6-7 Oct 2017.
- M. K. Singh, Pravin Kumar, and S. Agrawal (2022). Analyzing the Green Manufacturing and Organizational Performance of the Indian SMEs: 3rd International Conference on Computational and Experimental Methods in Mechanical Engineering (ICCEMME-2021) organized by Department of Mechanical Engineering, G. L. Bajaj Institute of Technology & Management, Greater Noida, UP, India on 11-13 Feb 2021.

BIOGRAPHICAL PROFILE OF THE RESEARCHER

Manoj Kumar Singh is M. Tech in Production Engineering from Delhi Technological University (Formerly known as Delhi College of Engineering), Delhi. He has more than 27 years of teaching and industry experience. He is presently working as a Lecturer (Mechanical Engineering) at the Department of Mechanical Engineering, Pusa Institute of Technology, Department of Training and Technical Education, GNCT of Delhi. He has been involved in research work in the Department of Mechanical Engineering, Delhi Technological University, since August 2016.