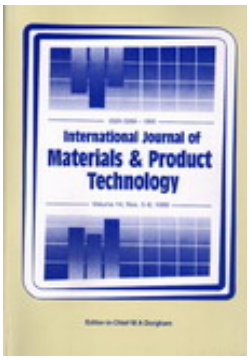

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Effectiveness of green manufacturing in resolving environmental issues: a review

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Effectiveness of green manufacturing in resolving environmental issues: a review

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Abstract: Green manufacturing (GM) has been garnering the attention of academia since the 1990s, with the evolution of many related concepts, as one of the most essential topics for human beings' sustainable development. After nearly three decades of growth, a general map of existing research is now required to reflect the major concepts and concerns at hand. A bibliometric analysis is used to do this. The main contribution of this research is to concentrate on the use and impact of lean and green manufacturing approaches. The manufacturing industry's frequent issues and misunderstandings are investigated. This study examines the parallels and benefits of both lean and green techniques. It enables industries to have a better grasp of the tools' use and challenges before moving on with the lean and green approach's actual deployment. This report also addresses potential research gaps related to the industry's need for an effective green implementation approach.

Keywords: green manufacturing; GM; sustainable manufacturing; lean and green; sustainability; manufacturing industry; green implementation.

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1 Introduction

First, there is no consensus on the effect of GM on operating costs (OC):

> "some studies have found that eco-friendly operations can reduce manufacturing costs (Jayaraman et al., 2012; Rusinko, 2007; Yu et al., 2014), while others have found that rising costs are a barrier to environmentally aware manufacturing (Esfahbodi et al., 2016; Lü et al., 2015; Mittal and Sangwan, 2013); finally, Jabbour The conflicting results indicate that the GM–OC link should be investigated further. Furthermore, existing research has primarily relied on surveys (Esfahbodi et al., 2016; Jabbour and de Sousa Jabbour, 2016; Yu et al., 2014) and case studies (Jayaraman et al., 2012) to investigate the cost performance of green operational techniques. To close this research gap, this study analyses objective secondary data from a broad sample of manufacturing enterprises to investigate the impact of GM on OC."

Second, because the environment is a public good,

> "GM goes beyond the manufacturer's own operations, and external institutional constraints impact the adoption of environmentally friendly manufacturing practises (Yan et al., 2022; Zhu et al., 2013). Institutional pressures have been studied as drivers in the adoption of environmental management systems (Fikru, 2014; Phan and Baird, 2015), as well as the impact of institutional pressures on environmental management systems' achievement of goals such as eco-innovation, competitiveness, and improved corporate reputation (Fikru, 2014; Phan and Baird, 2015). Firms could also translate external institutional constraints into internal expenses. Environmental standards are still evolving, particularly in emerging economies, and variable degree of economic protectionist from local governments imply that the effectiveness of environmental law and regulations varies as well. This creates an unfavourable competitive environment for rule-followers vs free riders, and it means that external environmental costs are dependent on local circumstances. However,

> to the best of our knowledge, the impact of external environmental forces on GM cost in emerging economies is still unknown."

To close the second study gap, this paper uses the objective pollution level of the local city (PLLC) and the pollutant information sharing of local government (PITLG) to investigate the synergistic effects of external environmental stressors on GM.

Third, many existing research have primarily focused on industrialised countries with earlier

> "Green development and better sustainability practices (Liu et al., 2017; Schaltenbrand et al., 2015; Wiengarten et al., 2013). However, because many emerging economies have historically pursued rapid economic development at the expense of the environment, and are now experiencing major environmental challenges, the implications of GM adoption in emerging economies may differ from those in industrialised countries. More research on pressures, performance, and environmental practises is needed, according to the literature assessment, particularly in developing nations (Vanalle et al., 2017). This is the study's third gap to investigate."

Green manufacturing, as a concept that emerged in industrialised countries in the 1990s, can help to reduce negative environmental impacts and increase resource efficiency throughout the entire system or process of factory output.

> "Green manufacturing has evolved from "technology for the nineties" (Weissman and Sekutowski, 1991) to concerns for the new millennium (Sarkis, 2001), becoming the frontier in the achievement of sustainable development and receiving increasing attention in both academic and practical aspects. Scholars have expanded study into green manufacturing from various viewpoints, including the development of green manufacturing techniques, the drivers and effects of green manufacturing, and green manufacturing technologies, after over 30 years of development. As a result, existing research must be examined, and academic divisions in this field must be discovered by identifying the primary sub-topics and research problems involved. Some studies looked at relevant research on green manufacturing from a variety of angles. For example, Paul et al. (2014) introduce several related concepts – environmental process analysis, sustainable manufacturing, sustainable green operations, green supply chain management, and green applications – to review the definition, significance, and approaches of green products from a practical perspective. Garetti and Taisch (2012), on the other hand, examine the trends and challenges of sustainable manufacturing from the standpoint of technological application, concluding that there are four research clusters involved – marketing strategies and processes, asset and product life cycle managerial staff, resource and energy management, and enabling technologies – each with numerous topics."

The evolution of green products in polluting industries has been examined in some detail. These evaluations use qualitative methods to look at a few typical papers, but they do not provide a thorough picture of the area. Using a bibliometric approach, this study aims to determine the challenges in this field that receive the greatest academic attention, as well as how research in each topic is related. "Bibliometrics is a valuable method for examining how concepts are connected (or unconnected) within a single academic subject quantitatively (Kamalski and Kirby, 2012)". We cannot only summarise existing research into different categories, but also clearly show the internal key issues of each classification, thus depicting the established picture of green production research, and

further defining the boundaries of existing research and where to expand in the future, by analysing the keywords of published papers.

Manufacturing is an important objective in the big picture of sustainability because of its role in modern society (Garetti and Taisch, 2012).

> "Although environmental issues and conflicts have a long history in human history, it is widely acknowledged that the transition from agrarian to industrialised society has been accompanied by an alarming rate of resource exploitation and environmental destruction (Sarkis and Rasheed, 1995), with global and profound consequences (Ahuti, 2015)."

The invention of mechanical energy sources such as steam engines and electricity characterised the first and second Industrial Revolutions, which lasted from the 1760s to the 1840s and 1870s to the 1910s, respectively, involving a large leap from manual to machine manufacturing ultimately based on fossil fuel consumption.

> "The innovations, which began in England, quickly spread throughout Europe and then North America, propelling western countries into rapid industrialisation, increased productivity, and rapid economic growth, albeit at a significant environmental cost in terms of air pollution and greenhouse gas emissions. The UN Stockholm Conference on the Human Environment, held in 1972, sparked a worldwide debate on economic and environmental issues and sparked additional academic research."

The subsequent 1987 World Commission on Environment and Development (WECD) report, Our Common Future, defined sustainable development as "development that meets current needs without jeopardising future generations' ability to meet their own needs" – and the burgeoning concept of 'sustainability' – drew public attention.

> "Although the economy, society, and environment are typically considered the three pillars of sustainability, the latter has received the most recent attention, while the first has proven to be the most straightforward to implement, as industrial technology has traditionally focused on increasing the quantity and quality of production with little regard for environmental or social costs."

Most firms have been compelled to consider the effects of their actions beyond mere financial concerns as environmental consciousness has grown (Sarkis and Rasheed, 1995).

Natural resources on the planet are rapidly depleting as a result of growing industrialisation and urbanisation.

> "As a result, the world community is at a critical juncture at which it must deal with severe resource scarcity (Kothawade, 2017). Environmental issues have harmed regional cooperation and even sparked war in some circumstances (Tol, 2018). Green manufacturing (GM) methods have become normal practise for all members of cooperating nations in order to foster regional cooperation and protect natural resources. GM stands for manufacturing processes that not only reduce waste generation and natural resource depletion, but also assure that garbage does not end up in landfills (Cortellini, 2001). In general, genetic modification is an ecologically conscientious procedure that has a smaller negative influence on the environment. The Intergovernmental Panel on Climate Change (IPCC) recently stated that the average temperature increase had risen by 0.850 degrees Celsius (Porter, 2018). As a result, several corporations in a variety of nations have either implemented or expressed interest in implementing GM policies (Moldavska and Welo, 2017). Many manufacturing organisations have adopted the six 'R's (Reduce, Reuse,

> Recover, Redesign, Remanufacture, Recycle) practise, zero waste production, and lean manufacturing methods as GM strategy (Cimatti et al., 2017)."

Such GM practises benefit businesses financially by assuring the most efficient use of resources and maximising the value of waste (Rehman and Shrivastava, 2013a).

While implementing GM practises is vital for both large and small businesses, SMEs are more hesitant to do so (Tumpa et al., 2019).

> "SMEs are classified according to their size, organisational structure, staff count, and sales volume (Mukherjee et al., 2018). The adoption of GM methods is critical since SMEs' survival in global competitiveness has become difficult without them, and SMEs play a critical role in the economic development of countries all over the world. In this regard, it is vital to investigate the hurdles to GM deployment in SMEs. As a result, the goal of this research is to investigate and model the challenges to applying such GM techniques in SMEs. The limited adoption of GM practises by SMEs could be due to a variety of factors, including a lack of data, technical skills, infrastructure, and capital resources (Mittal and Sangwan, 2013). The situation is considerably worse in emerging-market SMEs, as there is a gap in GM advancement between developed and developing countries. The industrialised countries (such as the United States, the European Union, and Germany) have witnessed advances in GM deployment due to rigorous environmental rules and policies (Biju et al., 2015). In poor countries, however, the situation is rather different (Mittal and Sangwan, 2013). For example, Gandhi et al. (2018) found in a recent study on GM practises in India that the majority of manufacturing SMEs are unaware of GM techniques and so fall behind in adoption. Because SMEs are the most frequent form of business in developing nations, their low adoption of GM practises has a negative influence on these countries' environmental score."

In 2017, India, for example, ranked third in global CO2 emissions (Le Quéré et al., 2018).

Companies are being forced to take green initiatives seriously as a result of the paradigm change in policy towards a green economy. Companies, particularly those in the manufacturing sector, must take a proactive rather than a reactive approach in this regard. According to a UNEP assessment from 2011,

> "the global manufacturing industry consumes 35% of all electricity utilised globally and is responsible for 20% of global CO2 emissions, which is harmful to human life. While the foregoing arguments suggest that now is an excellent time for empirical study on green manufacturing and the implementation of green manufacturing frameworks, particularly for nations like India, which is rapidly becoming one of the world's leading manufacturing hubs alongside China."

It's crucial to understand the evolution of green manufacturing before we get into the issue of 'green manufacturing'.

1.1 What does it mean to be 'green'? Why is it significant

Green stands for biological manageability and encompasses a wide range of issues, including, but not limited to, air pollution, soil pollution, energy use, efficiency, and waste. Human influence should be reduced by green activities.

Society's growing concern about the green environment can be grouped into three categories:

a *Increasing emissions and the resulting climate change*

"Greenhouse gas (GHG) emissions have been quickly increasing in recent years, and this trend is expected to continue. Global temperatures have risen by 0.74°C in the last century1, the fastest rate of warming ever recorded". By 2050, emissions will have doubled compared to 2000 levels, if present trends continue. By the end of the century, this might imply a 4–6°C increase in temperature over pre-industrial values 2. It is expected that this unusual development will have a significant impact on the global ecology, hydrological system, sea level, grain output, and associated actions.

b *Rapid exhaustion of finite natural resources*

With the development in population and industrialisation, demand for common assets (for example, wood, coal, oil, food, water, and so on.) is rapidly increasing, while their availability is decreasing. This demand resulted in sporadic demand–supply mismatches, as well as wildly shifting prices, affecting both business margins and consumer spending. There may be a significant necessity

a to have enough wrist bindings to maximise the use of these assets

b to find and build less inadequate alternatives

c increasing pollution and waste generation.

The demand for increased industrialisation and urbanisation caused notable growth. Previously, waste creation and natural contamination were the main sources of pollution. Modern trash for concoction arrangement might be detrimental to one's health, and its transfer without medicine will result in contamination of the environment and water.

The release of mechanical effluents clogged beside streams and other water bodies would devastate the natural environment of the surrounding area. As people's interest in and use of electronic devices grows, e–waste will become a major source of natural pollution.

1.2 Transformation to green manufacturing

Companies in the manufacturing industry may solve these issues by focusing on three areas:

a *Renewable energy*

Green energy encompasses both processing and the use of greener energy. Given the firm's faith in the energy sector, this will be the first step. Green energy encompasses both the deployment of renewable energy sources such as CNG, solar, wind, and biomass, as well as increased energy efficiency in operations.

b *Eco-friendly products*

The second step in this transformation is to create greener products. 'Recycled', 'low carbon footprint', 'natural', and 'organic' are becoming popular buzzwords that are associated with green outcomes. It's possible that making green products will result in greater fetches. Organisations may get extra volumes and value premiums by designing

green goods that are aimed at customers and properly promoting them, which can offset their cost of improvement.

c *Environmentally friendly procedure in business operations*

The third domain is the implementation of green forms into operations. This comprises making efficient use of critical resources, reducing waste output via optimising operations, lowering carbon emissions, and conserving water. Green methods improve business efficiency while lowering expenses.

1.3 Factors influencing green manufacturing

Multiple companies have already started incorporating green efforts into their regular tasks. Five factors are driving these initiatives:

- increasing the cost of energy and inputs
- increasing customers appeal for green products
- regulatory constraints are increasing as policymakers enact new and more stringent environmental and waste management rules
- new business opportunities created by innovative advancements
- the necessity to improve competitive difference, especially for first movers or those who can break the compromise between short–term greater costs and a plethora of benefits (example: brand premium, new customer segments)

Green has progressed from being viewed as a 'necessary evil' to being regarded as 'excellent business'.

> "Green initiatives benefit companies in terms of brand enhancement, political influence, and regulatory requirements, as well as increased capacity to attract and retain personnel, improved client retention, and potential cost savings. However, because the economics of green manufacturing are still unknown, these benefits will necessitate a long-term commitment and trade-offs with short-term goals."

1.4 Background

Since the early days of the mechanical disturbance, those who investigate and control modern contamination have been identifying issues for society. Association's need been paying expanding thoughtfulness regarding ecological protection since the negative effects from claiming industrialisation were settled on government funded eventually by reports and books for example, such that 'Silent Spring' by Rachel Carson in 1962, which might have been republished by Mark Lytle in 2007. Government funded and governmental response on this book incorporated propel from claiming extra regulations and formation of the US Environmental Protection Agency.

That history about natural administration in Canada need generally reflected that of the US. Similarly, the Inception of the mainstream just-in-time (JIT) Intuition done manufacturing and supply chain management (SCM) – formed and popularised by Japanese Producers in the 1980s – could a chance to be followed again on Henry Ford's deliberations on vertically incorporate those automotive supply chain practices, and the

standards about JIT were main actualised for manufacturing effectiveness furthermore to decrease waste (Faurote, 1928). However, waste decrease in the early days of JIT might have been not for ecological security however for asset sparing high profit (Porter and van der Linde, 1995).

Stakeholder consideration and the risk of negative networking consideration rouse organisations with furnish majority of the data around their polishes (Nawrocka and Parker, 2009). Hence, sustainable supply chain administration (SSCM), otherwise called green supply chain management (GSCM) hones have been progressively received likewise associations battle until make green. Looking at those operational techniques and screening supplier exercises need get vital errands to managers, and a amount of organisations may be attempting with suppliers to decrease unnecessary bundling and conceivably.

Perilous materials and additionally with move forward their ecological profile, expansion benefit margins, and see all the supplier's suppliers on assess and diminishing natural expenses (Rao and Holt, 2005). Walley and Whitehead (1994) stated that reacting on ecological issues need continuously been a no-win proposition for managers; thus, managers bring translated ecological issues as a absurd logic and bring underestimated their company's abilities to turned green. As stated by late thinking, turning into green implies that both those benefits of the business and the nature's domain could incidentally proof win, and setting off green may be no more an expenses risk on organisations it may be a facilitator for innovation, new business opportunity, and riches production (Clarke and Manton, 1997). Nonetheless, some associations even now think that setting off for green practices might wind up for secondary costs which could forestall their results alternately benefits starting with getting focused preference again those rivals.

Due to global warming, "a scarcity of natural resources, and other difficulties related to waste management, the industrial industry is finding it difficult to comply with environmental norms and regulations (Rehman et al., 2016; Rusinko, 2007)". Green manufacturing practises (GMP) are being adopted by organisations all over the world as stakeholders become more aware of environmental challenges (Ghazilla et al., 2015; Rehman et al., 2016).

> "Consumers are crucial stakeholders who are becoming more aware of organisations' environmentally friendly efforts (Akehurst et al., 2012; Samarasinghe, 2012; Waheed et al., 2020). As a result, firms must transition from traditional to green manufacturing techniques, as customer behaviour shifts away from traditional purchases and toward environmentally friendly purchasing of products (Akehurst et al., 2012)."

Environmental research became popular in the early 1990s, and academics are still trying to grasp the implications of such topics in various dimensions and contexts around the world (Farrukh et al., 2019; Shetzer et al., 1991).

> "The public's attitude toward the environment and its protection is today overwhelming (Brochado et al., 2017; Farrukh et al., 2019; Muttakin and Khan, 2014). People are aware of the effects of organisational activities on the environment and are therefore drawn to companies that use green environmental manufacturing practises in their operations (Brochado et al., 2017; Deif, 2011a; Roberts and Bacon, 1997; Singh et al., 2019a; Tseng et al., 2013). The environment is an important aspect of corporate social responsibility initiatives, and it is regarded as an external activity or stakeholder of a company (Kim et al., 2011). Internal and external CSR initiatives have

> been studied by experts (Kim et al., 2011; Skudiene and Auruskeviciene, 2012)."

Internal activities concern internal stakeholders such as employees and the board of directors, and external practises concern external stakeholders such as the environment, which is the study's main focus.

Globalisation has given manufacturing companies all across the world access to global markets.

> "This promotes healthy international competition in the provision of high-quality goods. The rise of global competition in the manufacturing industry has driven businesses to expand and seek out new ways to improve their competitiveness. The manufacturing industry has also experienced difficulties from the global market, such as monetary fluctuations, political sway, economic stability, technological advancements, regulatory reorganisation, and concerns about the environment, all of which have shifted the competitive landscape on a routine basis (Issa et al., 2010)".

As a result of rising demand and limiting supply, the price of power and resources is always rising, according to Paul et al. (2014). These factors have a great impact on a company's operational and financial success.

> "One of the simplest ways for a manufacturing company to stay competitive is to reduce production and operating waste. Several large manufacturers have adopted the lean strategy to be competitive in the global market (Anand and Kodali, 2008). Lean is a well-known idea that has been used by a variety of industries (e.g., Toyota, Ford, Boeing, etc.). The notion of lean can be interpreted in a variety of ways, making determining its impact difficult (Parker et al., 2003)."

The term 'lean' is difficult to define.

> "Lean is more of a mindset than a set of tools, according to Bicheno and Catherwood (2005). On the other side, practical and project-based approaches define lean as a set of waste-reduction measures (Pettersen, 2009). Rodríguez et al. (2017) define lean as an integrated socio-technical system whose main purpose is to reduce waste by simultaneously lowering or reducing supplier, consumer, and internal variability. Nonetheless, waste reduction or elimination is at the forefront of all lean initiatives. The lean method provides various tools, practises, and tactics that can be used to find possible efficient production systems that consume fewer resources and generate less waste (Pettersen, 2009). Since the successful deployment of the Toyota Production System (TPS), lean manufacturing (LM) has been introduced in the industry (Maynard, 2013)."

LM is defined as a technique that eliminates any non-value-added activity in a production process, in addition to characterising it in terms of resources (Womack and Jones, 1994).

"Green manufacturing, as a concept created in developed countries in the 1990s, can help to reduce negative environmental impacts and increase resource efficiency across the entire industrial production system or process". Green manufacturing has evolved from 'technology for the 1990s' (Weissman and Sekutowski, 1991) to "concerns for the new century" (Sarkis, 2001), becoming the cutting edge in the pursuit of sustainable development and receiving increasing academic and practical attention.

> "Scholars have widened their research into green manufacturing from a variety of viewpoints, including the design of green manufacturing techniques, the drivers and consequences of green manufacturing, and green manufacturing

> technologies, after more than 30 years of development. As a result, existing research must be examined, and academic divisions in this field must be identified by determining the important sub-topics and research issues."

Some studies examined relevant green manufacturing research from a variety of angles". For example,

> "Paul et al. (2014) introduces several related concepts – environmental management tools, sustainable products, sustainable green operations, green supply chain management, and green applications – to review the description, importance, and approaches of green manufacturing from a practical standpoint. Garetti and Taisch (2012), on the other hand, examine the technological trends and challenges of sustainable manufacturing, concluding that four research clusters are involved – business models and procedures, asset and short product cycle management, asset and power system, and empowering technologies – each with a variety of topics. Green manufacturing's progress in polluting industries has been studied in depth. Shrivastava and RL (2017), for example, examines green production in the cement industry in depth".

Environmental issues are growing more significant, particularly in emerging economies. "As customers, the general public, and governments around the world become more concerned about environmental issues, many businesses have begun to employ greening strategies in order to gain consumer trust and public support, thereby improving their competitiveness (Zhu et al., 2008)". Earlier stages of industrialisation had a negative impact on the environment due to over-exploitation of natural resources and pollution/destruction of ecosystems.

> "As a result, more sustainable production processes are clearly needed to reduce the use of natural resources and harmful materials while also reducing waste and pollution emissions (Gap, 2017). Circular economies, which have been described in a variety of ways but are generally thought to improve resource efficiency by reducing waste and resource extraction (Lieder and Rashid, 2016), are envisioned as a new business model that will lead to more sustainable growth (Ghisellini et al., 2016)."

Natural resources on the planet are rapidly depleting as a result of growing industrialisation and urbanisation. As a result, the world community is at a critical juncture at which it must deal with severe resource scarcity (Kothawade, 2017).

> "Environmental issues have harmed regional cooperation and even sparked war in some circumstances (Tol, 2018). Green manufacturing (GM) methods have become normal practise for all members of cooperating nations in order to foster regional cooperation and protect natural resources. GM stands for manufacturing processes that not only reduce waste generation and natural resource depletion, but also assure that garbage does not end up in landfills (Cortellini, 2001). In general, genetic modification is an ecologically conscientious procedure that has a smaller negative influence on the environment."

The Intergovernmental Panel on Climate Change (IPCC) recently stated that the average global temperature had risen by 0.850 degrees Celsius (Porter, 2018). As a result, several corporations in a variety of nations have either implemented or expressed interest in implementing GM policies (Moldavska and Welo, 2017). "Many manufacturing organisations have adopted the six 'R's (Reduce, Reuse, Recover, Redesign, Remanufacture, Recycle) practise, zero waste production, and lean manufacturing methods as GM strategy" (Cimatti et al., 2017).

> "Such GM practises benefit businesses financially by assuring the most efficient use of resources and maximising the value of waste (Rehman and Shrivastava, 2013b). Multidisciplinary techniques confound green manufacturing. With a focus on lowering energy and material demands in industrial processes, energy consumption may be reduced by 60–70% with the primary use of renewable energy sources."

Green manufacturing will be linked to a variety of different environmental technologies, in addition to the inventive handling of energy demands. Green manufacturing entails three types of conversion for industrial use:

a using green energy

b using recycled materials

c using recycled materials.

(b) Developing and selling green products, and (c) incorporating green practises into business operations.

The origins of green GSCM may be traced back to the mechanical upheaval. However, morality have recently risen to the forefront because to increased sensitivity across countries and cultures to the negative effects of mechanical and other waste on the environment. As the concept of SCM gained traction, organisations began to integrate with suppliers and clients through various supply and conveyance logistics networks in place to ship items to clients with a competitive advantage. These natural concerns prompted organisations to incorporate components in regards to disposal, recovery, reusing, and reuse of material/energy waste generated within the scope of supply chain foundation. Significant manufacturing commercial enterprises over India need aid centring for decreasing energy consumption, water consumption, perilous Substances and waste emanation. Green obtaining organise is spreading very much quickly over India. The sway from claiming green processes likewise varies by those industry divisions.

For example – Green activities done control segment bring the greatest sway ahead. Lessening co2 discharges. The mechanical segment successful execution from claiming green manufacturing obliges setting off Past little standalone activities and adopting an incorporated three step framework;

a organising to become green as a primary and exclusive corporate strategy

b carrying out green activities across the quality chain by advancing toward green energy, green outcomes, and green forms

c communicating and promoting the benefits of green initiatives to stakeholders.

Green manufacturing will provide massive advantages to those countries and businesses, both tangible and intangible. Green manufacturing refers to production processes that are highly efficient and produce little or no waste, as well as pollution. Source reduction, often known as minimum waste or pollution, or prevention, repurposing, and green product design are all part of green manufacturing. Source reduction will be thoroughly defined and included. Using or reusing wastes similarly to components before, a transformation or related illustration a powerful replacement to company goods, or giving back are all examples of waste reduction activities. Those wastes from the initial transform that were used as a raw material feedstock alternative.

2 Literature review

The literature was searched using the Google Scholar (GS) database by various keywords like 'Green manufacturing', 'Environmentally conscious manufacturing', 'sustainable manufacturing', 'clean manufacturing', and 'sustainable production' were used to find papers.

> "Instead of using the Thomson ISI Web of Knowledge database, which is regarded the most often used source of bibliometric data, the GS database was used for literature search due to its larger data coverage (e.g., including conference proceedings, working papers, and books). The coverage of the GS database is not as methodological as that of the Thomson ISI database (Harzing and van der Wal, 2007; Schiederig et al., 2012). However, citation coverage is more complete when using GS data, especially in the fields of management and international business (Harzing and van der Wal, 2007)."

The literature also contains evidence that the data taken from the GS database covers the relevant literature Schiederig et al. (2012). As proposed by Webster and Watson (2002), the literature search was undertaken by topic rather than by (top) journal to include 'all' published publications in this discipline. Journals, conference proceedings, books, book chapters, and working papers were among the paper genres extracted.

This section is divided in to two different sections. In Section 1 summery of the different principles and explanations of ongoing efforts in the area of green manufacturing. GMP and methods discussed within the evidence of current research are contained in Section 2. These two phases ensure that the ideas highlighted in this paper are better understood.

2.1 Green manufacturing

With the evolution of standards, especially in the UK, the government started introducing environmental policies in the early 1990s, which culminated in an increasing interest in GMP. Main objectives of GM are to reduce the utilisation of natural resources by replacing it with alternative methods to manufacture finished products, efficient production methods and products (CII, 2011). More and more businesses started to adopt GMP after the inclusion of ISO 14001 in 1996, resulting GM sector expanding rapidly, and scientists started to investigate these strategies. There are other drivers, apart from the motivational power of ISO 14001, which pressurised the implementation of GM. In the study of Turkish SME enterprises, researchers Agan et al. (2013) examined the impact of drivers on the company performances. Earlier, GM was named as environmental conscious manufacturing (ECM); Richard examined the ECM challenges and barriers with very interesting way, for instance life cycle analysis method design advice. Zhang and Po Yuk (1998) implemented the approach to the life cycle and the expense of the life cycle in the implementation of quality functions to enhance GM as demonstrated by an illustration. With numerous factors, including environmental, social, and economic indicators, the metrics for GM were suggested by Reich-Weiser et al. (2013). Rao (2011) looked into GM's advantage in terms of technical, operational, management of financial and circumstantial threats. Mittal and Sangwan (2013) used statistical analysis to investigate a framework and the most powerful barriers to environmentally conscious development (ECD). Internal hurdles are the most challenging obstacles to GM, according to the researchers, and they must be solved. Jian et al. (2021)

derived the fundamental concepts of green manufacturing as well as the factors that are needed to boost green manufacturing activities by promoting low-carbon energy efficiency.

Lee et al. (2009) collected data from two businesses, one in the acoustic equipment industry and the other in the electronics industry, using qualitative methodologies, case studies, in-depth interviews, and document analysis. The findings revealed that existing business and management literature has mainly disregarded green management approaches in small and medium-sized businesses. Small and medium-sized businesses may become greener by implementing strategic and organisational improvements, according to the report. Organisational structure, innovative capabilities, human resources, cost savings, and competitive advantage can all affect organisational change for greener management. The findings of the case studies backed up this assertion. More research is needed, according to the paper, to determine how management practises can prevent negative sustainability implications. The study contends that such study can benefit from other fields' methodological and theoretical ideas. Li et al. (2010) investigated the atopic design and implementation of green manufacturing strategies for Chinese businesses in the context of energy saving and pollution reduction. Green manufacturing strategies in major developing countries must be implemented over time and with an emphasis on continual development. An integrated framework at the system level is required for formulating and implementation the strategy. A five-layer theoretical model for designing and implementing a green manufacturing strategy in a developing world context is proposed. Because the planning and implementation of a green production strategy may differ by industry, further empirical study is needed to strengthen the conclusions.

Feng (2010) investigated Green Company and Green Consumers with the goal of re-examining corporate social responsibilities in terms of the ethical criterion of 'greenness' by examining one company's response to green consumers over a period of time.

> "In order to balance the short-term profit-oriented drive with the long-term desire of fulfilling one's duty, he concluded that all corporations should transition to Kantian responsibility with appointment of a senior ethical officer and the development of an ethics department. The relationship between green sustainability and green performance was explored by Kung (2012). This was accomplished by taking into account each operational element, such as upstream material supply and purchase, research and development, production and packaging, marketing, promotion, and education, and recycling activities. They conducted a study of 118 Taiwanese manufacturers and collected data from them. The findings suggest that green value chain governance and environmental performance are linked."

According to the findings, organisations that simply apply green management in specific areas have a negligible impact; nevertheless, a full application can result in a significant positive effect on environmental performance.

> "Sezen and Sibel (2013) investigated the impact of green manufacturing and eco-innovation on industry sustainability. They used a questionnaire-based survey to collect data from 53 automobile, chemistry, and electronics industries, and then used regression analysis to assess the empirical model and verify the study's hypothetical links. Green manufacturing applications have a considerable positive impact on environmental and social performance, according to the findings of this study."

Furthermore, eco-process innovation has a positive impact on business sustainability. Eco-product innovation, on the other hand, did not appear to have a substantial impact on any of the three types of performance.

Digalwar et al. (2013a) investigated how to measure the performance of green manufacturing techniques in Indian manufacturing industries. They look at the questionnaire, which had 128 items/variables and was constructed based on literature and conversations with nine manufacturing industry oracles, with a focus on green manufacturing. The contemplation discovered Top leadership dedication, organisational learning, employee training, green process and product design, employee empowerment, ecologic health and security, suppliers and materials management, production schedules and command, quality, cost, customer environmental examination, customer responses, and company growth are among the 12 performance counts of green manufacturing that have been developed. This survey received 108 legitimate responses from Indian manufacturing firms; however, the study's sampling was insufficient. Vamsi et al. (2014) investigated the notion of 'green product development', which has become a worldwide phenomenon. The primary goal of green product development is to lessen the global impact of industrial expansion on the environment. They notice a significantly disjointed use of elements when it comes to developing green products. With the help of a relevant survey, the study identified 80 distinctive characteristics and 11 pillars to provide a comprehensive theoretical foundation in the green field product creation.

Sangwan (2015) investigated the origins, definitions, breadth, similarities, differences, and publications of green manufacturing and similar frameworks. He discovered that scholars have utilised all eight frameworks interchangeably, but that some uniformity is needed. During the literature review,

> "it was discovered that in order to standardise terminology, researchers must explicitly state in their studies the use of various life cycle engineering approaches, clarity on end-of-life strategies, clarity in the use of various components of triple bottom line perspectives, inclusion of the entire supply chain, and integration of environmental improvement strategies with business strategy. Fore and Mbohwa (2015) investigated a continuous process industry, the cement manufacturing industry, in order to find greening opportunities in its operations. The study examines aspects of the cement industry that have an environmental impact, with a particular focus on the industry in a developing, low-income country."

In a case study approach, a cleaner production technique was adopted, concentrating on issues such as gaseous emissions and particle pollutants. There are choices that are both capital intensive and less capital heavy. The study sheds light on how change is implemented in the continuous process industry. It proposes that strong leaders operate as 'integrating forces' on two levels: integrating corporate identity elements and mediating between corporate branding systems and individuals. The clinker conveyor was redesigned, and the dust transport network was restructured, among other capital interventions. It is necessary for developing nations to detect and monitor modern industrial interventions, as well as to embrace them. The case study approach utilised in this work has the drawback of focusing on a single cement factory in a low-income country. As a result, the conclusions and options presented may not be generalisable, as processes in different industries and economies tend to differ.

The positive relationship between GM and OC is strengthened by lower pollution levels in the local city. Furthermore, the degree of local pollution and the transparency of

local government pollution information have a synergistic effect. Businesses' OC rises when both local pollution levels and local government pollution information transparency are high. Firms' OC rises when both local pollution levels and local government pollution information transparency are low (Tong et al., 2018). A thorough assessment of the literature yielded critical success factors (CSFs) for GM and its sub-factors. The Cronbach's alpha was used to assess the variables' reliability. The analytical hierarchy process (AHP) pair-wise comparison approach was used to finalise the priority of CSFs after computing internal consistency. In this main area for improvement, it is suggested that a collection of measures be taken to improve the adoption of GM practises in Indian organisations. They also learned about how GM CSFs are identified, interacted with, weighted, and ranked in Indian manufacturing organisations. SAP-LAP is used to analyse three case studies and validate their constructs. This validation looked into the scope and efficacy of the proposed GM paradigm in the Indian setting (Toke and Kalpande, 2019). In today's global market, the most pressing challenge is supply chain production and distribution of commodities to improve customer satisfaction in the shortest time possible while spending the least amount of money. On the other hand, lowering the total cost of transportation and distribution is one of the most significant goals for businesses. This study attempts to solve this problem by offering an inter multifacility model of a greener closed-loop supply chain (GCLSC) operating in an unpredictably changing environment. In this paradigm, the GCLSC proposes three classes for the leading chain and three classes for the recursive chain. The GCLSC's total profit, need satisfaction, client satisfaction, and reaching to the correct cost of customers, distribution centres, and recurrence centres are all objectives. Then, in order to evaluate the chance of product recovery, a model is constructed by taking into account a range of objects over a variety of time periods (Karimi et al., 2019). Finally, to evaluate the proposed model, a large number of numerical cases are generated at random and then solved using a nondominated sorting genetic algorithm and a nondominated ranking genetic algorithm. They are then ranked in order of preference by resemblance to the ideal response, utilising TOPSIS and the so-called analytical hierarchy (AHP-TOPSIS).

Bennett et al. (2019) looked at how flow chemistry is developing and how it could be applied in green strong chemical manufacturing and effective chemical reaction space screening. Continuous manufacturing techniques are being used more frequently to reduce the amount of material and energy used in a process while also including real-time analysis, control, and process safety. Flow screening methods, in addition to continuous production, may quickly explore an inter reaction area to increase process design, efficiency, and efficiency. Time and material-saving (green) flow screen platforms can also be used to generate a new generation of process development technologies, such as predictive reaction models and procedure scale-up techniques. (Mao et al., 2019) Process safety concerns include recognised knowledge acquisition with scarce labels, knowledge-based reasoning for process safety, proper synthesis of heterogeneous data from varied sources, and effective learning for dynamic risk assessment and assisted decision-making. Green manufacturers must determine whether or not to collect quality data from third-party assessment organisations and whether or not to share that data with other supply chain partners. While prior closed-loop supply chain (CLSC) research has not looked at voluntary and required information sharing, this study looks into a green manufacturer's quality information disclosure techniques after acquiring quality data in the CLSC. Green manufacturers must determine whether to collect quality information from third-party assessment agencies and whether or not to share such information with other supply

chain players, according to Hong et al. (2021). While prior CLSC research has not looked at voluntary and required information sharing, this study looks into a green manufacturer's quality information disclosure techniques after acquiring quality data in the CLSC. They also unveiled a new decision-making tool to assist green manufacturers in determining whether or not to seek quality information from a third-party quality review organisation prior to revealing it. Surprisingly, the research shows that when a green manufacturer refuses to analyse product quality and instead acquires information from a third-party quality evaluation agency, CLSC members earn more. Consumer preferences for green products are also taken into account in their research, giving useful management insights such as a green manufacturer's readiness to spend a higher information acquisition cost in order to receive high-quality data when customers demand it. In addition, the new condition under which a green manufacturer is willing to provide product quality information in CLSCs was found, as well as its practical implications.

Green manufacturing has been gaining academic attention since the 1990s, with the growth of several associated concepts, as one of the most important topics for human development's long-term sustainability. Following nearly three decades of expansion, a broad map of extant research is now needed to highlight the major concepts and challenges at hand.

> "Pang and Zhang (2019) created a framework for integrating green manufacturing into the economic-social-environmental system, and classified green manufacturing research into three categories: application, organisation, and system. They use a framework to incorporate the current research structure and research boundaries in the discipline, as well as to propose future research paths."

Businesses are increasingly focused on green manufacturing as the relevance of environmental effect and wasteful use of production resources caused by industrial expansion grows. The present green manufacturing standard system covers all aspects, levels, activities, and functions of green manufacturing. However, it does not go into detail about the specific components of the green production line and framework in different industries. The research described in this publication can help to close this gap. (Zhang et al., 2019) identified a general paradigm and framework for green manufacturing in industrial settings. As a result, businesses may devise and implement a clear strategy for implementing green manufacturing that is tailored to their own needs and circumstances. It will be feasible to increase the overall green rate improvement ratio for firms by doing so. This research proposes a generic reference model for green manufacturing based on the IIPG (Industrial Implementation for Product Cycle based on Green Index System) modular. The model is then tweaked and evaluated by creating a case study with three companies from three different industries. Greater data processor efficiency and computation speed in green index systems, which is the obey work, could improve this system by incorporating with intelligence technology such as artificial intelligence and industrial cloud.

In a fuzzy context,

> "the identified barriers are ranked and their interrelationships are investigated using a novel integrated multi-criteria decision making (MCDM) framework that combines the Decision- Making Trial and Evaluation Laboratory Model (DEMATEL), Analytical Network Process (ANP), and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS). To ensure that the results are consistent, a sensitivity analysis is undertaken. According to the

> findings, the most crucial category of barriers for manufacturing SMEs in India is the core category, which includes many challenges connected to a lack of internal capabilities and strategy. Lack of research and development (R&D), failure in eco-design, and lack of accreditation are the three most significant impediments, respectively."

The findings of the study can be used to design appropriate methods to overcome the hurdles, which will be useful for SME practitioners in Indian manufacturing SMEs.

Yin et al. (2020) investigated to improve green technology innovation (GTI) capability and multi-agent cooperation competitiveness, capability and its affecting elements. First, a questionnaire survey was used to create a GTI competency evaluation index system for manufacturing businesses working in multi-agent collaboration (MEUMC). Second, the consistency and decision-making trials assessment model and the evaluation laboratory (DEMATEL) model were integrated to assess GTI's competence and affecting elements. The following are the most important empirical findings. The evaluation approach for MEUMC's GTI capabilities should consider four factors: input elements, technical output, economic output, and GTI's social impact.

> "The proportion of green R&D expenditure in total R&D expenditure and the share of new green products in the total number of new products are the core factors influencing MEUMC's GTI capability; the proportion of green technology transformation and regulatory incentives are the direct influencing factors. The most essential factors are the percentage of green technology transformation, user acceptance of green technology products, market driving forces, and regulatory incentive factors."

To assess GTI's capability, a combination of subjective and objective approaches might be used. The results of single-evaluation approaches can be integrated using compatibility and consistency criteria.

Green human resource management (HRM) has long been seen as an important strategy for companies looking to become more sustainable. (Yong et al., 2020) used qualitative exploratory study to find out more.

> "They acquired the data through moderately face-to-face discussions with human resource management managers and directors from four major Malaysian manufacturing companies. After that, the data was separated into four categories. Four key factors influence the adoption of Green HRM, according to the survey and stakeholder pressures: relative advantage, which refers to the perceived benefits of integrating Green HRM, upper executives, and green intellectual resources, which refers to intangible resources incorporating green initiatives or environment protection. Surprisingly, only green human capital and green structural capital were heavily discussed by human resources directors and managers, whereas the importance of green relational capital in the implementation of Green HRM was barely highlighted."

Afum et al. (2020a) investigated the relationship between green manufacturing, operational competitiveness, corporate reputation, and long-term performance, as well as a mediation technique.

> "According to the experts, green manufacturing has a major positive effect on social, financial, and environmental results. Firm reputation and operational competitiveness, on the other hand, were shown to have little impact on economic performance. According to the mediation study, operational competitiveness, corporate reputation, and environmental performance have little effect on green manufacturing and economic performance. Furthermore,

> social performance appears to influence the association between green manufacturing and economic performance."

Environmental protection is a significant issue that must be addressed, according to Hao and Lin (2020). Green manufacturing must be the foundation for the manufacturing industry's long-term success. As a result, based on a full understanding of the meaning and features of green manufacturing technology, efforts are made in core technologies such as green design, green materials, green process, and green treatment. Integration, parallelism, intelligence, industrialisation, and socialisation will be used to create a faultless green manufacturing system, and globalisation of green products will be realised through assimilation, parallelism, intellect, industrialisation, and social conditioning.

Lean practitioners employ optimal lot sizing as a major tool to remove irregularities in the production system by reducing inventories, which are usually viewed as waste in the lean culture. "Managers strive to understand the environmental implications of the industrial system and find strategies to alleviate these effects while aiming for environmental protection. From a sustainability standpoint, carbon emissions are the principal causes of pollution contamination and degradation". Tayyab et al. (2019) proposed a quantity production model with unknown demand and process data. This weakness in the manufacturing process leads in an unpredictably high proportion of defective goods that must be reworked to improve quality and reduce waste.

> "To control this uncertainty in the manufacturing process, the decomposition idea and the signed distance approach of fuzzy theory are applied. The manufacturing process is studied from an environmental standpoint, and a viable lot size is found using an active Weight Fuzzy Goal Programming (WFGP) approach to achieve both economic and environmental sustainability."

The model's practical implications were tested through experimental research, and the results were assessed using a sensitivity analysis. Significant management insights and visual demonstrations are added to the model.

> "Green supply chain integration (GSCI) was used to develop an explanatory relationship between green manufacturing (GMPs) and sustainable performance (Afum et al., 2020b). (economic [EP], environmental [EnP], and social [SP] performances). They investigated whether GMPs had a significant positive impact on long-term performance (EP, EnP, and SP). GMPs had a considerable positive impact on GSCI once more. GSCI also serves as a link between green manufacturing practises and long-term performance."

Li et al. (2020) looked into the relationship between stakeholders, green production, and practise effectiveness in the Chinese fashion industry, with the goal of helping firms raise environmental awareness and apply green manufacturing practises. They acquired information by designing questionnaires for a number of Chinese companies. "A five-point Likert scale is used to allow respondents to indicate how very much they agree with the items. The questionnaire was shown to be reliable, the structural model model has a high degree of fit, and the hypotheses were found to be correct through testing and analysis". Corporate stakeholders have a strong positive impact on green manufacture and practicing performance in the context of Chinese fashion enterprises, and green manufacturing has a large positive effect on practise performance.

The Lean Manufacturing tool ensures product quality and an efficient method of production and processing. Logesh and Balaji (2021) showed through study that how lean manufacturing may be used at all phases of the manufacturing process to detect and

eliminate waste. The production of electrical switches and switchboards necessitates the use of hazardous chemical powder moulding under high pressure. Employees and the environment are both at danger in this manufacturing process.

> "The process of generating and developing eco-friendly safe products for consumers, workers, and those who utilise them is known as green manufacturing. Environmental contamination is covered, including sewage disposal and supply, environmental conservation, pollution control, compliance, material recycling, and other issues related to green manufacturing."

They also look into the connection between lean waste and its impact on green activities. This clearly indicates that by eliminating lean wastes during production, negative environmental effects can be reduced, resulting in green manufacturing. In this study, "Leong et al. (2019) looked at the evolution and contributions of lean production and green manufacturing. The research's key contribution is to focus on the use and impact of lean and green manufacturing practises. The frequent challenges and misunderstandings in the manufacturing industry are investigated". This research looks at the similarities and benefits of both lean and green methodologies, as well as the synergy effect, application tools, and common misconceptions about lean and green. "It allows industries to have a better understanding of the tools applications and challenges before implementing the lean and green approach. This paper also fills in any research gaps relating to the industry's need for a lean and green implementation strategy". Closing the achievement gaps for lean and green approaches will make a significant contribution to industrial sustainability in the long run. The influence of green manufacturing (GMP) in two streams – pollution protection practises (PPP) and product stewardship procedures (PSP) – on pro – environmental behaviour (ECCB), as well as the mediating effect of green product innovation (Waheed et al., 2019). Consumers in China who buy ecologically friendly products were polled. GMP and ECCB have a favourable association, according to the findings. GPI, on the other hand, was discovered to have a positive mediation impact on GMP and ECCB. According to the multidimensional study, PPP and PSP show good relationships with ECCB. The findings have implications for green production in terms of how organisations can achieve stakeholder participation by incorporating green practises such as GMP, PPP, PSP, and GPI into their manufacturing operations. This study also makes recommendations for academicians and practitioners in the future.

Each initiative and organisation must deliver excellent quality while lowering costs. Nowadays, it is really difficult to compete with our firms when they undergo growth. So, in order to get exceptional results, these companies use a lean assembly technique. SCM aims to raise the yield standard by identifying and eliminating the sources of flaws. (Singh et al., 2018) gathered data from a variety of businesses and used the unshakable quality test, AHP, and VIKOR. They deduced from these findings that profitability and cost are dependent on many aspects of each industry. A visible commitment, representatives working even more usefully, a change in the nature of the item, and efficient working aids in achieving favourable outcomes, according to SCM. The execution is influenced by senior management's inspiration and support, as well as the group's pioneer. Singh et al. (2021a) explored that in order to remain competitive in the market, businesses must focus on core competencies. All manufacturing companies have comparable core competencies. The improvement of the organisation's performance parameter is aided by core competency. According to the literature, every company should invest in enhancing its core competency in order to achieve a competitive

advantage. Technical or managerial core competencies are also possible. These essential talents can lead to a better product, possibly one-of-a-kind. Finally, each company should develop its own distinct items that will help it remain competitive in the marketplace. Companies are always changing in order to renew capabilities and get a competitive advantage in today's hyper-competitive environment. Owning and nurturing the resources and competencies that make up the business's soul is the key. Industry regulators and professional bodies must foster innovation in a wide spectrum of high-tech manufacturing facilities while keeping the environment in mind, according to Singh et al. (2021b). The success of the industry is decided by its manufacturing facilities and the competitive advantage gained as a result of improved quality and reliability. The bulk of production strategies are now influenced by quality, affordability, delivery, innovation, and response. Production tactics such as simultaneous engineering, increasing efficiency through defect removal, setup reduction, and so on, as well as worker empowerment, have traditionally been used to achieve these goals. This study provides a multi-criteria decision-making analytical paradigm (MCDM).

2.2 Implementation barriers for GM

According to Kogg (2003), one of the key reasons why organisations do not implement GSCM techniques is a lack of clout. Small businesses, in particular, claim that they have the ability to modify their ways. Suppliers' attitudes toward more environmentally friendly manufacturing practices are limited. Some people proposed. The following are some tactics to encourage other businesses to adopt GSCM practices: locating someone another person of similar size to cooperate with in order to balance the power; Premiums are paid to encourage participation.

Collaboration; Facilitation of the changes that suppliers must make by assisting them through the process selection of the suitable partners in terms of a trustworthy relationship; provision of skills and training relationship, as well as the prospect of mutual improvement.

According to Hervani et al. (2005),

> "a number of issues inhibit small and medium-sized businesses from implementing GSCM techniques, including a lack of financial resources, the organisation's management structure, managers' lack of knowledge and training, and so on. Employees as a result of their short-term orientation and the low status of environmental issues in the workplace company, as well as a lack of ability to secure key environmental technologies."

Interactions with stakeholders However, same stumbling blocks can also be seen in larger organisations. Companies are particularly concerned about a shortage of financial resources. According to Robinson and Wilcox (2008), some businesses view environmental challenges as a risk of increased expenses. Nearly half of the companies polled believe that a stronger environmental commitment will result in greater costs. Nonetheless, the other half sees this as a cost-cutting opportunity.

Another flaw discovered in Kogg's (2003) case study is that the investigated company became more reliant on fewer suppliers as there were fewer green product wholesalers. As a result, for other organisations interested in using GM, this dependency is a deterrent. However, as more companies become green and offer more sustainable products, this element may lose its relevance in the future. Handfield et al. (2005) stated some environmental issues, such as the 'low-hanging fruit', are relatively easy to capture.

Following these initial steps, top management must go beyond simply committing to green policies and must actively support them at all levels.

> "Managers, in particular, need to know what to do at the operational level, such as whether to buy traditional items based on cost, quality, and lead time targets, or whether to acquire more expensive environmentally friendly materials. These problems are difficult to solve and necessitate a new set of methods and information. Companies have difficulty locating sufficient data and information for GSCM choices, according to Thierry et al. (1995)."

According to reports, information is frequently dispersed around the organisation, as well as among all essential companies in the supply chain, or is unavailable entirely.

The absence of integration of environmental factors in purchasing decisions is identified as a barrier to GM in a report for the Business for Social Responsibility Education Fund (Suppliers' opinions on greening the supply chain (2001). Companies demand environmental sensitivity from their suppliers, but do not factor this into their purchasing decisions, instead focusing solely on cost, quality, and lead time. Other roadblocks include increased environmental product costs, a lack of lead time to create ecologically friendly solutions, technological challenges, existing procurement standards, and a lack of invention protection. Lack of motivation resulting from a weak business culture, according to Angel del Brio et al. (2008), is one of the most significant barriers to organisations implementing environmental policies. Similarly, according to Heymans (2002), ineffective implementation of new ideas and practices is due to weak leadership. Some employees in these firms may have the desire to make environmental changes, but top management must initiate and encourage a growing supportive attitude and company culture. "Nathan (2007) examines the effects of the just-in-time method on a company's environmental performance. A positive or negative influence might occur depending on the design and environment. However, in most circumstances, it has a negative impact due to poorer efficiency as a result of more empty truck journeys". This means that just-in-time tactics are incompatible with businesses' desire to go green.

2.3 Commonly used tools, techniques, and approaches

Researchers use a variety of approaches and statistical tools to investigate GM-related challenges, as detailed in this section. Bocken et al. (2014) developed plausible business model archetypes to represent groups of processes and solutions that could help in the development of a long-term business model. According to Jayaram and Avittathur (2015), who used a Delphi research process to develop a theoretical framework for GSCM, green design, reusing materials, and outward logistics were significant parts of green supply chain strategies. Sarkis (2003) analyses if the analytical network process (ANP) model can be used to make decisions in the green supply chain. Scholars (Govindan et al., 2014, 2015) used the analytical hierarchical process (AHP) technique to develop a foundation for defining and prioritising the easily follow of GM, as well as an abstract model based on cross research study analysis to measure the influence of lean, adaptable, and green SCM practises. Two-tailed t tests and static analysis of variance (ANOVA) techniques were employed by Seth and Tripathi (2005, 2006) to compare the effects of quality methodologies on firm performance in India's manufacturing industry, underlining the importance of green improvements. To assess and evaluate the green and lean connections in the study model created a model and employed structural equation modelling (SEM). Kirchoff et al. (2016) use SEM to test a theory-based GSCM model

that looks at how organisations achieve both economic and environmental objectives. Confirmatory factor analysis (CFA) was utilised by Zhu et al. (2007) to examine the measuring features of GSCM implementation elements and performance results. Rather than utilising SEM (Dubey and Ali, 2015) used factor analysis and hierarchical regression analysis to investigate the effects of supply chain (SRM) and total quality management (TQM) on sustainability impact (HRA). Green performance can be judged on three levels, according to the EPA: strategic, strategic, and practical (Andersen and Fagerhaug, 2002). Diabat and Govindan (2011) used a structural model programming (ISM) approach to build and analyse a GSCM model. López and Montalvo (2015) created a concept for the chemical industry that represented five stages of environmental issues and stated that the business is evolving along new technical trajectories. Mittal and Sangwan (2013) build a model that takes into account environmental, social, and economic issues using a fuzzy technique. (Teles et al., 2015) investigated GM businesses in Brazil using cluster analysis. (Laari et al., 2016) employed partial least squares SEM to establish whether or not GSCM procedures in Finnish manufacturing are customer-driven. Jabbour and de Sousa (2016) provided a conceptual and functional framework for GSCM interactions that includes social and economic factors to contribute to sustainable organisations. AHP was utilised by Govindan et al. (2013) to describe GSCM strategy implementation hurdles in Indian manufacturing businesses.

3 Conclusion

Through literature review of more than 200 papers, most influential parameters are concluded which have positive effects for the implementation of green manufacturing in the Indian manufacturing industries. These parameters are shown below in Table 1. These parameters can also be sub divided into more parameters for covering all type of manufacturing industries.

Table 1 Green manufacturing parameters

S. No.	*Green manufacturing parameters*
1	GM implementation issue
2	Role of legislation in promoting GM
3	Organisational style
4	Eco-knowledge
5	Business environment
6	Society influence
7	Financial incentive
8	Innovations

4 Future scope

These identified parameters can be further utilised to implement the green manufacturing in various industries and the performance can also be tested. Apart from this these

parameters also plays important role to implement green and sustainable manufacturing concept other than manufacturing industries also.

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