Analyzing the Key Performance Indicators in SME using Hierarchy Process

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Abstract: Small to Medium Enterprises (SMEs) in a country play an important role in its socio-economic well-being. Its development and well-being will be beneficial for the firm as well as the country itself, recognizing the same governments have provided policy reforms and incentives to SMEs. Now a day, many companies may have performed poorly because they lack effective and efficient performance management frameworks. Moreover, strategies to adequately and judiciously allocate resources to meet organisational goals. So most of the SME's lack an awareness of their performance compared to their peers and the areas in which they are slacking. For that, Performance measurement plays a vital role to improve the performance of the firm by identifying the obstacles in the system.

Therefore, this paper aims to analyse the performanceindicators for measuring the performance of SMEs and ranking it against its peers, it will identify the areas the firm is lagging in and will help in improvement. Performance measurement enables an organisation to plan, measure, and control its performance with the aid of pre-defined strategy. Therefore, it enables it to achieve its desired goals and to create shareholder value. For analysingthe performance indicators, , A Multi criteria decision-making tool ,Analytic Hierarchy Process is used.

Keywords: Small and Medium Enterprises, Performance Index, Multi Criteria Decision Making, Best Worst Method**.**

Introduction

Global economic development has been greatly assisted by the manufacturing sector. Creating jobs and export revenue that can be reinvested in the domestic economy is a net positive. It's no secret that economists, scientists, and politicians are eager to establish metrics for evaluating manufacturing performance. Although neither the small nor the large scale manufacturing sectors saw a significant movement in the technological forefront over the study period, they are both incredibly efficient as a result of enhanced operation and management. Large-scale industrial industries benefit more from scale efficiency than from effective operation and management. In contrast, the efficiency seen in the medium and large-scale industrial sectors may be the result of advancements in both operation and management that have made it possible for them to adopt new technologies and innovations. Inadequate progress has been made in the pace of growth of productivity across any of these industrial sectors. Intending to increase production, manufacturers have been attempting to leverage their current infrastructure and managerial practices to their fullest potential.

The performance measurement system is the backbone of the whole quality management. Normal performance indicators include both process and result metrics [1]. In today's competitive business environment, efficiency is the single most important factor in determining a company's success or failure. A company's efficiency is one metric that should be considered while evaluating its success. Maximizing output, minimizing expenses, and maximizing earnings are all indicators of productivity. The ability to maximize earnings from a given set of resources or to reduce the amount of labour needed to generate a certain output is one indicator of a company's technological efficiency. Producers attempt to be as frugal as possible with their output. Traditionally, financial metrics including revenue growth, net income, cash flow, and return on investment have been the primary focus of KPIs used for performance evaluation. [4]

Both monetary and qualitative metrics are necessary for measuring an organization's performance[2]. Measuring efficiency is important since it is a key measure of a company's performance. Factories, banks, and private enterprises of all sizes need top-notch performance to keep up with the competition in today's global economy. As a result, increasing productivity is a top priority in today's business world. For every country to thrive, its government and businesses must function at peak efficiency. This is the main concern of every group since it is the key to achieving their goals.

The manufacturing sector has always been a major driver of economic expansion. Nations with a strong industrial base tend to build and expand their economies over longer periods. Globally, industries are undergoing profound changes as a result of technological developments and processes that have allowed the development of new goods and services and new methods for guaranteeing regulatory compliance. The health of the economy as a whole is profoundly impacted by the manufacturing sector. Yet, the development and expansion of this sector are determined by external variables such as improved availability of raw materials, experienced labourers, reliable power sources, cutting-edge technologies, a plethora of competitors, globalization, etc.

More than any other part of the company, the introduction of new products is received with excitement and expectation. Managers in both well-established businesses like automobiles and electrical appliances and newly-emerging industries like computers see the introduction of new products as a way to gain an advantage over their competitors. If an invention is revolutionary, it will either create new industry standards that make it difficult for other firms to enter the market or it will open up whole new consumer markets.

Literature review

This part of the study reveals that for companies to successfully embrace the lean production paradigm, they need to demonstrate the impact of applying various practices using a variety of performance measures. Indicators track development so far and point to places for potential expansion in the face of fierce and ever-changing market competition. By putting them in order of priority, the AHP technique helps us prioritize our efforts. Based on a review of the literature and discussions with academics and practitioners, the authors have identified

18 factors/indicators that significantly measure leanness in MSMEs and have proposed categorizing them into three groups (organizational aspects) according to impact and similarity: financial, operational, and human resources. Each of these three groups is essential to a well-executed plan [33]. Also, these elements aid in the development of the system and the achievement of our ultimate objective of providing a comprehensive and developing view of the deployment process.

To close knowledge gaps and uncover industry demands for the assessment of equipment, studies on key performance indicators (KPIs) have been done. These studies analysed the cutting edge energy-use metrics in the industry. Job creation, equality, latent resources, the trickle-down effect, insurance against social tension, a distributive impact, the formation of a social eco-system, decentralization, and so on are all arguments in favour of small-scale enterprises in a nation like India. It's easy to overlook the contributions of small businesses to the growth of an economy. Sections of government budget documents are often dedicated to celebrating the success of small and medium-sized businesses. The minimal overhead expenses of creating a high quality product or service in a short period are only one of the many benefits of running a small company. Businesses in the area do well, which helps the economy as a whole. The contribution of the small-scale sector to the national economy may be measured in several ways, including the number of units, output, employment, and exports.

Small businesses in India have not changed their technology despite the widespread availability of more advanced options; this is likely owing to a lack of operational and investment know-how, a reluctance to spend money, an inability to take part in technical discovery and advancement, etc. Labour productivity declines as a result of ICT investment, while the economy as a whole benefits from the increase in output. It is impossible to conduct a once-and-for-all study on the causal relationship between the elements that help in assessing the performance of small companies because of the dynamic nature of small firms.

MSMEs have become an essential and dynamic engine/sector for the growth of economies in developing countries throughout the world as a result of their use of local resources, high job generation, and low investment costs. The overwhelming majority of the world's companies are micro, small, and medium-sized enterprises (MSMEs), according to the International Enterprise Association [34]. These companies are crucial to economies since they account for 60% of all net new employment.

Besides trade and other services, some 31% of these businesses are engaged in manufacturing; they are vital to India's economic and social progress. Moreover, this industry contributes 32% to GDP growth and 32% to employment gains[35]. The significance of these industries in India's development and economic success is highlighted by this fact. Yet, they are unable to expand because of several factors, the most significant of which are a lack of resources and a scarcity of technically qualified and managerially adept personnel [12,13].

Optimizing processes and resources, making the most of available equipment, and being on good terms with vendors and customers are all challenges to long-term success [6]. These limitations prevent Indian firms from realising their full potential, placing extra pressure on

them to innovate and improve their methods on a regular [7,8]. They're concentrating on honing their manufacturing techniques to provide their customers with competitively priced, premium products and services. To increase efficiency and stay competitive, businesses should adopt a lean manufacturing strategy. Ultimately, the purpose of Lean is to provide producers an edge in the marketplace by reducing costs and increasing output [9,10].

The study presents a systematic analysis of indicators, rankings, and weights using an AHP technique to help experts, practitioners, and researchers in the industry determine which indicators are the least and most important for MSMEs. Managers may utilize this data to boost the company's bottom line, operations, and human resources, all while providing superior customer service. The Lean Production System incorporates a wide range of management tools including Just-in-Time (JIT), quality systems, working teams, etc. to optimise product and process value while decreasing waste [36]. Lean manufacturing has become the industry standard because of its ability to solve problems in both production and service, its groundbreaking improvements in manufacturing quality, and the competitive pressure it puts on even the smallest of businesses. [14,15]. Small and medium-sized firms (SMEs) in India cite the operational benefits of implementing lean manufacturing principles, including increased productivity, customer satisfaction, cost savings, and shorter cycle and lead times. Results showed that implementing lean led to significant improvements in inventory management, collaboration, maintenance, layout and handling, supplier relationships, and output. This article[18] analyzed the effects of lean and green manufacturing practices on SMEs in India, and it mentioned TPM, Kaizen, and 5S as three particularly useful lean strategies. Hence, production techniques have developed with technological advances and a paradigm shift towards a customer-driven market, from handcraft to mass production, to handle the challenges of global manufacturing and environmental and social issues [19]. Organizational and government sectors have documented strategic changes accomplished with lean implementation [20].

Many companies have reported success with lean implementation, but many more have not realized the full potential of the concept because they lack the tools to identify the success factors, track their progress as they transform into a leaner organization, and compare their progress with that of other companies [21,22]. This highlights the need of monitoring the results of lean adoption and the company's overall progress toward its objectives. Nevertheless, if those objectives change, so does the difficulty of doing this. This is why companies need to establish their metrics for success in their economic sectors. The criteria for a successful company in the manufacturing sector are different from those in the service sector, and vice versa. Businesses of all stripes use their own unique sets of performance indicators to quantify their achievements in areas like product quality, cost, and timeliness of delivery.

While looking at the literature on leanness assessment, it becomes clear that most of the case studies focus on Indian businesses, with just a tiny percentage originating from the United States and the United Kingdom. [23,24] Despite being the birthplace of the lean idea, Japan does not have any literature on the topic has been published. Cutting down on wasteful operations like scrap and rework may have a notable influence on a company's bottom line

and, in turn, lower production costs, as detailed in quantitative research that found 21 indicators to assess performance in a lean setting [25]. Four Indian firms' supply chains were evaluated using 23 indicators, and their performance was ranked using AHP's 36 criteria. [26]. Using lean assessment, according to a study done at an Indian manufacturing firm, resulted in a measurable rise in production. [27]. Lean six sigma, if correctly adopted, may enable French companies to achieve significantly better financial and operational outcomes than each of these methodologies could on its own [28]. A supply chain performance assessment system based on cost, speed, and reliability is used to rank Thai SMEs[29].

Ford and GM's leanness levels were measured and compared using the Honda Motor Company as a benchmarking tool [30]. Although the benchmarking approach has potential, it is challenging to identify the best practices for every specific situation. While researchers looked at the performance dimensions and the two performance metrics for each dimension, they failed to take into consideration an appropriate weighting strategy for the performance meter in the manufacturing system. There has been a lot of development in the system and framework for assessing leanness, yet many companies still rely on monetary metrics.

These markers might range from quantitative to qualitative. Both measurable and non-measurable indicators are important [16]. The topic of how these two factors may interact in a lean system and what results might be produced arises. Barriers to lean adoption by SMEs often include a lack of human resources, a lack of expertise, a lack of a supportive corporate culture, and a lack of management's adherence to lean techniques.

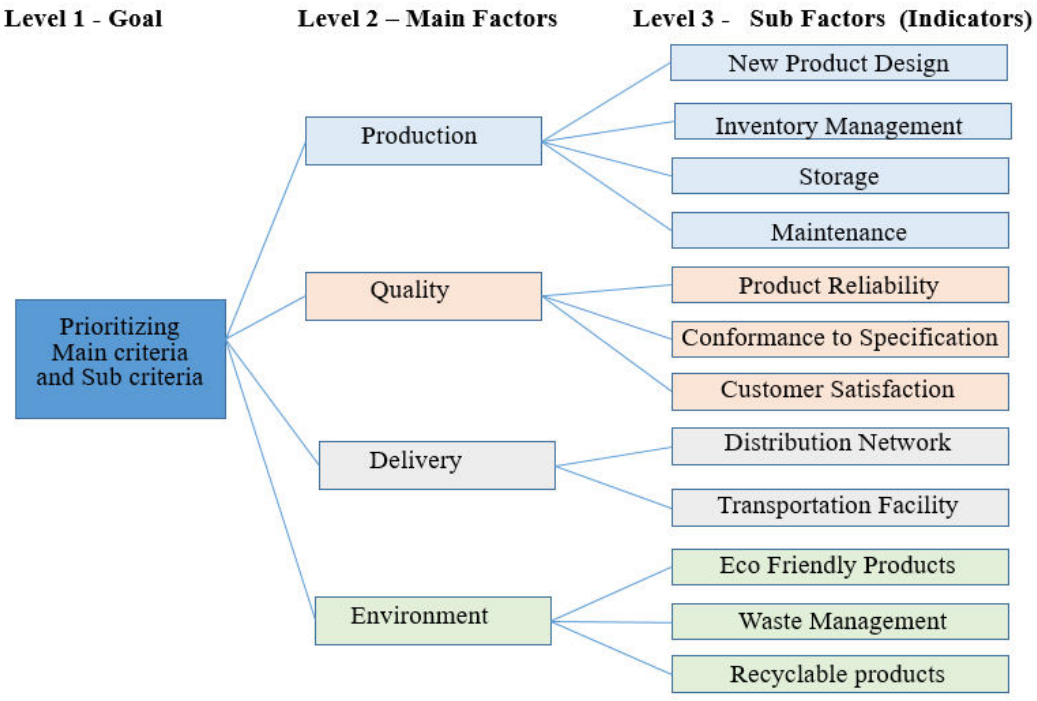
Methodology - Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a theory-based approach to making multi-criteria decisions in hierarchical circumstances by establishing ratio scales from which to do discrete and continuous pairwise comparisons. In the 1970s, it was initially suggested by Thomas Saaty, and since then, it's been the focus of much study and development. The AHP method streamlines the decision-making process by reducing the problem at hand to a series of criteria and sub-criteria that may be compared and contrasted using a weighted score. Saaty developed a comparison method for this strategy, modeling a hierarchical decision problem framework with numerous mutually exclusive criteria. AHP employs a hierarchy in which both subjective and objective factors may coexist. It's a method that incorporates both hard data and subjective experience to help people make better decisions. [11] When it comes to estimating and, ultimately, improving priority setting uniformity among decision-makers, the AHP method provides appropriate measurements. The methodical use of collective preferences is supported by extensive theories for aggregate preference formation. As this research might benefit from group decision-making help, the AHP methodology could be a valid choice for completing the study.

Saaty used this concept to develop a comparison method that mimics a hierarchical decision problem framework by using severalunidirectional related criteria. AHP places a premium on logical and numerical consistency when evaluating criteria and selecting a winner [11]. To

rephrase, the AHP is a structured process for making decisions that take into account past knowledge, future projections, and intuitive leaps, all within the confines of a clearly defined methodology based on sound mathematical ideas [35]. To solve a certain kind of issue that calls for prioritizing potential solutions, AHP is often used. Multi-criteria techniques give a helpful framework for modeling preferences as well as gathering, storing, and organizing all relevant data. Because of its comprehensive nature, AHP may be used to make choices with a wide range of uncertainties, given a wide range of goals, criteria, and stakeholders. Each set of criteria and alternatives is assumed to be operationally distinct from the other sets it belongs to in the hierarchy (objectives and criteria). The Analytic Hierarchy Process (AHP) is a flexible framework for making choices with uncertain consequences, which include various goals, many criteria, and several parties.

Each level of the hierarchy assumes that the criteria and choices it contains are operationally distinct from the levels above it. The AHP provides a well-structured, systematic analysis and aids in decision making, taking into account both qualitative and quantitative aspects. Since it considers several interrelated factors, the AHP model is useful for disentangling complex problems.



Identification of key performance indicators

Companies, especially in light of rising pricing competitiveness and market pressure, are always looking for ways to boost their productivity. As businesses become increasingly interconnected, supply chain efficiency has a greater impact on overall company success. It's

safe to believe that taking everything into account is essential for peak performance including the supply chain. Key performance indicators (KPIs) are widely utilized for both network and business improvement. It is far more difficult to optimize inter-business value chains when each firm sets its KPIs based on its own goals, eliminating any possibility of comparison.

KPIs are used in the manufacturing industry for analysis, monitoring, and improvement of the manufacturing process

Key performance indicatorsare an effective method of monitoring and highlighting the health of a company. They are quantitative measures of how well a firm is meeting its goalsand are a sort of performance assessment used in the manufacturing industry to assess the success of a company or a specific division. Manufacturing companies may use KPIs to better understand how they can enhance customer satisfaction, boost competitiveness, and reduce costs. KPIs allow manufacturers to monitor their progress toward crucial goals and make course corrections as required.

Key performance indicators for lean manufacturing should measure efforts to eliminate waste or boost output. In lean manufacturing, KPIs are used to evaluate the success of lean and process improvement campaigns. It is important to adjust KPIs as needed, such as while trying to keep tabs on a developing crisis. KPIs should be used solely to monitor crucial management concerns. Too many KPIs may be overwhelming for management and provide no tangible benefit for the company.

This study uses a literature review to construct the first set of fundamental performance criteria for assessing sustainable manufacturing inside a manufacturing firm. The base metrics are an integration of manufacturing performance indicators and sustainable manufacturing measurements. Early efforts have included the "triple bottom line" of environmental, economic, and social performance. As was seen, the initial measurements included three parts, which were then broken down into four main elements and a total of twelve minor factors.

Main Factors	Sub Factors (Indicators)
Production	1) New product design
	2) Inventory management
	3) Storage facility
	4) Maintenance
Quality	5) Product reliability
	6) Conformance to specification
	7) Customer satisfaction
Delivery	8) Transportation facility
	9) Distribution network
Environment	10) Eco-friendly product
	11) Waste management
	12) Recyclable products

New product design

One of the most important parts of developing a product is the industrial design of a new product. The quality of the industrial design of a product has a significant impact on customers' final purchases. Industrial designers are responsible for developing products that meet the demands of customers while also meeting the requirements of their business. A good industrial design product has significance for the user and solves a problem they face. Although several alternatives and items are essentially the same, industrial design is what sets a business apart and should highlight any innovative qualities. A lot of obstacles stand in the way of industrial designers. It is the responsibility of the industrial designer to define the visual language of the product and the company's visual identity throughout the development process. Working together with the engineers, an industrial designer must figure out how to keep prices down via the use of other production methods, materials, or features. Reusing existing designs is another factor that may greatly improve the design process. Although standard components and engineering are the usual focus of reuse discussions, an integrated design platform provides other advantages that may be used by designers. Innovation in industrial design is enabled through adaptability, cooperation, and integration. The form, fit, and function of a design may be brought into harmony with the needs of other disciplines in the concept-to-market process via the use of an integrated and collaborative platform. Improvements in design productivity and quality may be achieved by providing more assistance throughout the preliminary stages of the design process.

Inventory management

The effectiveness of a company's manufacturing inventory management will depend on how well its inventory process works. Large-scale production makes inventory management in manufacturing even more challenging. Gaining efficiencies in managing production inventories may help manufacturers save both time and money. A company may avoid shortages, duplicate output, and extra carrying costs by enhancing its manufacturing inventory systems. To maintain efficiency and profitability while meeting rising client demands, the vast majority of firms use some kind of inventory management system. Most businesses engage in some kind of inventory management, which involves ensuring there is sufficient stock on hand to meet demand without incurring unnecessary costs. When it comes to production, though, inventory management becomes an even more precarious balancing act. Overstocking of inventory is a major annual cause of financial loss for the industrial sector. Losses may also arise when essential supplies are either misplaced or just unavailable, as in the case of understocking. In an industry, inventory management is essential. Not only does this help ensure the smooth operation of the supply chain as a whole, but it also affects the balance sheet and cash flow statement, two key indicators of a business's financial health. To keep operations running smoothly and profits coming in, every business makes it a priority to have just the right amount of inventory on hand at all times. To keep inventory under control, it is necessary to regularly assess both internal and external elements, as well

as use a combination of these methods. Planners for stocks of goods need to keep a close eye on stock while also coordinating with the manufacturing, purchasing, and accounting teams.

Storage facility

In a workplace dedicated to manufacturing or heavy industries, storage might be one of the trickiest parts to organize. Problems with stock levels may slow down operations, reduce output, and increase overhead. If the manufacturing sector wants to become more efficient and robust, storage facilities must be upgraded. Industrial storage equipment is used to arrange or store goods, products, and commodities in a designated location temporarily or permanently storing them. The size, weight, and regularity of usage of the stored objects will determine the best kind of static storage system to utilize. The quantity and nature of the goods to be stored, as well as the nature of the machinery used to transport them, all have a role in the design of the storage system's structure. Items at a warehouse are usually packaged in some way before being kept there. Buffering, or keeping of reserved stock, is a common application of storage systems to ensure there are enough parts or goods on hand to fulfill projected needs. As their businesses expand, many industries find it difficult to keep up with demand in the same footprint. When the economy improves, firms may quickly outgrow their current facilities and need more space. Sometimesindustries just can't keep up with rising demand by adding more production space.

Maintenance

The primary goal of maintenance is to keep all manufacturing gear and equipment running at peak efficiency at all times. In addition, regular maintenance is essential for effective production. The prosperity of a manufacturing company depends on the possession of suitable machinery. Yet, having high-quality machinery isn't enough; it's also important to maintain it effectively. Doing regular maintenance on industrial equipment is essential for keeping production on track. Businesses may save money and time on repairs and downtime by maintaining their machinery regularly. Preventing injuries and accidents that may have been caused by malfunctioning equipment is another benefit of regular equipment maintenance. The lifespan of the equipment is another important benefit of routine maintenance. In the long term, a corporation may save money by extending the life of its equipment via preventative maintenance. The maintenance department of an industry is in charge of keeping all of the equipment, systems, structures, and services necessary for the operation of the other departments in it running smoothly and at peak efficiency. Preventing failures and maximizing machine performance are the primary goals of preventative maintenance in manufacturing. Nonetheless, there is still a sector of the production industry that considers maintenance to be a waste of production time. Preventing unanticipated downtime due to neglected machinery is as easy as keeping everything in working order. In addition to extending the life of the machine itself, preventing the need for rework or scrap product due to the production of out-of-spec material, routine maintenance, and early detection of worn machine components are essential for minimizing waste and maximizing efficiency.

Product reliability

When production time, quality, and velocity are all in place, we can be confident in our output. As a result of equipment breakdown and subsequent outages, product quality suffers. Constant machine failures slow production, cutting into the available time. Having a dependable outcome as an objective is a good theoretical aim to have for your staff. As a result, it is very difficult to estimate the dependability of current devices, since most industrial items experience unexpected failure, and only failure information can be acquired. Better manufacturing quality will boost output and shorten the time it takes to go from raw materials to final goods. Improved dependability lays the groundwork for a more efficient and secure production process. Delays in delivery, excess production, WIP, and power consumption may all be reduced in this way. Once the industrial revolution began, a flood of new goods began flooding the market. To satisfy customers' loftier expectations, product complexity has skyrocketed. Eventually, used or old products will wear out to the point that they can no longer perform their intended tasks, rendering them useless. The study of reliability theory seeks to answer questions like these: how goods degrade, what makes for a product's reliability in the first place, and how to best handle the use of unreliable items. Customers want to know that their purchase will last as long as possible while still providing the expected level of performance. Furthermore, the laws enacted to safeguard consumers' rights are becoming increasingly strict.

Conformance to specification

Every manufacturing company has to have final product requirements in place and should be reviewing and updating these standards regularly. They are crucial for assuring the product's viability, legitimacy, and quality. The goals and standards of a firm or organization are reflected in the criteria and specifications established for a product throughout its design phase. Non-Conformance may occur when a manufacturer produces an item, but its declaration conflicts with the item's real standards and needs. If it happens, it means the company producing the goods didn't adhere to the required guidelines. Delivering a subpar product is one possible outcome of failing to satisfy and adhere to criteria such as specifications, standards, and guidelines. Errors in products, incorrect configurations, malfunctions, and a negative impact on the end-user experience are all ways in which non-conformance may enhance the organization's exposure to risk and liability.

Customer satisfaction

Having happy customers is more important to a company's success than almost everything else. Companies all over the globe, and especially those involved in the industrial manufacture of hardware items, are always on the search for innovative methods to better

serve their consumers and other important stakeholders. Most manufacturers in the industrial sector serve a small number of clients solely. Commercially viable scenarios often include the creation of volume by Industrial Manufacturing facilities, which in turn results in the generation of income. It's crucial in the year 2023. Eighty-one percent of marketers agree that customer happiness is the most important competitive factor in their sector. Nevertheless, that's not all there is to get a leg up on the competition. Research shows that after only one negative interaction with a firm, 17% of consumers would never return. Maintaining a high level of customer satisfaction is crucial to retaining existing customers and gaining new ones for a business. A quick turnaround time from when an order is placed to when it is delivered is crucial to maintain happy customers. When competition and costs rise, it becomes more challenging for businesses to sustain high levels of revenue and profit over the long run.

One-third of the points for the Malcolm Baldrige National Quality Award, which is administered by the National Institute of Standards and Technology, is dependent on customer satisfaction, therefore the United States government also raises awareness of this problem among its citizens.Publications like Consumer Reports, which claim to be impartial, regularly publish and disseminate ratings of a broad variety of goods and services based on reader feedback on their performance and satisfaction. Stats on how satisfied customers are often used in auto commercials to convince consumers.

Distribution network

One of the most important factors in the health of any country's economy is the efficient flow of products and services from manufacturers to consumers. Products must be sent to customers at a fair price and on time. Goods and their titles are recognized to take certain pathways from producer to consumer as part of the delivery function. This network of connections goes under a few other names: distribution channels, trade channels, etc. Academics, professionals, manufacturing enterprises, and distribution agencies have all written extensively on distribution channels and their effects on production costs in the marketing literature throughout the years. The expense of distribution might have a major influence on the bottom line of manufacturing companies. Despite producing high-quality goods, many businesses fall short of their goals because they fail to give distribution the attention it deserves. A company's distribution channel strategy needs to be carefully diagnosed, planned, and implemented to fully realize its profit objectives and to ensure customer satisfaction. In addition, it is worth noting that organizations have huge, often unexplored chances to build distinctive long-term strategic advantages via the design and management of effective and efficient distribution channels. Increasingly, the best way to wow your customers is to put in some serious work to improve the efficiency of your channel operations.

Transportation facility

As well as a greater variety of items being manufactured and sold, mass manufacturing and a broader global market have expanded the scope of commerce in contemporary cultures. Having reliable modes of transportation is crucial for ensuring that industries never run out of raw materials and that finished products reach customers quickly and easily. It helped large-scale enterprises expand by making it easier to get raw materials in and finished products out. The ability to move items around allows business owners to respond to fluctuations in regional demand. As a result, market swings are kept to a minimum. Transport infrastructure improvement is crucial for rapid industrialization. The growth of transportation is essential to the success of mass production and distribution. Logistics support high-volume manufacturing. One of the other kinds of transportation is required whether it's to acquire and deliver raw materials or to move completed items. In doing so, both current and potential new markets benefit. So, there will be a greater need for commodities, and production levels will need to rise to meet that need. Food and other perishable items produced by these sectors need to be transported quickly to reach customers in various time zones. If not, it would be impossible to provide these goods to customers. In the context of the economy, transportation is one of the most important activities. Transportation is a critical business function because it connects a firm to its suppliers and consumers by transferring commodities from their points of origin to their points of demand. It is a critical step in the logistics process that enables location and timing-based economic utilities.

Eco-friendly product

To achieve ecological, economic, and social sustainability, the manufacturing sector recognizes the need for eco-innovation. Regulation, accountability, and competition are the three key forces that may improve manufacturing's sustainability. Products, procedures, promotions, and establishments all fall under the broad category of eco-innovation. Eco-friendly product creation, however, has emerged as a hot topic for academics in the 21st century. The Organization for Economic Cooperation and Development states that eco-innovation is an "essential pre-requisite for sustainable development" since it has far-reaching, beneficial consequences on a country's economy, society, and environment. Constant attention is paid to the value of eco-innovation by a wide range of public and commercial institutions, including international organizations, research centers, universities, and others. The term "eco-innovation" refers to the creation and implementation of a business model guided by a revised business strategy that integrates sustainability into all aspects of a company's operations using lifecycle thinking and soliciting input from stakeholders throughout the value chain. It comprises a concerted effort to improve a business's performance and competitiveness by implementing a series of adjustments or new solutions across four areas: products (or services), processes (or how they are carried out), the way they interact with the market, and their internal structure. The eco-design method enhances efficiency in manufacturing by minimizing waste. Most obviously, optimization may be seen in the decreased need for energy, the decreased use of raw materials, and the decreased production of pollution and other nuisances. Eco-friendly product design refers to any method used in the creative process to enhance a product's environmental friendliness. The

objective of an eco-design is to lessen negative effects on the environment via forethought while keeping the items' use intact.

Waste management

A manufacturer's or manufacturer's commitment to environmental responsibility may be gauged in large part by its handling of industrial waste. Waste from industry has emerged as a major problem in the past two decades, raising serious worries about its global sustainability and environmental implications. Industrial trash is created or used in large quantities in manufacturing facilities; this garbage must be properly handled to avoid posing a threat to human health and the natural environment. The effective management of industrial waste begins and ends with compliance with the law. The Environmental Protection Agency (EPA) is responsible for implementing federal regulations on the proper disposal of hazardous and non-hazardous waste. Waste management regulations are often enacted at the state, county, and municipal levels. Although certain industrial waste is indeed more hazardous than others, there's no denying that any sector, when poorly managed, may cause significant environmental damage. The extraordinary waste output and the contribution to boosting the productivity of natural resources make the chance to improve production sustainability via waste minimization more attractive. Even if all of the materials used are safe, the production process may nevertheless create some hazardous by-products. The industrial sector throughout the world seems to be on the rise. Increases in product demand and manufacturing activity have resulted from globalization, industrialization, and economic development, leading to a 26% increase in global GDP and a 35% increase in global manufacturing activities between 2001 and 2010. This has increased industrial (material) waste. Concern about the planet's finite resources has been in the spotlight since the term "sustainable development" was first used and the European Union pledged its support to the United Nations Commission on Sustainable Development.

Recyclable products

It is promising that more and more businesses are considering how they may use recycled materials and reduce their environmental impact throughout the manufacturing process. Instead of just reusing their manufacturing waste, manufacturers are beginning to incorporate recycled materials in their product development and exploration processes. Several of the obstacles may be overcome with sufficient investment in scalable technologies for producing recycled materials, the utilization of high-quality data, and the establishment of sustained demand for greener goods. As the world moves forward in its efforts to construct a circular economy, one approach to recoup the value of garbage is to put it to use in new goods. This might be facilitated by linking upstream and downstream product value chains via the careful reuse of waste-derived materials. This may lead to iterative design changes that make it simpler to salvage usable parts from products. Also, these items may help spread information about new sustainable options and stimulate the growth of environmentally friendly

marketplaces. When the recycled or recovered content moves up the supply chain to become a raw material, it might be difficult to keep up with the demand. Careful inventory planning is required to match the supply and demand demands of two supply chains and prevent under or over-supply. Because of this, the price of storing goods rises. The use of recycled materials by manufacturers is increasing in popularity as the sustainable development movement expands. Manufacturers are being forced to assess their procedures and implement environmentally friendly improvements due to increasing demand from community stakeholders, government authorities, shareholders, consumers, and workers to source resources ethically. Using recycled materials introduces additional difficulties for us as producers in terms of material availability, process modification, efficiency, and anticipating customer interest in eco-friendly goods. These challenges may seem insurmountable, yet they are all surmountable.

Development of sustainable manufacturing performance evaluation

The Analytic Hierarchy Process (AHP), created by Thomas L. Saaty in 1971, is one of the most widely used methods for tackling MCDM-related problems. It's a way to evaluate potential options and make a choice based on several factors. It's been used for years as a go-to reference for management and decision theorists in the classroom and on the job . The AHP model is flexible and systematic enough to break down a multifaceted problem into its constituent parts. An effective first step in solving any difficult problem is to break it down into a series of smaller, more manageable problems. Second, it may help elicit more information from experts or decision makers by having them compare specific groupings of objects with one another. In the end, it decides how the weights of the individual elements will be computed. Four, it employs the consistency metric to ensure that the ratings provided by experts and stakeholders are accurate. The steps below show how an AHP-based model was developed to assess the manufacturer's efforts toward greener production methods.

Construct the hierarchy

A pyramid is constructed using the essential performance criteria for green production. We created a pyramidal framework consisting of an overarching goal, main factors, secondary factors, and tertiary elements. The hierarchy was created to provide some sense of structure to the various factors being considered. The next level consists of production, quality, shipping, and the local ecosystem. Product design, stock, reliability, customer satisfaction, distribution network, transportation, eco-friendly product, storage, maintenance, client specification, and waste management are only a few of the twelve factors considered at the third level. A final tier in the company evaluation and comparison hierarchy offers the options that the decision maker must consider.

Relative weights

Ranking the metrics by significance is the next step once the hierarchy has been established. To achieve this goal, the AHP technique was used. The relative relevance of several metrics for green production was calculated using the AHP approach. Next, we devised a questionnaire that allowed respondents to compare their companies to others in the industry, and we sent it to 12 top executives at Indian manufacturers. The managers were selected because of their extensive experience in the relevant pitch. There were a total of 10 answers. Each expert's paired comparisons were checked using the Consistency Ratio (CR). There are no values of CR greater than 0.1, hence it passes the consistency check. The comparison must be redone if it is still inconsistent. We used a geometric mean averaging of the responses to each question to determine their relative weights. A preference matrix was built using Saaty's 1–9 preference scale. All of the combined pairwise comparison matrices were subjected to the consistency test. The findings reveal that the CR values are close to 0.03, which indicates that all pairwise comparisons are reliable. This number is well within the tolerance range suggested by Saaty. This finding suggests that the experts have been consistent in the significance weights they've ascribed to the various metrics used to assess sustainable manufacturing performance in the sector as a whole.

Normalized Decision Matrix (Main Factors)

	Production	Quality	Delivery	Environment	Weights	Avg Wt	Eigen Value
Production	0.27	0.24	0.39	0.27	0.29	1.21	4.13
Quality	0.55	0.50	0.42	0.45	0.48	1.97	4.10
Delivery	0.08	0.13	0.11	0.17	0.12	0.50	4.02
Environment	0.11	0.12	0.07	0.11	0.10	0.42	4.06

Consistency Index	Random Index	Consistency Ratio
0.03	0.9	0.03

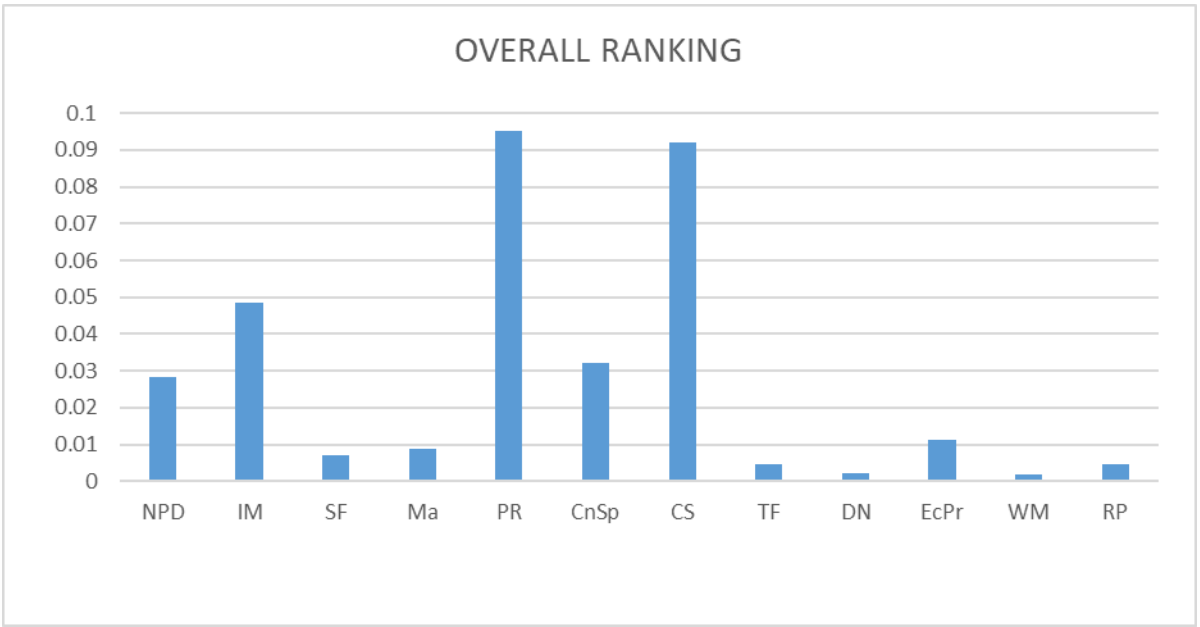
Random Index Table

Number of attributes,n	1	2	3	4	5	6	7	8	9	10	11	12
Random Index RI	-	-	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.54

Normalized Decision Matrix (Sub Factors - Indicators)

		NPD	IM	SF	M	PR	CnSp	CS	TF	DN	EcPr	WM	RP	Weights	Eigen Value
1	NPD	0.07	0.04	0.11	0.12	0.07	0.16	0.06	0.11	0.12	0.04	0.12	0.16	0.10	13.49
2	IM	0.23	0.13	0.16	0.15	0.09	0.24	0.08	0.19	0.14	0.25	0.15	0.18	0.17	14.16
3	SF	0.02	0.02	0.02	0.01	0.04	0.02	0.03	0.02	0.05	0.02	0.04	0.01	0.02	12.51
4	M	0.01	0.02	0.05	0.03	0.03	0.02	0.03	0.02	0.06	0.02	0.06	0.02	0.03	12.39
5	PR	0.23	0.36	0.14	0.18	0.24	0.10	0.41	0.09	0.13	0.25	0.11	0.15	0.20	13.72
6	CnSp	0.02	0.03	0.07	0.08	0.12	0.05	0.04	0.12	0.09	0.03	0.08	0.07	0.07	12.83
7	CS	0.22	0.28	0.17	0.18	0.11	0.21	0.18	0.19	0.14	0.25	0.15	0.22	0.19	14.08
8	TF	0.02	0.02	0.05	0.05	0.08	0.01	0.03	0.03	0.06	0.02	0.07	0.02	0.04	12.32
9	DN	0.01	0.02	0.01	0.01	0.04	0.01	0.03	0.01	0.02	0.01	0.03	0.01	0.02	12.66
10	EcPr	0.14	0.04	0.12	0.13	0.08	0.15	0.06	0.16	0.12	0.08	0.11	0.11	0.11	13.71
11	WM	0.01	0.02	0.01	0.01	0.04	0.01	0.03	0.01	0.01	0.02	0.02	0.01	0.02	12.83
12	RP	0.02	0.03	0.07	0.05	0.06	0.02	0.03	0.06	0.06	0.03	0.06	0.04	0.04	12.77

	Performance Indicators	Local Weight	Global Weight	Overall Rank
1	New product design	0.10	0.0281	5
2	Inventory management	0.17	0.0481	3
3	Storage facility	0.02	0.0070	8
4	Maintenance	0.03	0.0087	7
5	Product reliability	0.20	0.0953	1
6	Conformance to specification	0.07	0.0321	4
7	Customer satisfaction	0.19	0.0920	2
8	Transportation facility	0.04	0.0046	9
9	Distribution network	0.02	0.0022	11
10	Eco-friendly product	0.11	0.0108	6
11	Waste management	0.02	0.0017	12
12	Recyclable products	0.04	0.0044	10



Discussion

The major objective of this research is to identify and rank the most essential success-related aspects that may impact the successful completion of infrastructure development projects, particularly in low-income countries. Having a well-defined end state in mind before the planning phase starts considerably improves the consulting team's chances of completing the comprehensive design and documentation of infrastructure projects on schedule. This, in turn, affects whether or not infrastructure projects meet their deadlines, budgets, and claimed quality levels. The last of the most crucial factors in determining success is the experience and reputation of the consulting and design firms involved. Based on the findings, consultant competency (0.0109), consulting company experience (0.0106), and consulting firm willingness and cooperation (0.0109) were the second, third, and fourth priorities in the hierarchical model (0.099). Consulting/design firms are among the most important participants in a project, thus it makes sense to include them as early as possible. This might include the planning and initiation phases. The consulting industry's capability and competence are important to the success or failure of infrastructure projects.

Conclusion

Considering that micro, small, and medium-sized firms (MSMEs) in India are the lifeblood of the country's economy, we must learn what makes them tick. Several lean performance indicators have been pushed for use in production systems by researchers and practitioners. For this reason, the present research aims to identify the most useful performance indicators for process changes and to quantify the effects of these indicators.

The study may be used as a resource to help businesses improve their sustainable manufacturing practices. Through this method, businesses may boost their efficiency and competitiveness. By keeping close tabs on personnel, equipment, and supplies, as well as by churning out actual work with fewer mistakes, the lean implementation strategy aims to remove waste at every stage of the process. The widespread adoption of the lean idea, which was pioneered by the Toyota Production System in the auto industry, has spread to other sectors as a result of the system's success. The emphasis on aspects that contribute to or inspire management is critical for the application of the lean concept in enterprises, and so is the measurement of leanness variables/indicators in decision making during planning. However, there is currently no reliable system to define and monitor leanness before and after implementation, which is often regarded as the primary reason why most lean implementation strategies and practices fail.

As a result, businesses need to regularly evaluate their performance to ensure they are staying competitive. By comparing outcomes from before and after implementing lean, management may utilize performance evaluation to identify shifts and opportunities for growth. As a whole, it will make customers happier and increase the success and profits of businesses.Since different industries employ different sets of indicators, there has been little attempt to define or even discuss lean performance indicators despite their potential usefulness. In addition to being an effective motivator, key performance indicators help pinpoint problem areas and the factors that contribute to them.

With the performance indicators in hand, policymakers will be able to make future choices that will affect the company's competitiveness. Common indicators of efficiency include quality, price, timeliness, adaptability, and output.Some indicators may be more illuminating than others, although this may vary from procedure to operation. The Analytic Hierarchy Process (AHP) is a method of MCDM that may be used to prioritize and weigh different criteria. With an AHP, one may create a tree-like hierarchy of options from which to choose the course of action that best suits their requirements. Numerous authors have utilized MCDM to analyze the interrelationships between the variables, quantify the effects of those interactions, and evaluate the viability of the manufacturing process from a sustainability perspective.

As part of this research, we provide our thoughts on developing an AHP-based model to evaluate a company's progress toward environmentally responsible production. The AHP model was used as the blueprint for the instrument. A hierarchical structure was developed in accordance with the indicated major indicators of sustainable manufacturing performance evaluation for a manufacturing organization. Each statistic was then assigned a weight based on its relative importance to the others using the AHP method. A score between 1 (very bad) and 10 (very good) on a scale from 0 (very good) to 10 (excellent) was given to each value (excellent). The rating was derived to assess the business's efforts in green manufacturing. After tabulating all of the scores, the companies were ranked.

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