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Planning and strategies for implementing sustainable production in small and medium enterprises Optimization of production processes in Indian industries TOPSIS

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ABSTRACT

This study investigates the use of TOPSIS and fuzzy analytic hierarchy process (FAHP) in materials science and engineering and sustainable manufacturing in small and medium-sized enterprises (SMEs). TOPSIS, as a multi-criteria decision-making method, helps in analyzing options based on maximum output and optimizing supply chain competitiveness. The results show that this technique can be effective in assessing and improving competitiveness in various industries, especially in India, given the challenges of sustainability. Barriers to implementing sustainable practices are identified in four categories and nine strategies are proposed to overcome these barriers. Ineffective regulations and complexities associated with sustainable practices are among the main challenges. The most important strategies are the implementation of lean and green manufacturing techniques and the establishment of performance measurement systems. The paper also refers to the applications of TOPSIS in eleven different industries in India, including metal processing and electronics industries. These findings provide important insights for decision-makers in the fields of materials engineering and sustainable manufacturing, and demonstrate the importance of this method in optimizing production processes and supply chain competitiveness

Introduction

1-Problem Definition:

The paper, which examines the optimization of manufacturing processes in Indian industries using TOPSIS, addresses the key challenges in multi-criteria decision making and the limitations of existing methods in this area. Manufacturing processes are usually influenced by conflicting characteristics and parameters that require balancing. On the other hand, small and medium-sized enterprises (SMEs) are also facing increasing pressure to transition to sustainable manufacturing processes. These changes are not only beneficial to the environment, but can also improve the competitiveness of these companies.

The challenges in process optimization and evaluation require new approaches such as TOPSIS, which has the ability to simultaneously manage multiple criteria and objectives. While many traditional methods fail in this regard, TOPSIS can help decision makers identify optimal options. In addition, SMEs face several barriers such as financial constraints and lack of technical knowledge in implementing sustainable production practices, which are also due to the walls of inefficiency and complexity in implementation.

To analyze these barriers and find practical solutions, the study considered the use of qualitative and quantitative methods, including expert surveys, and prioritized these barriers using fuzzy analytic hierarchy process and fuzzy TOPSIS techniques. The findings indicate the negative impact of key barriers, such as ineffective law enforcement and complexity in implementing sustainable principles, on sustainable production processes.

Finally, the main objective of this study is to identify and analyze the barriers to implementing sustainable production practices in Indian SMEs and provide solutions to overcome these barriers. Given the increasing importance of sustainability in production, this study can help SMEs adopt more effective strategies to improve their processes and increase their competitiveness. Also, the findings of this research can be used as models for other countries and industries to advance sustainable production. 1- Problem Classification:

According to the content presented in the abstracts of the two articles, the following classifications can be considered for the issues raised in them:

2-1 First article:

Main topic: Barriers and strategies for implementing sustainable production in small and medium-sized enterprises: A fuzzy hybrid AHP-TOPSIS framework

Summary of analysis of barriers and strategies for sustainable production

Barriers to sustainable production

1. Socio-environmental barriers (B1)
- Lack of social responsibility: Lack of full understanding of social responsibilities by businesses.
- Fluctuations in customer demand: Rapid changes in customer needs that lead to instability.

2. Legal and government barriers (B2)
- Ineffective legal framework: The existence of unclear laws that make it difficult to implement sustainable strategies.
- Ineffective implementation of laws: Insufficient monitoring of existing laws.

3. Organizational and economic barriers (B3)
- Inappropriate leadership: Lack of strong leadership in the organization.
- Lack of financial resources: Lack of investment in sustainable technologies.

4. Knowledge and technology barriers (B4)
- Lack of sufficient knowledge: Insufficient information about sustainable technologies.
- Lack of technical training: Lack of access to relevant training programs.

Strategies to overcome barriers

1. Government promotion and regulation (S1): Government support through effective legislation.
2. Implementation of lean and green production practices (S2): Reducing waste and optimizing resources.
3. Investment in R&D (S3): Developing new innovations.
4. Use of sustainable materials and energy (S4): Reducing environmental impacts and costs.
5. Stakeholder engagement (S5): Sharing knowledge with the community and suppliers.
6. Establishing measurement systems (S6): Accurately assessing progress in sustainability.
7. Fiscal policies (S7): Encouraging investment in sustainability.
8. Skills Development (S8): Conduct training courses to increase awareness.
9. Effective Strategic Planning (S9): Clarity in organizational goals.

2-2 Second article:

Main topic: Optimization of manufacturing processes in Indian industries using TOPSIS

1. Challenges of multi-criteria decision making
Conflict of criteria: In manufacturing processes, decision makers are faced with different and conflicting variables, such as quality, cost, time and safety. These conflicts can complicate the selection of the best option.
The need for balance: The need to achieve a balance between conflicting criteria in order to improve quality and reduce costs.
2. Limitations of existing methods
Inadequacy of traditional methods: Many traditional decision-making methods are complex and time-consuming, and they do not have the necessary efficiency and cannot manage multiple criteria well simultaneously.
3. The need for multi-objective optimization
Simultaneous management of multiple criteria: Optimizing processes in order to improve efficiency and reduce costs requires an approach that can simultaneously consider multiple objectives. TOPSIS, as a multi-criteria analytical method, meets this need.
4. Inadequate use of TOPSIS method in Indian industries
Lack of recognition and application: Despite the advantages of TOPSIS, this method is still not widely used in various industries in India and there is a need to expand its application.
5. Need for literature review
Related article analysis: Review and analysis of existing articles on TOPSIS in order to identify challenges and new trends in the use of this method, which can help in productivity in industries.
6. Advantages of TOPSIS
High accuracy and efficiency of the optimization process: TOPSIS helps decision makers to identify the best options by providing the possibility of simultaneous evaluation of conflicting variables.
Simplicity and speed: This method can provide effective results in a shorter time due to its simplicity and efficiency in calculations.

1 -Mathematical modeling:

3-1 First article
In this research, two main mathematical techniques have been used to analyze the barriers and strategies for sustainable production in SMEs: the fuzzy analytic hierarchy process (Fuzzy AHP) and the ranking technique of ordering by similarity to the ideal solution (Fuzzy TOPSIS). In the first stage, the fuzzy AHP model was used to determine the relative weights of the various barriers identified during the research. For this purpose, decision-makers evaluated their peers for pairwise comparison of barriers using a fuzzy scale and entered their various dimensions into this process. According to the results of this stage, weighting equations and matrices were created and the final equation was calculated to obtain the final weights of each barrier.

In the second stage, the fuzzy TOPSIS technique was used to rank the identified strategies for overcoming the barriers. In this stage, the fuzzy scale was also used to evaluate and compare the strategies pairwise. Each strategy was evaluated in terms of its performance in reducing the relevant barriers. By creating a decision matrix for the strategies and calculating their distance from the positive and negative ideal points, the score of each strategy could be calculated. The final process of ranking the strategies was achieved using these scores, which helped to identify the most efficient solutions for SMEs to implement sustainable production.

This mathematical modeling specifically helps managers and decision makers to identify and prioritize the barriers and opportunities for implementing sustainable production techniques with a logical and reliable system. This process increases the efficiency of resource allocation and strategic planning, so that SMEs can operate more effectively in the field of sustainable production in the industry and take steps to increase social responsibility and reduce environmental impacts. These results demonstrate the value of

mathematical modeling in facilitating the decision-making process and prioritization in complex and uncertain environments.

3-2 The second article:
Describes the analysis and optimization of production processes using the TOPSIS technique as a multi-criteria decision-making method. In mathematical modeling, first, the key parameters that affect production performance are identified. These parameters include input criteria such as cost, production time, and product quality. Then, for each of these parameters, objective functions are defined that seek to maximize quality or minimize production costs.

In the next step, mathematical equations are created to describe the relationships between the parameters and their impact on the final results. These equations can include differential or algebraic equations that describe how the input and output parameters interact. The goal of this step is to identify the best combination of parameters to achieve minimum cost and maximum quality in the production process. These equations help decision-makers to better understand the interactions between the criteria and achieve deeper analysis.

Finally, mathematical modeling using the TOPSIS technique evaluates and prioritizes the alternatives based on their distance from an ideal solution. In this step, the coefficient of proximity of each alternative to the ideal solution is calculated and the alternatives are ranked based on several key criteria. This method allows decision makers to select the best alternative given the needs and constraints. As a result, mathematical modeling not only helps in optimizing the production process, but can also lead to increased efficiency and competitiveness in Indian industries.

1-Problem-solving method:

4-1First article:
To solve the problem of identifying barriers and sustainable production strategies in SMEs, it is first necessary to conduct a comprehensive analysis of the existing barriers. In this regard, the fuzzy analytic hierarchy process (Fuzzy AHP) has been used. At this stage, the research team identified 21 different barriers by collecting expert opinions and studying existing sources. These barriers were then divided into four main groups: socio-environmental barriers, government policies and laws, organizational-economic barriers, and knowledge and technology barriers. Pairwise comparisons were used to determine the relative weight of each of these barriers, and by using fuzzy techniques, the sensitivities in the opinions of decision-makers were carefully considered.

After identifying and weighting the barriers, the next step is to evaluate and rank the existing strategies to overcome these barriers. For this purpose, the fuzzy TOPSIS technique has been used. In this step, various strategies that can help reduce the effects of the barriers were identified and evaluated according to their ability to solve the problems. Pairwise analysis and comparison were performed for each strategy and then the score of each strategy was averaged. By calculating the distance of each strategy from the positive and negative ideal, it was possible to achieve an accurate ranking of the strategies.

Finally, using the results obtained from the previous steps, it is possible to combine and prioritize the barriers and strategies. This problem-solving method not only helps decision-makers to choose more effective solutions by better understanding the challenges they face, but also allows them to allocate their resources in an optimal way. As a result, this process will not only lead to increased production efficiency in SMEs, but will also contribute significantly to preserving the environment and achieving the goals of sustainable development.

4-2The second article:
First, it systematically reviews the literature related to process optimization and analyzes reliable sources, including articles published in Scopus, Google, and EBSCO. This review includes articles published from 2005 to 2021, which means the validity and quality of the available information. The

selection of these articles was based on specific criteria, including English language and direct connection to engineering and materials science. Finally, 77 articles were evaluated and selected for further research.

The problem-solving method of the article is based on the use of various multi-criteria decision-making (MCDM) techniques such as TOPSIS, AHP (Analytic Hierarchy Process) and GRA (Gray Relationship Analysis). TOPSIS has been introduced as a main tool for optimizing input parameters and selecting the best options in situations where the criteria may conflict with each other. The most important advantage of using TOPSIS is its simplicity and efficiency compared to more complex methods, which allows decision makers to quickly reach optimal results.
The results obtained from the application of TOPSIS in various industries, especially in the fields of metalworking and machining, have improved product quality, reduced production costs and increased productivity in production processes. The article also emphasizes the importance of integrating different MCDM methods and its role in the success of decision-making. The studies conducted show that TOPSIS is an effective management in solving complex and multi-criteria problems and can be used as a key tool in optimizing production processes.

1- Literature Review
5-1 First article:
Furthermore, it can be noted that most of the existing studies in the field of sustainable production have mainly focused on specific geographies or specific industries and therefore the results obtained from them may not be generalizable to all SMEs in general. While some researchers have pointed to the potentially stronger effects of new technologies in facilitating the implementation of sustainable practices, there is still a need for more studies in the field of practical applications and evaluating the effectiveness of these technologies. Especially in developing countries where most SMEs have limited access to financial and technological resources, the process of adapting to green innovations can be different. Also, weaknesses in information and management infrastructure in these countries can become a serious obstacle to the implementation of sustainable practices.

On the other hand, in many studies, less attention has been paid to the social and cultural dimensions of changes in consumer behavior and their impact on sustainable production. While changes in consumer attitudes and behavioral patterns can act as a strong driver for SMEs, in the existing literature, research on how these factors affect production and operational decisions still needs to be further developed. Thus, given these weaknesses and disagreements in views, this article not only examines the relevant barriers and strategies, but also attempts to provide an effective analytical and practical framework for SMEs that is able to specifically respond to the needs of these organizations and at the same time add to the richness of the existing literature.

5-2 Second paper:
Reviews and analyzes the TOPSIS method as a multi-criteria decision-making (MCDM) technique. The authors emphasize that TOPSIS has become an effective tool in various industries in India due to its ability to solve optimization problems with conflicting criteria. The available literature from 2005 to 2021 shows that this method has been increasingly used in the machinery, energy, and polymer industries and has had a positive impact on improving product quality and reducing costs. The paper also states that TOPSIS has high comparability with other MCDM methods such as AHP and GRA, which helps in providing faster and more accurate results.

On a critical note, the paper points out the need for more research on the applications of TOPSIS in various disciplines. Although TOPSIS provides effective results, there are limitations in the independent influence of input parameters. Some studies have pointed out that combining TOPSIS with other methods such as TAGUCHI and VIKOR can lead to improved results and system efficiency. Overall, the literature review of the article emphasizes the need for deeper and more comprehensive research on the efficiency of TOPSIS in different industrial contexts and changing conditions, in order to achieve a more comprehensive understanding of the capabilities and challenges of this method.

Subject	Article 1: Barriers and strategies for sustainable production in small and medium-sized enterprises	Paper 2: Optimization of Production Processes in Indian Industries	Suggestions
Research Objective	Identification of barriers and implementation strategies for sustainable production in small and medium-sized enterprises	Optimization of Production Processes Using TOPSIS	Failure to simultaneously examine implementation barriers and their impact on process optimization
Methods Used	TOPSIS technique for analyzing barriers and strategies	TOPSIS for Process Optimization	Failure to use a comprehensive approach to simultaneously examine barriers and optimization
Evaluation Criteria	External and internal barriers, cost, technology, training, and organizational culture	Quality, Cost, Production Time, and Process Flexibility	Failure to identify common criteria between implementation barriers and process optimization
Key Findings	Identification of important barriers such as lack of capital, inadequate training, and infrastructure problems	Improving Production Performance through Implementation of Optimization Strategies	No connection between the results of implementation barriers and process optimization
Economic Implications	Impact of barriers on competitiveness and sustainability of companies	Increasing Productivity and Reducing Costs	Investigation of joint economic impacts on both areas
Recommendations for Future Research	Research on solutions to identified barriers	Developing Optimization Models for Other Industries	Need to simultaneously examine barriers and optimization strategies in a comprehensive approach

Conclusion:

This paper examines the challenges and barriers to implementing sustainable manufacturing practices in small and medium-sized enterprises (SMEs) in India and analyzes the optimization of manufacturing processes using the TOPSIS method. The results show that the major barriers fall into four broad categories: social and environmental barriers, government policies and regulations, organizational and economic barriers, and knowledge and technology barriers. Inability to effectively implement regulations and complexities related to sustainable practices have been identified as the highest barriers.

The paper also presents effective strategies to overcome these challenges, which include implementing agile and green manufacturing techniques, upgrading employee skills, and establishing performance measurement systems. These strategies can help improve the environmental and economic performance of SMEs.

On the other hand, the TOPSIS method, as an effective tool in multi-criteria decision-making, plays an important role in optimizing manufacturing processes and has the ability to improve product quality and process efficiency. The results of the paper emphasize that to fully exploit the potential of TOPSIS, there is a need for further research in various fields, including supply chain management and environmental studies.

Finally, this paper helps SME managers to identify key barriers and make more informed decisions to achieve sustainable production goals and success in competitive markets.

Resources

1. Barriers and strategies for sustainable manufacturing implementation in SMEs A hybrid fuzzy AHP-TOPSIS framework
2. Optimization on Manufacturing Processes at Indian Industries Using