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LITERATURE REVIEW ON IMPLEMENTATION OF INTUITIONISTIC FUZZY SET USING ANALYTICAL HIERARCHY PROCESS (AHP) FOR FOOD MANUFACTURING INDUSTRY BASED ON MULTI-FACTORS

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A B S T R A C T

This literature review explores of Analytical Hierarchical Process (AHP) application in conjunction with Intuitionistic Fuzzy Sets (IFS) as a powerful decision-making framework within the context of the food manufacturing industry. The review synthesizes a wide array of research contributions and findings to provide insights into the dynamic and uncertain nature of this industry.

The study reveals that the AHP-IFS methodology offers a structured approach to address the complexities inherent in the food manufacturing sector, which undergoes distinct phases from inception to maturity, and potentially, decline or renewal. Decision criteria and factors, including market dynamics, technological advancements, regulatory compliance, sustainability concerns, and financial considerations, are analyzed and prioritized using AHP-IFS, considering their interdependencies and uncertainties.

Strategic planning, resource allocation, and competitive analysis within the industry have been significantly enhanced through the application of this methodology. Moreover, as sustainability and environmental issues become increasingly important, AHP-IFS is also employed to evaluate the environmental impact of business decisions, aligning with global efforts to promote sustainability.

Challenges associated with data availability and computational complexities have been acknowledged, but the potential for refinement and expansion of the methodology, including the incorporation of machine learning techniques, offers promising avenues for future research. Ultimately, AHP-IFS stands as a valuable tool to guide informed decision-making processes throughout the ever-evolving business life cycle of the food manufacturing industry, ensuring adaptability and competitiveness in a complex and uncertain landscape.

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1. INTRODUCTION

The food-related business refers to the stages that a food enterprise typically drives through from its initiation to its ensuing exit or evolution. This process is characterized by various stages, each having its own set of difficulties, prospects, and considerations. Understanding this life cycle is essential for entrepreneurs and business owners in the food industry as it helps them plan, adapt, and make informed decisions at different stages of their business journey.

An introduction to the implementation of a food-related business:

Idea and Conceptualization: This is the starting point where entrepreneurs conceive a food-related product or concept. Market research is conducted to assess the feasibility of the idea and its potential demand. A business plan is developed outlining the vision, objectives, target market, and initial strategies.

Startup: In this phase, the business is launched and begins its operations. Securing funding, whether through personal savings, loans, or investors, is crucial to get the business off the ground. Legal and regulatory requirements, such as permits and food safety standards, must be met. Product development and testing take place to refine the food product or menu.

Growth: This phase involves scaling up production and distribution to meet increasing demand. Expansion may include opening additional locations, entering new markets, or diversifying the product line. Building brand recognition and customer loyalty becomes a focus. Strategies for marketing, operations, and supply chain management are refined.

Maturity: At this stage, the business has established a solid presence in the market. Operations are streamlined, and cost control measures are implemented. Maintaining product quality and consistency becomes critical. Competition may intensify as similar businesses enter the market.

Decline: Businesses may face a decline in sales and profitability due to market saturation, changing consumer preferences, or other factors. Reevaluating the business model, product offerings, and pricing strategies may be necessary. Some businesses may consider exiting or selling the company.

Reinvention or Expansion: To revive or sustain the business, owners often innovate their products or menus. Exploring new distribution channels, such as online sales or partnerships, may be undertaken. Adapting to evolving consumer trends and preferences is essential. Businesses may explore opportunities for growth in different directions.

Exit or Succession: Owners may choose to exit the business by selling it to another entity. Alternatively, they might pass it on to family members or a new owner. In some cases, businesses may need to be closed down if they are no longer viable. (Karacan I et al., 2020, Kahraman, C etl al., 2020, Gegovska T et al., 2020)

The business life cycle of a food-related business is not strictly linear, and businesses may move back and forth between stages as they adapt to changing circumstances and opportunities. Successful management at each stage requires a keen understanding of industry dynamics, market conditions, and strategic decision-making.

Introducing the concept of using the Analytical Hierarchy Process (AHP) with Intuitionistic Fuzzy Set (IFS) in the development of the manufacturing industry involves combining two powerful decision-making methodologies to address complex and uncertain situations. Here's an introduction to this approach:

Analytical Hierarchy Process (AHP):

AHP is a structured decision-making technique developed by Thomas Saaty that helps individuals and organizations make multi-criteria decisions. It breaks down complex decisions into a hierarchical structure, where the main goal or objective is at the first priority and is followed by various principles that contribute to achieving that goal. AHP assigns numerical values to each criterion's importance and evaluates alternatives by comparing them pairwise. It is particularly useful when there are multiple factors to consider, and their relative importance is subjective. (Haq A. et al., 2006, Abdel-Basset et al., 2020).

Intuitionistic Fuzzy Set (IFS):

Intuitionistic Fuzzy Sets are an extension of classical fuzzy sets. They allow for handling uncertainty more effectively by introducing three parameters for each element: membership degree, non-membership degree, and hesitation degree. IFS is valuable in situations where information is incomplete or ambiguous, which is common in real-world decision-making. (Nazli Goker 2021).

Application in Manufacturing Industry Development:

Integrating AHP with IFS in the context of manufacturing industry development allows for more robust and informed decision-making in various aspects:

Site Selection: When choosing the location for a new manufacturing facility, decision-makers can use AHP to define criteria (e.g., cost, proximity to suppliers, infrastructure) and IFS to handle uncertain or imprecise data, such as incomplete information about infrastructure quality or land availability.

Supplier Selection: Manufacturing businesses often rely on a network of suppliers. AHP can help prioritize criteria for supplier selection (e.g., quality, cost, lead time), and IFS can manage the uncertainty associated with supplier performance.

Production Process Optimization: In improving manufacturing processes, AHP can assess criteria like efficiency, cost, and environmental impact, while IFS can handle imprecise data related to the efficiency of new technologies or the environmental impact of processes.

Resource Allocation: For resource allocation decisions, such as investments in new equipment or workforce expansion, AHP can prioritize criteria, while IFS can model the uncertainty in the availability of funds or the return on investment.

Market Expansion: Decisions about entering new markets can be complex. AHP can evaluate factors like market size, competition, and regulatory challenges, while IFS can accommodate uncertainty in market forecasts or regulatory changes.

Risk Management: Combining AHP and IFS enables a more comprehensive approach to risk assessment in manufacturing. AHP identifies and ranks risks, and IFS handles the uncertainty associated with risk probabilities and impacts.

Supply Chain Management: In managing supply chains, AHP can help prioritize criteria like cost, reliability, and flexibility, while IFS can address uncertainties in demand forecasts or supply disruptions.

By integrating AHP and IFS in the decision-making processes of the manufacturing industry, stakeholders can make more informed and resilient choices. This approach not only considers multiple criteria but also accounts for the inherent uncertainty and imprecision in real-world data, ultimately leading to more robust and adaptive manufacturing strategies.

2. LITERATURE SURVEY

A literature survey on the Implementation of the intuitionistic fuzzy set using an analytical hierarchy process for the food manufacturing industry based on multi-factors is a complex topic that requires an in-depth exploration of multiple areas including business life cycle models, the food manufacturing industry, AHP, and IFS (Table 1). Below is a brief overview of each of these components as they pertain into my research area.

Table 1. Exploration of multiple area

SI. No	Area	Overview
1	Business Life Cycle Models	Business life cycle models provide a framework for understanding the various stages that a business goes through from its inception to maturity and potentially decline. Some well-known models include the Startup Growth Model, the Product Life Cycle, and the Greiner Growth Model. These models help in identifying critical decision points and strategies appropriate for each stage. (Akhavan P et al., 2015)
2	Food Manufacturing Industry	The food manufacturing industry is a huge sector in the production, processing, packaging, and delivery of various products & goods. It has a crucial role in global economies and is subject to various challenges such as changing consumer preferences, regulatory requirements, and technological advancements. (Akhtar M et al., 2021, Arabsheybani A et al., 2018)
3	Analytical Hierarchy Process (AHP)	AHP is a multi-criteria decision-making method that enables the systematic structuring and evaluation of complex decision problems. It involves breaking down a problem into a hierarchical structure, followed by pairwise comparisons to establish relative priorities. AHP is widely used in business, engineering, and management for decision support. (Awasthi A et al., 2016)
4	Intuitionistic Fuzzy Set (IFS)	Intuitionistic Fuzzy Sets extend the concept of fuzzy sets by incorporating additional information related to the degree of membership and the degree of non-membership, along with a hesitation degree. This allows for a more nuanced representation of uncertainty and vagueness in decision-making processes. (Awasthi A et al., 2018)

Table 2. Analytical Hierarchy Process (AHP) Gap identification

Paper Title	Authors	Gap Identification	Year
Decision Making Using the Analytic Hierarchy Process (AHP). (Hamed Taherdoost 2017)	Hamed Taherdoost	Provides a step-by-step approach for decision-making using AHP	2017
Understanding the Analytic Hierarchy Process. (Konrad Kulakowski et al., 2021)	Konrad Kulakowski, et al.	Presents the method and methodology of the AHP and its application in multiple-criteria decision-making (MCDM)	2021
Applying the Analytic Hierarchy Process in healthcare research. (Katharina Schmidt et al., 2015)	Katharina Schmidt , et al.	Discusses the application of AHP in healthcare research and how it helps in decision-making for complex problems	2015
Decision Making Using the Analytic Hierarchy Process (AHP). (Hamed Taherdoost 2018)	Hamed Taherdoost	Summarizes the process of conducting AHP and highlights its effectiveness in making decisions with multiple criteria	2018
State-of-the-art on analytic hierarchy process in the last 40 years. (Madzík P et al., 2022)	Peter Madzik et al.	Explores the AHP method as a frequently used decision support tool and its principles of decomposition, comparative judgments, and synthesis of priorities	2022

Table 3. Intuitionistic fuzzy set (IFS) Gap Identification

Paper Title	Authors	Gap Identification	Year
An Overview on Intuitionistic Fuzzy Sets. (P. A. Ejegwa et al., 2014)	P. A. Ejegwa et al.	Provides an overview of Intuitionistic Fuzzy Sets and discusses their applications and limitations	2014
Information Quality for Intuitionistic Fuzzy Values. (D. Xie et al., 2022)	D. Xie et al.	Proposes a measure to quantify the information quality of intuitionistic fuzzy values and rank them accordingly	2022
Fuzzy/Intuitionistic Fuzzy Set Theory. (Tamalika Chaira 2019)	Wiley Telecom	Describes the definition, operations, and examples of fuzzy and intuitionistic fuzzy set theory	2019
A Novel Approach to Generalized Intuitionistic Fuzzy Sets. (Pavle Milosevic et al., 2021)	Pavle Milosevic	Presents the LBIFS-IBA approach based on interpolative Boolean algebra for generalized IFS and enhanced descriptive power	2021
Special Issue "Intuitionistic Fuzzy Sets and Applications" (Dr. Vassia Atanassova 2021)	Vassia Atanassova (Editor)	Highlights a special issue of the Mathematics journal focused on Intuitionistic Fuzzy Sets and their applications	2021

Introduction:
- Introduce the topic and its significance in the context of business development and decision-making.
- Highlight the relevance of AHP and IFS in handling complex and uncertain decision scenarios.

Business Life Cycle and Industry Development:
- Discuss key business life cycle models and their applicability to the food manufacturing industry.
- Explore empirical studies that analyze the life cycle stages of businesses in the food manufacturing sector. (Chen, K.S et al., 2019).

Analytical Hierarchy Process (AHP):
- Provide an overview of AHP, its principles, and its steps in decision-making.
- Present examples of how AHP has been applied in business contexts, emphasizing its role in strategic decision-making. (Gulcin Buyukozkan et al., 2019, Chan A.T et al., 2017).

Intuitionistic Fuzzy Set (IFS):
- Explain the concept of IFS and how it extends traditional fuzzy set theory.
- Discuss studies that showcase the use of IFS in handling uncertainty and imprecision in decision-making processes. (Bhattacharya A et al., 2019, Barhmi A. 2019, Beikkhakhian Y et al., 2015).

3. INTEGRATION OF AHP WITH IFS FOR BUSINESS LIFE CYCLE ANALYSIS

Present studies that combine AHP with IFS to address decision-making challenges specific to business life cycle stages in the food manufacturing industry.

Highlight the advantages of using this integrated approach compared to traditional methods.

Applications and Case Studies:

- **Provide real-world examples** and case studies where the integrated AHP-IFS approach has been applied to analyze to implement in various stages in the food manufacturing sector.
- **Discuss the outcomes,** insights, and recommendations derived from these applications.

Challenges and Future Directions:

- Identify any limitations or challenges in using AHP and IFS for business life cycle analysis.
- Suggest potential areas for future research and improvements in methodology.

Conclusion:

- Summarize the key findings and insights from the reviewed literature.
- Emphasize the significance of the integrated AHP-IFS approach in enhancing decision-making processes within the food manufacturing industry's.

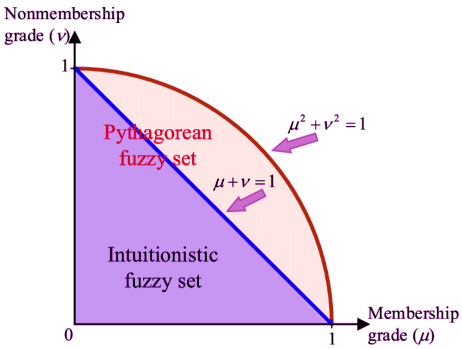

Figure 1. Membership vs Non-membership in Intuitionistic and Pythagorean fuzzy set

Remember that this is a high-level overview, and we need to delve into specific studies and sources to provide a comprehensive literature review. Make sure to critically analyze and synthesize the information we gather to create a coherent narrative that advances the understanding of your research topic. (Cheraghalipour A et al., 2018, Fan Z.P et al., 2020)

3.1 Previous Work

Comparing previous work on manufacturing industry development using the Analytical Hierarchy Process (AHP) and Intuitionistic Fuzzy Set (IFS) involves assessing how these two decision-making methodologies have been applied in the context of manufacturing. Here, I'll provide a general comparison by highlighting the key characteristics and benefits of each approach:

Analytical Hierarchy Process (AHP): Structured Decision-Making: AHP provides a structured framework for decision-making, particularly when dealing with complex problems that involve multiple criteria and alternatives.

Pairwise Comparison: AHP uses pairwise comparisons to assess the relative importance of criteria and alternatives, allowing decision-makers to quantify their judgments.

Transparency: AHP offers transparency in decision-making, as it clearly displays how priorities and rankings are determined based on the judgments of experts.

Deterministic Approach: AHP primarily operates with crisp (precise) data and preferences, assuming that decision-makers can provide exact values and preferences.

Consistency Check: AHP includes a consistency check to ensure that the judgments provided by decision-makers are coherent and do not contain contradictions. (Fei L et al., 2019, Garg C.P et al., 2020)

Intuitionistic Fuzzy Set (IFS):

Handling Uncertainty: IFS is effective at handling uncertainty and imprecision in data and preferences, which is common in real-world decision-making situations.
Membership, Non-membership, and Hesitation: IFS introduces three parameters (membership degree, non-membership degree, and hesitation degree) for each element, allowing for a more nuanced representation of uncertainty.

Realistic Modelling: IFS provides a more realistic and flexible modelling approach when dealing with vague or incomplete information.

Extension of Fuzzy Sets: IFS is an extension of classical fuzzy sets, which makes it suitable for situations where both fuzzy and non-fuzzy data coexist.

Complexity: IFS-based decision-making models can be more complex than AHP models due to the additional parameters and computations involved. (Ghorabaee M.K et al., 2017, Goker N 2021)

Comparison:

Data Nature: AHP works well with crisp data and well-defined preferences, while IFS is designed for situations where data is uncertain, vague, or imprecise.

Complexity: AHP is generally easier to implement and understand, making it a practical choice for straightforward decision problems. In contrast, IFS introduces more complexity but offers a more expressive way to handle uncertainty.

Transparency: AHP provides transparency through its hierarchical structure and clear numerical values for judgments. IFS, while capable of modelling complex uncertainties, may be less transparent due to the intricacies of fuzzy parameters.

Application: AHP is widely used in various industries, including manufacturing, for tasks like supplier selection, product design, and process optimization. IFS is more specialized and tends to be applied in situations where uncertainty and imprecision play a significant role.

Sensitivity to Data Quality: AHP may be sensitive to the quality and consistency of data and judgments. IFS is designed to accommodate varying degrees of data quality and imprecision. (Haoues M et al., 2021, Helo P et al., 2021)

In summary, the choice between AHP and IFS for manufacturing industry development depends on the nature of the decision problem and the available data. AHP is suitable for structured problems with clear preferences, while IFS excels in situations where uncertainty and imprecision are prevalent, allowing for a more realistic representation of decision-making scenarios. Researchers and practitioners often select the approach that aligns best with the specific characteristics of their problem.

4. CONCLUSION

If the consistency index is not satisfied then we have to start from the initial stage, to overcome this issue we can use the Delphi method to reduce the time of repetition. In the intuitionistic fuzzy set, we are using membership, non-membership, and discriminant values. If this condition is not satisfied we can't able to get the solution to the given problem, to overcome with this issues we can use Pythagorean intutionsitic fuzzy set, moreover to get the best results we can combine an intuitionistic fuzzy set with AHP or Pythagorean fuzzy set with AHP.

The integration of AHP with IFS has emerged as a valuable approach for addressing the complexities and uncertainties of the food manufacturing industry's. It offers a structured framework for decision-making, strategic planning, and competitive analysis, while accommodating the vagueness and imprecision inherent in this dynamic sector. As the industry continues to evolve, further research and practical applications of AHP-IFS are expected to play a pivotal role in supporting informed and effective decision-making processes.

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