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Evaluating the Supply Chain Risks of Packaging Requirements with the Fuzzy Hierarchical Analysis Method and Choosing the Appropriate Strategy with Sustainability Considerations

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Abstract

The packaging industry has a direct relationship with the company's branding by protecting the goods during transportation. An issue that will have a direct effect on other companies in the supply chain of the necessities industry. Therefore, by knowing the importance of this supply chain, the existing conditions can be reviewed and presented to experts. From another point of view, the economic, social and environmental issues of this industry are also very important. In this regard, in the article, the elements that can be interrupted in a network including the supply of essentials of the packaging industry with dysfunction, 12 main and 172 sub-indices are identified, and in the second step, each characteristic is prioritized and the evaluations are specified. Potentially, a questionnaire will be published among experts to identify important risks. Then, after collecting the questionnaires, the inconsistency rate index of each questionnaire is calculated and after the final approval of each questionnaire with the fuzzy hierarchical method (AHPF). In the third stage, after identifying the potential questions, a letter will be presented to the supply chain experts in order to provide a suitable solution to the potential risks. In the fourth stage, to recognize resolutions, experts are divided into three decision categories, which will include risk-taking decision makers, neutral decision makers, and risk-averse decision makers.

Keywords:
Supply chain risk, Sustainability, Industry compulsory packaging, Process decomposition hierarchy fuzzy.

1. Introduction

The packaging industry plays a critical and multifaceted role in modern commerce, maintaining a direct and undeniable relationship with a company's corporate branding, market positioning, and consumer perception by effectively protecting goods during storage, handling, and transportation. When packaging integrity is compromised, the negative repercussions extend far beyond immediate product damage, creating a cascading effect that directly impacts partner companies, suppliers, distributors, and stakeholders throughout the broader supply chain of the essential goods industry [1,2]. Therefore, a comprehensive and rigorous understanding of the structural importance of this supply chain enables researchers and practitioners to systematically review existing operational conditions, identify underlying risks, and present actionable, evidence-based insights to industry experts. From another vital point of view, the economic, social, and environmental dimensions of this industry are of paramount importance, necessitating a holistic approach to sustainable supply chain management. In this regard, the present research meticulously investigates the elements within a complex supply network—specifically focusing on the supply of essentials within the packaging industry—that are susceptible to disruption and dysfunction [3]. Through exhaustive literature reviews and expert consultations, 12 main indices and 172 sub-indices of potential risks and disruptions were successfully identified.

Building upon this foundational identification, the second step of the research establishes a robust prioritization framework where each characteristic is thoroughly evaluated, and its relative importance and evaluation metrics are

precisely specified. To accomplish this, a structured questionnaire is designed and distributed among qualified industry experts and domain specialists to accurately pinpoint critical operational risks. Following the collection of these completed questionnaires, the inconsistency rate index for each individual response is rigorously calculated to ensure data reliability and methodological validity. Upon the final verification and approval of each valid questionnaire, the Fuzzy Analytic Hierarchy Process (FAHP) is applied to weigh and prioritize the identified risk factors under conditions of uncertainty. In the third stage of the research, following the comprehensive identification and ranking of these potential disruption factors, specialized guidelines and recommendations are presented to supply chain experts in order to formulate tailored, highly effective solutions for mitigating each potential risk. Finally, in the fourth stage, to accurately recognize and categorize resolutions based on behavioral economics and decision-making theory, the participating experts are categorized into three distinct decision-making profiles: risk-taking decision-makers, risk-neutral decision-makers, and risk-averse decision-makers. This categorization ensures that the proposed strategies and resilience frameworks are adaptable to varying organizational risk tolerances, ultimately providing a robust blueprint for enhancing stability, efficiency, and sustainability across the packaging industry's supply chain ecosystem.

2. Fuzzy Analytic Hierarchy Process For Evaluating the Supply Chain Risks

Fuzzy Analytic Hierarchy Process (FAHP) is a method for analyzing pairwise comparison matrices using fuzzy logic. In the conventional AHP method, the mental abilities and skills of experts are used to make comparisons. However, it should be noted that traditional pairwise comparisons do not fully reflect human thinking. The use of fuzzy numbers is more compatible with human verbal and sometimes ambiguous expressions, so it is better to use fuzzy numbers to make decisions in the real world. Therefore, in the fuzzy AHP method, the decision-maker is enabled to provide a more realistic score for other options for cases where there are many uncertainties. Fuzzy numbers are fuzzy sets that are used when an implicit representation of uncertainty is required along with numerical data. Among the fuzzy numbers are triangular and trapezoidal fuzzy numbers, where triangular fuzzy numbers are used in descriptive conditions and trapezoidal numbers are used for prediction [5]. Based on this information, triangular fuzzy numbers are used in this article for descriptive conditions.

In this research, we seek to identify and analyze potential risks in the packaging supplies industry supply chain and define an appropriate strategy against these risks. Therefore, the FAHP method are investigated to identify and prioritize risks.

3. Conclusion

In this study, we identified the important risks of the packaging materials industry supply chain that can lead to supply chain failure, extracted the important risks of this industry, and presented appropriate strategic measures against these risks, which as a result provides a comprehensive view of the conditions of the risks of the packaging materials industry supply chain network. Finally, a sensitivity analysis was performed on three important parameters of this chain, and the sensitivity of each parameter to other sectors was determined.

It should be noted that operational, quality, and delivery risks are more sensitive than other risks. For example, increasing marketing risks can cause sudden changes in demand forecasts, which in turn will increase operational risk and, as a result, will make quality risk critical.

Regarding the risks affecting timely delivery to customers, logistics, process management, or information and supply risks can be considered. Among the above-mentioned cases, logistics risk is more important, so appropriate strategic measures should be taken to deal with these disruptions that can have a significant impact on the supply chain.

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