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Article

Sustainable Supply Chain Risk in Food Packaging Industry: Integrated Delphi-CRITIC-COPRAS Method Using Fuzzy Set Theory

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Abstract: The present study aims to develop a framework for sustainable supply chain risk management evaluation in the food packaging industry based on multi-criteria decision-making (MCDM) methods in the fuzzy environment. An integrated MCDM approach is proposed based on Delphi, CRiteria Importance Through Intercriteria Correlation (CRITIC), and COmplex PRoportional ASsessment (COPRAS) methods. Through reviewing the research literature, related criteria were identified and selected based on experts' opinions and the fuzzy Delphi method. The fuzzy CRITIC method was used to determine the weights of the criteria. Finally, based on weighted indices and the fuzzy COPRAS method, food packaging suppliers were ranked according to their ability to manage the risks of sustainable supply chain activities. The results show that operational risks are essential in evaluating suppliers' risks in sustainable supply chain activities in the food packaging industry. Also, the three sub-criteria with the highest weights are defined as product quality risk, machines and equipment risks, and restrictions on green processes.

Keywords: Risk assessment, Sustainable supply chain, Food packaging industry, Delphi-CRITIC-COPRAS approach, Fuzzy environment

1. Introduction

Food packaging fulfills many essential functions. It protects food from detrimental physical, chemical, and biological influences. The containment function enables distribution and prevents product losses through spillage, the friction of loose materials, and the mixing of different products. Packaging adds convenience to food and facilitates accessibility and easy preparation. It informs the consumer about a product's content, shelf life, and storage conditions (Pauer et al., 2019). However, the food packaging industry is increasingly required to become more sustainable since the packaging's production, use, and disposal are associated with many environmental direct impacts. In addition to the direct effects, there are also adverse environmental effects indirectly caused by inadequate packaging activities. Thus, focusing on sustainability and sustainable actions in the industry's supply chain can lead to better and more productive performance.

For many reasons, such as political issues, new technologies, technological replacement, and demand fluctuations, companies displayed a loss of readiness for supply chain management activities (Rostamzadeh et al., 2018). Sustainable development balances economic, ecological, and social impacts (Sikdar, 2003). Focusing on sustainable actions and taking responsibility for a company's business-related activities without harming nature and society has become an important asset for companies. It is now widely accepted that investing in the sustainable performance of organizations improves business profitability and performance by increasing resource efficiency and promoting innovations over a long period (Lindgreen and Swaen, 2010). Companies' sustainable performance has been considered one of the most critical subjects in the modern study of operations management (Lim et al., 2017).

On the other hand, risk is one of the ever-present dimensions of organizations. In particular, due to the vulnerability and emergence of customers' needs and regulatory agencies, sustainable supply chain management approaches face many risks. This has made it difficult to predict the occurrence and effects of such risks, especially in critical chains of supplying needed products and services of companies (Stindt, 2017). These risks can harm the quality of sustainable actions along the chains because risks can undermine the factors that enhance the sustainable performance of companies. Therefore, they need to be well considered.

A company's sustainability depends on purchasing, and the supply management function is largely dependent on implementing sustainable supply programs (Schneider and Wallenburg, 2012). Studies have shown that accepting and employing a green supply chain helps companies conserve their resources (which can further strengthen their economic and environmental performance) and contributes to the company's sustainable development (Mangla et al., 2015a). However, although contributing to the sustainable development of a company is an effort by all company units, ensuring responsiveness and transparency in the supply chain is the main and key driver of risk management and supply chain management (Schneider and Wallenburg, 2012). Although companies may show great effort and commitment to sustainability, most of them face serious challenges and problems, and because of that, sustainable implementation becomes a challenging and risky issue (Lindgreen et al., 2009) and transforms into different risks. Therefore, more knowledge is needed on implementing and controlling sustainability and related activities in the business and supply chain.

One of the most important reasons for increased risk in companies' supply chains is that many firms are expanding their supply chain to reduce costs and cooperation with more companies. Such firms encounter new risks because of various events or standards or regulations in various areas or countries (Ellis et al., 2011). Christopher and Lee (2004) proposed that a high-risk supply chain is not effective and cannot meet the company's expectations of supply chain processes. If a company focuses only on profitability (reducing supply chain costs) and ignores risk management, it is doomed to failure in its supply chain activities (Fan et al., 2017). Because of the great importance of sustainable activities in companies' supply chains (Wang and Sarkis, 2013), the issue of risk and risk management needs to be considered by managers of companies. To improve the sustainability of the supply chain, specific uncertainty and risk factors of different companies must be defined and continuously monitored, and pay special attention to supply chain risk management.

Supply chain risk management is useful for the company in several ways: preventing the misuse of resources, reducing costs by identifying, ensuring key steps in the process, increasing the capability of the company to respond optimally to unpredictable events, creating capabilities and competencies in the company to gain customer satisfaction, and ensuring that the business continues to operate effectively (Abdel-Basset et al., 2020). There are many challenges and problems in managing the sustainable supply chain effectively. One of the most important problems is uncertainty, which is in the process of evaluating the effectiveness of sustainable supply chain risk management. Recent studies on sustainable supply chain risk management evaluation have shortcomings in considering the different factors that can affect risk creation and providing appropriate frameworks and methods for risk assessment. In this regard, the use of traditional methods such as TOPSIS and the lack of use of newer methods is one of the factors of the inefficiency of the introduced frameworks.

The contribution of the present study is two-fold. The first is the development of risk criteria in the sustainable supply chain risk management studies, and the second is creating a framework that includes methods with higher simplicity and optimization in comparison to traditional methods. In particular, previous studies show that there has been no significant study in the field of risk management for a sustainable supply chain among food packaging manufacturers. Therefore, in this study, fuzzy COmplex PRoportional ASsessment (COPRAS) and fuzzy CRiteria Importance Through Intercriteria Correlation (CRITIC) methods have been used to create a framework for sustainable supply chain risk management evaluation.

The rest of this paper is structured as follows. The second section discusses related literature on sustainable supply chain risk management. The proposed framework for evaluating sustainable supply chain risk management using a Delphi-COPRAS-CRITIC method in the fuzzy environment is presented in Section three. The practical application of the proposed framework for risk evaluation in a real case is discussed in Section four. In the fifth section, the discussions and results are provided, and finally, in the sixth section, research limitations, future work suggestions, and conclusions are presented.

1.1. Sustainable supply chain risk management

In various studies in the field of the supply chain, sustainability has been defined in different ways. Ahi and Searcy (2013) defined the sustainable supply chain as "the creation of coordinated supply chains through the voluntary integration of social, environmental, and economic considerations with key inter-organizational business systems designed to effectively and efficiently manage the capital, information, and material flows associated with the production, procurement, and distribution of services and products, or to improve the resilience of the organization over the long and short-term and increase the profitability and competitiveness and meet stakeholder requirements." Also, from the viewpoint of researchers such as Christopher and Lee (2004), risk in supply chain activities is defined as any potential risk in the area of products, raw materials, or financial flows of the company from suppliers and has an impact on the offering of the final product. Many studies focus on risk management to achieve a sustainable supply chain. For example, Venkatesh et al. (2015) used interpretive structural modeling (ISM) to propose a risk prioritization model and a framework to analyze supply chain risks in Indian apparel retail chains. Aqlan and Lam (2015) provided a combined framework based on Bow-Tie analysis and fuzzy inference system (FIS) in which decision-makers based on the individual and aggregated risk scores, can focus on the significance of effective risks that could impact their business performances. Behzadi et al. (2018) considered robustness and resilience as two critical techniques for managing supply chain risk in the agricultural sector. Er Kara et al. (2020) also used a data mining framework to measure different types of risks in the supply chain. Shojaei and Haeri (2019) proposed a comprehensive approach to supply chain risk management in construction projects by using grounded theory and fuzzy cognitive mapping under an uncertain environment. Yang et al. (2019) also focused on financial risks in the supply chain using data analysis methods. As it is evident, a variety of techniques are used by different authors in managing the risks in the (sustainable) supply chain.

Although enormous research has generated understanding and analyzed the supply chain risks, little study has been done to advance risk considerations that include the idea of sustainability across the supply chain. Understanding what SSCRM means and which information needs to be controlled is puzzling. By thinking of the sustainability of the supply chain as a process of risk management, the studies with this view are scarce. In today's supply chain management, supply chain risk and sustainability are the two outstanding issues that are frequently intertwined and often viewed in separation. Therefore, it is necessary to pay attention to these two important issues in the studies of supply chain management in combination and interference with each other. More research is necessary to focus on the intertwining of these two critical areas. This is especially more serious in the field of research related to the supply of food products. Because the lack of studies in this industry is obvious and the development of related studies is required in this field, more specific risks can appear in different industrial sectors. Thus, methods to reduce the negative effects of risks are demanded to develop.

1.2. Application of Multiple-criteria decision-making methods in supply chain risk

In recent years, by using multi-criteria decision-making (MCDM) techniques, various models have been suggested to manage risk in the supply chain. For example, Moeinzadeh and Hajfathaliha (2009) used a combined fuzzy decision-making approach based on the Analytic Network Process (ANP) and VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) to the assessment of supply chain risks. Risks were identified and categorized from the literature and weighted using the ANP method. Then, the VIKOR method was used to identify the riskiest partner and rank the supply chain members. Wang et al. (2012) presented a model for supply chain risk assessment in the fashion industry, which provides the possibility of performing and implementing risk assessment of various activities of greening this chain. Samvedi et al. (2013) used an integrated approach of fuzzy hierarchical analysis process methods and fuzzy technique for Order Performance by Similarity to Ideal Solution (TOPSIS). The use of fuzzy values and the final conversion of these values into definite numbers facilitates a more accurate gathering of experts' opinions and makes the results more comprehensible. Ganguly and Guin (2013) used the Fuzzy AHP approach in their study to assess supply risks for a product category. The technique determines the supply related to risk and its potential impact on the buyer organization. The proposed model is simple and flexible and could be followed by practitioners. Rajesh and Ravi (2015) used decision-making trial and evaluation laboratory (DEMATEL) approaches and grey theory to identify the major enablers of supply chain risk mitigation. The results show that supply chain risk mitigation's enablers are intertwined and have network relationships. Mangla et al. (2015) proposed an integrated methodology of Fault-tree analysis (FTA) and the fuzzy Analytical Hierarchy Process (AHP) approach. They sought to provide a framework for integrating qualitative and quantitative information for decision-makers to analyze green supply chain risks in a fuzzy environment. The main weakness of this study is the focus on the traditional approach of AHP and subjective judgments of experts without considering the possibility of deviations and errors in decision-making.

Song et al. (2017) investigated the critical risk factors of sustainable supply chain management. They looked for different sources of risk in sustainable supply chain management. In this regard, the fuzzy DIMATEL method was selected as the main approach to identify the relationships between risk sources and also identify the most effective of these factors. This study only identified the causal relationships between sources of supply chain risk management in the communications industry. The identified structure is a good source for future studies to identify the importance of these risk sources. Mangla et al. (2018) used the fuzzy FMEA approach for assessing the risks associated with the Green Supply Chain for benchmarking the performance in terms of effective GSC management adoption and sustainable production. In this study, fuzzy logic was applied to conventional FMEA to overcome the issues in assigning risk priority numbers. This study focused on one of the dimensions of sustainability, the environmental dimension. According to environmental approaches, Kumar et al. (2019) conducted a study on supply chain risk management in India's pharmaceutical industry to identify green supply chain risk management indicators in the pharmaceutical industry based on the study of research literature and to achieve aggregation in the field of these indicators through fuzzy Delphi and weighting them through fuzzy AHP. Rostamzadeh et al. (2018) developed a framework for evaluating sustainable supply chain risk management (SSCRM). To this end, an integrated fuzzy multi-criterion decision-making (MCDM) approach was proposed based on the technique in order of preference by similarity to the ideal solution (TOPSIS) and criteria importance through CRITIC method. Sharma et al. (2018) provided a framework for examining the risks involved in the sustainable supply chain management of the food production industry. The researchers extracted the proper indicators from the existing literature on sustainable supply chain and risk management and ranked them using the fuzzy AHP method. The most significant risks identified in this area included financial, technical, and safety risks. Paksoy et al. (2019) provided a framework for assessing the green supply chain management risk. In this study, a fuzzy framework was developed to evaluate the risk of suppliers' green activities. The risk criteria were identified and determined to obtain their relative weight based on the fuzzy AHP method. Second, the suppliers' scores were assessed according to the linguistic variables. Third, the suppliers' risk level was calculated to provide the performance ranking of the suppliers based on the given weight of risks and the VIKOR method.

1.3. Research framework and the case study

The company's external environment, operations, risk status changes, and the severity of the risks associated with its activities are not static. Therefore, by identifying substantial risks related to the company and continuously monitoring them, the level of changes in risks and their consequences can be understood, and the possibility of these risks occurring in the future is predicted. In addition, due to the intertwined nature of risks, potential risks are identified in the future. Hallikas et al. (2004) stated that it is necessary to update risk assessment approaches to monitor customer needs, partner strategies, changes in the market trends, and competitors' performance for identifying these factors. Due to the complexity of interactions and competition in the market, uncertainty in the supply chains has increased. It has forced organizations to adopt approaches to reduce vulnerability and strengthen the stability of the supply chains. Therefore, risk management, especially in the company's supply chain, is a pivotal activity to identify and manage current and potential risks, which requires corporate investments to anticipate demand ambiguities, supplier performance, and in-house performance (Rostamzadeh et al., 2018). Management of supply chain risk is necessary to identify and deal with this uncertainty and reduce the supply chain's vulnerability (Olson and Dash, 2010).

Nowadays, the food and packaging industry is highly interdependent. The packaging industry plays a vital role in the food industry to maintain and develop the quality and health of its final products. The present study evaluates the suppliers of one of the largest dairy companies in Iran, namely Kalleh Company, which uses packaging for various dairy products. Kalleh Amol Dairy Company, the largest subsidiary of Solico Holding, is one of the largest Iranian companies in dairy production, producing pasteurized milk, yogurt, cheese, ice cream, and others. These companies provide various packages for more than one hundred and seventy types of Kaleh Amol Company's dairy products and other products of the Solico subsidiary (various protein products). These suppliers are all subsidiaries of Solico Holding and have a close management relationship with Kalleh (the largest subsidiary of Solico Holding). These five packaging suppliers of Kalleh products are located in different parts of Iran: two suppliers in Mazandaran province, two in Tehran, and one in Golestan. Based on this distribution and to keep the details secret, they are called as follows: Mazandaran 1, Mazandaran 2, Tehran 1, Tehran 2, and Golestan. Based on the research literature in supply chain risk management (sustainable and green), 42 risk assessment indicators were identified, of which 21 risk assessment criteria were selected and categorized in 5 selections using expert opinions and the Delphi Fuzzy method.

2. Materials and Methods

The proposed research model is based on fuzzy sets theory and the fuzzy Delphi-CRITIC-COPRAS method. With collected data, the opinions of 6 experts were reflected. The panel of experts consisted of experts with the necessary expertise and operational experience in the field of risk assessment in the management of the sustainable supply chain of the food industry. These experts all have at least 20 years of work experience and hold managerial positions in Kalleh Company.

2.1. Fuzzy Delphi

The Delphi method is an effective predictor tool and is widely used in technology forecasting, strategy planning, knowledge acquisition, urban systems planning, public policy summarizing and planning, market research, large-scale project planning, developing a new product, designing systems, and identifying important components of a measurement system. The Delphi method is used in two ways: prediction and screening. If the goal is prediction, it is usually done in several rounds, but the screening mode can also be done in one round (Noh et al., 2019). Ishikawa (1993) proposed the fuzzy Delphi technique, which was a combination of the traditional Delphi technique and fuzzy set theory. Researchers such as Schwenk (1995) have argued that using fuzzy Delphi in group decision-making significantly solves the complexity and ambiguity of experts' perceptions and opinions. Since previous studies have generally used triangular and trapezoidal fuzzy numbers in their data collection processes, fuzzy triangular numbers are used in this study to reduce the level of computational complexity. The steps of the single-stage fuzzy Delphi method to select the criteria are introduced (Hsu et al., 2010):

Step 1- Gathering experts' opinions: this step begins with extracting the criteria and factors from the literature. For this purpose, a standard questionnaire containing the extracted criteria is prepared (the requirements for sustainable supply chain risk assessment) and provided to the experts in the form of a general question: what is the desirability of criteria to measure supplier performance in the field of sustainable supply chain risk management? Respondents selected their answers from Table 1.

Table 1. Qualitative values and corresponding fuzzy values

Qualitative values	Fuzzy values
Highly inappropriate	(0,0,0.1)
inappropriate	(0,0.1,0.3)
Low inappropriate	(0.1,0.3,0.5)
indifferent	(0.3,0.5,0.7)
Low appropriate	(0.5,0.7,0.9)
appropriate	(0.7,0.9,1)
Highly appropriate	(0.9,1,1)

Step 2- Receiving the opinions of experts and aggregate these opinions: based on the opinions of each expert, these criteria are aggregated to be examined in the form of a general and aggregated view. For this purpose, simple and geometric averaging approaches are used in studies. In the present study, a geometric averaging method was used due to a more logical aggregation of fuzzy data. This approach was proposed by Yuan and Klir (1996).

$$\begin{aligned} a_{ij\,1} &= min\{a_{ij\,1}^{1}, a_{ij\,1}^{2}, \dots, a_{ij\,1}^{K}\}, \\ a_{ij\,2} &= \left(\prod_{k=1}^{K} a_{ij\,2}^{K}\right)^{1/K}, \\ a_{ij\,3} &= max\{a_{ij\,3}^{1}, a_{ij\,3}^{2}, \dots, a_{ij\,3}^{K}\} \end{aligned} \tag{1}$$

In fuzzy triangular numbers collected from experts, to aggregate these numbers, the lower limit includes the smallest lower limit among the lower limits. The upper limit includes the highest upper limit among the upper limits. The midpoint consists of the geometric mean midpoint of the fuzzy triangular numbers.

Step 3- Defuzzifying aggregated experts' opinions for each criterion: each triangular fuzzy number resulting from the consolidation of experts' opinions based on the following formula is converted from fuzzy to non-fuzzy mode to facilitate judgment on them. Assuming that $\tilde{v}$ = (a, b, c) is a triangular fuzzy number, the following equation is used (Rouhparvar and Panahi, 2015).

$$V = \frac{a+4b+c}{6} \tag{2}$$

Step 4- Screening the criteria using a threshold: this step is dedicated to removing the less important criteria to select the most important of them. For this purpose, a threshold limit is used, and criteria with scores smaller than this threshold are removed. In this study, based on Yuan and Klir (1996), the threshold was 0.8.

2.2. Fuzzy CRITIC

The fuzzy CRITIC method is considered one of the methods of criteria weight identification. In decision-making problems, criteria are considered important sources of information. Indeed, the weight and importance of the criteria reflect their intensity and importance from the point of view of the respondents to identify the actions of an organization or its suppliers or to perform an activity according to them. This weight and importance indicate the amount of information contained in each of the indicators in the decision matrix. These weights are also known as the objective weights of criteria. The CRITIC is a method for determining the objective weights of criteria in the decision-making problems with multiple criteria (Diakoulaki et al., 1995). The fuzzy approach of this method has been considered by researchers in recent years by using standard deviation between indices and linear correlation coefficient between them. Then, it calculates and offers the weights of the criteria based on the differences between them (Rostamzadeh et al., 2018). The weights extracted from this method consist of the intensity of the contrast and the intensity of the difference between the indices. The weights extracted from the CRITIC method are based on the intensity of the opposition and the intensity of the difference. In this context, standard deviation and linear correlation coefficient are used, respectively. The followings are the analytical steps of this method.

Step 1- Suppose that $\tilde{x}_{ij} = \left(x_{ij1}, x_{ij2}, x_{ij3}\right)$ represents the fuzzy performance value of ith alternative according to *j*th criteria $(i = 1,2,\dots,n \; and \; j = 1,2,\dots,m \;)$ and $\widetilde{w}_j^o = (w_{j1}^o, w_{j2}^o, w_{j3}^o)$ denotes the fuzzy weight of *j*th criteria. Also, B is the set of beneficial criteria (advantage), and the symbol N is the set of non-beneficial criteria (cost). The process of determining the fuzzy objective weights of criteria based on the CRITIC method is as follows.

$$x_{ijk}^T = \frac{x_{ijk} - x_{jk}^-}{x_{jk}^* - x_{jk}^-} \quad if \quad j \in B \tag{3}$$

$$x_{ijk}^T = \frac{x_{jk}^- - x_{ijk}}{x_{jk}^- - x_{jk}^*} \quad if \quad j \in N \tag{4}$$

$$X_{jk} = (x_{1jk}^T, x_{2jk}^T, \dots, x_{njk}^T) \tag{5}$$

In other words, each member of the Criteria-Alternative matrix, depending on whether the criteria are positive or negative, transforms to the vector (5) based on one of Eqs. (3) or (4). Thus, in positive criteria, each component of the fuzzy number (lower bound, upper bound, and middle bound) is first deducted from the smallest corresponding boundary of its column and then normalized and divided by the largest corresponding boundary column and the smallest corresponding column. In the case of negative criteria, the same process is repeated. The difference is that the smallest corresponding column boundary is minus the corresponding boundary of the fuzzy number. It is noteworthy that *k* contains the value of three because fuzzy triangular numbers were used in this study.

Step 2- Calculating the standard deviation (δ_{jk}) of each vector(X_{jk})

Step 3- Constructing three symmetric matrices with dimension $m \times m$ and the generic elements $r_{jj^*}^k$ based on which three matrices are obtained with these characteristics $\left(R^k = \left[r_{jj^*}^k\right]_{m\times m}, j^* = 1,2,\dots,m \; and \; k = 1,2,3\right)$. The elements of these three matrices include the correlation coefficient between the vectors X_{jk} و X_{j^*k}. In other words, the matrix of modified performance values is divided into three matrices in this step, based on low, medium, and high bounds, and by calculating the linear correlation coefficient between column vectors of each of the three matrices, three symmetric matrices are formed based on the values of these coefficients.

Step 4- Calculating the information indicator of each criterion as follows

$$H_{jk} = \delta_{jk} \sum_{j^*=1}^{m} (1 - r_{jj^*}^k) \tag{6}$$

Step 5- Determining the unsorted importance weights of components based on the following equation

$$W_{jk}^u = \frac{H_{jk}}{\sum_{j^*=1}^{m} H_{JJ^*}} \tag{7}$$

Step 6- Determining the initial weights of the criteria using the following equation

$$W_{j3}^{oi} = maxW_{jk}^u \tag{8}$$

$$W_{j2}^{oi} = maxW_{jk}^u \tag{9}$$

$$W_{j1}^{oi} = minW_{jk}^u \tag{10}$$

Step 7- Normalize the initial weights and determine the final weight based on the following equation

$$\widetilde{w}_j^o = \frac{\widetilde{w}_j^{oi}}{\frac{1}{m} \oplus \widetilde{w}_j^{oi}} \tag{11}$$

Table 2. Qualitative values and corresponding fuzzy values

Qualitative values	Qualitative values	Fuzzy values
Very high	Very good	(8,9,9)
indifferent	indifferent	(6,7,8)

high	good	(5,6,7)
indifferent	indifferent	(4,5,6)
moderate	moderate	(3,4,5)
indifferent	indifferent	(2,3,4)
low	weak	(1,2,3)
indifferent	indifferent	(0,1,2)
Very low	Very weak	(0,0,1)

2.3. Fuzzy COPRAS

In 1996, researchers at the Vilnius Technical University developed a method called COPRAS. This method is used to evaluate multiple criteria to maximize and minimize the value of the criteria. It is mainly used to evaluate complex processes by quantitative multi-criteria methods. In this method, the effect of maximization and minimization of criteria is considered separately. In recent years, the use of the COPRAS method as one of the multi-criteria decision-making methods has increased owing to the simplicity of calculation, complete ranking of alternatives, and considering positive and negative criteria. The classical COPRAS method calculates the criteria' weights and the options' ranking based on definite values. However, for two reasons, the set of fuzzy numbers is used in the COPRAS method: one is to get the experts 'opinions more accurately, and the other is to turn the experts' opinions into the desired outputs more accurately. The steps of the fuzzy COPRAS approach are similar to the classic COPRAS, and the main procedure of the COPRAS method involves several steps, which are discussed below (Rabbani et al., 2014).

Step 1- Creating a Decision Matrix (D): the COPRAS decision matrix is the same as the TOPSIS and Višekriterijumsko kompromisno rangiranje (VIKOR) or ÉLimination et Choix Traduisant la REalité (ELECTRE) decision matrix. That is the criterion-alternative matrix. The method of making the questionnaire of COPRAS is the same as the TOPSIS and VIKOR questionnaires. For example, Table 3 shows the criteria in the column and the options in the row. The decision matrix consists of fuzzy triangular numbers derived from experts' opinions about "Operational success of the alternative ..... in the field of criteria of ....". In this regard, experts have declared their opinions based on Table 2.

Step 2- Calculating the weight of the criteria: in this step, the subjective Weights of the criteria should be calculated based on experts' opinions. These weights are obtained based on experts' direct opinions. Then aggregation and normalization of opinions conduct to achieve the final subjective Weights of the criteria. These weights are calculated based on Eq. (2), with the objective weight obtained from the fuzzy CRITICAL method and the final weights of each evaluation criteria.

Step 3- Aggregating experts' opinions: in this step, the fuzzy scores collected from the experts are gathered together to achieve a single output. In this regard, the arithmetic mean is used. For this purpose, the corresponding members are considered in the expert opinion matrix. The arithmetic means of the lower, upper and middle bounds are calculated and placed in the aggregated matrix.

Step4- Defuzzifying fuzzy aggregated matrix: in this step, the fuzzy aggregate matrix of opinions is defuzzified with Eq. (12) and is implemented on each fuzzy member. If $\tilde{m} = (a, b, c)$ is one of the fuzzy members of the experts' aggregation matrix,

$$m = \frac{a+2b+c}{4} \tag{12}$$

Step 5 - Determining positive and negative criteria: positive metrics are criteria that increase in it cause to improve conditions, and negative criteria are criteria that reduce it more economically and improve conditions.

Step 6- Normalizing the decision matrix: in this step, the decision matrix of the COPRAS method is normalized.

$$d_{ij} = \frac{q_i}{\sum_{j=1}^{n} x_{ij}} w_j \tag{13}$$

Step 7- Calculating the normalized values: in this step, the sum of the normal values of the positive and negative criteria is calculated separately for each alternative.

$$s_j^+ = \sum_{z_i=+} d_{ij} \tag{14}$$

$$s_j^- = \sum_{z_i=-} d_{ij} \tag{15}$$

Step 8- Final ranking of alternatives: in this step, according to the following relationship, which is the calculation of the COPRAS index, we rank the alternatives. The larger the Qj value, the better the ranking of the alternatives. The alternative with the most value is the ideal alternative.

$$Q_j = S_j^+ + \frac{\sum_{j=1}^{n} s_j^- x}{s_j^- \sum_{j=1}^{n} \frac{1}{s_j^-}} \tag{16}$$

Step 9- The final step is to identify the best alternative among the criteria. Alternatives in the best position in terms of criteria are determined by *Nj*'s highest degree of importance, which is 100% of *Nj*. The overall value of each alternative that is calculated is from 0 to 100 %, which determines the best and worst alternatives within this range. The degree of importance of each *Nj* of the alternative of *Aj* is calculated based on the following equation.

$$N_j = \frac{Q_j}{Q_{max}} \times 100 \tag{17}$$

2.4. Integrated approach

In the present study, the combined approach of the Delphi-CRITIC process is used to identify the determination of the weights of the risk criteria, and the fuzzy COPRAS method is used to provide a performance ranking of suppliers based on the given weighted criteria. Based on studies such as Shemshadi et al. (2011), objective methods reduce the effect of respondents' mental deviations on output results (risk weights). These methods minimize the impact of mental instability and lead to more realistic results. The fuzzy COPRAS method has simplicity in ranking alternatives and a low computational time (Chatterjee et al., 2011) and is a newer method than the fuzzy TOPSIS method. Studies such as Mulliner et al. (2016) have shown that the fuzzy COPRAS method compared to other methods such as Modified Fuzzy AHP and fuzzy TOPSIS, is more transparent, straightforward, and optimal computational than the other methods. This method estimates the degree of desirability of the alternative as a percentage. In other words, it shows the extent to which an alternative is better or worse than other options. Simanaviciene and Ustinovicius (2012) showed that the decisions made by the COPRAS method have higher efficiency and less deviation compared to the decisions made through TOPSIS and SAW. Due to these advantages, in this study, the fuzzy COPRAS approach was used to rank the alternatives. The integrated steps of the present study are as follows.

Step 1- Extracting common and sustainable supply chain management risk assessment indicators through literature review

Step 2- Screening the risk management criteria of sus sustainable supply chain using a single-stage fuzzy Delphi method and achieving the most important risk assessment criteria. Classification of these indicators into general dimensions of risk assessment in the field of sustainable supply chain management

Step 3- Identifying the objective weights of sustainable supply chain risk management risk criteria using the fuzzy CRITICAL metho

Step 4- Calculating the final weight of sustainable supply chain risk management criteria and use these weights in the fuzzy COPRAS method. For this purpose, the objective weights obtained from the fuzzy CRITIC and the subjective weights obtained from the direct opinions of the experts are combined to gain the final weights.

Assuming that the matrix of W represents the matrix of the subjective Weights of the criteria, the structure of this matrix is as follows.

$$W = \left[\widetilde{w}_j^s\right]_{1\times m} \tag{18}$$

$$\widetilde{w}_j^s = \frac{1}{k}\sum_{P=1}^{k} \widetilde{w}_{jP}^s \tag{19}$$

where $C_j\ (1 \le j \le m)$ is determined by decision-makers of $p\ (1 \le p \le k)$ shown as $\widetilde{w}_{jP}^s$. To normalize these subjective weights for each index, the following equation is used (Rostamzadeh et al., 2018).

$$\widetilde{w}_j^{sn} = {\widetilde{w}_j^s}\Big/{k\left(\sum_{j=1}^{m} \widetilde{w}_j^s\right)} \tag{20}$$

Finally, to obtain the final weight of the criteria, the calculated subjective Weights and objective weights combine based on the following equation.

$$W_j = \frac{\widetilde{w}_j^o \widetilde{w}_j^s}{\sum_{j=1}^{m} \widetilde{w}_j^o \widetilde{w}_j^s} \tag{21}$$

Step 5- Ranking the suppliers using the final weights and fuzzy COPRAS method

3. Results

The steps of the Fuzzy Delphi- Fuzzy COPRAS - Fuzzy CRITIC methods implemented in a real case in the food packaging industry are presented as follows.

Step 1- In this study, we use the opinions of experts in Kalleh Dairy Company to select the criteria of sustainable supply chain risk assessment, determine the importance of risk chosen criteria, and finally, the ranking of suppliers based on sustainable supply chain risk criteria. The experts were all managers and experts with a good background in the company who have had experience working in various parts of Kalleh and Solico Holding over the years. Therefore, their opinions presented the realities of these units. In this step, the researchers reviewed international studies in the field of risk assessment and management of sustainable supply chains in various industries, especially industries related to food packaging, and extracted risk assessment criteria from these studies. These criteria are presented in Table 3.

Table 3. Criteria of risk management for sustainable supply chain risk management

No.	**Criteria**	**Author(s)**
1	Machines & equipment risks	Rostamzadeh et al. (2018)
2	Quality risk	Song et al. (2017)
3	Poor planning and scheduling	Lavastre et al. (2014)
4	Change in technologies due to green	Manuj and Mentzer (2008)
5	Long product lead times for green products/materials	Rostamzadeh et al. (2018)
6	Forecasting errors	Lavastre et al. (2014)
7	Demand risk	Song et al. (2017)
8	Production capacity risk	Lavastre et al. (2014)
9	Labor strike	Manuj and Mentzer (2008)
10	Product design risk	Cagliano et al. (2012)
11	Key supplier failures	Aqlan and Lam (2015)
12	Restrictions on green processes	Cagliano et al. (2012)
13	Capacity constraints	Cagliano et al. (2012)
14	Supplier quality	Aqlan and Lam (2015)
15	Supplier uncertainty	Olson and Dash (2010)
16	Inventory risks	Olson and Dash (2010)
17	Supplier's financial instability	Manuj and Mentzer (2008)
18	Demand fluctuations	Olson and Dash (2010)
19	Demand forecasting risks	Diabat et al. (2012)
20	Quality of roads	Olson and Dash (2010)
21	Human error	Cagliano et al. (2012)
22	IT system	Cagliano et al. (2012)
23	Security risks	Aqlan and Lam (2015)
24	Political instability	Diabat et al. (2012)
25	Natural disasters	Aqlan and Lam (2015)
26	labor dispute	Tang and Nurmaya Musa (2011)
27	Lack of proper sewage infiltration	Dües et al. (2013)
28	Groundwater pollution risks	Dues et al. (2013)
29	Discharging of wastes risks	Dues et al. (2013)
30	failure in social commitment	Maloni and Brown (2006)
31	work environment risk	Halldórsson et al. (2009)
32	inflation rate	Giannakis and Papadopoulos (2016)
33	Poor interrelationships	Diabat et al. (2012)
34	Price fluctuations of raw materials	Tang and Nurmaya Musa (2011)
35	greenhouse gas production	Giannakis and Papadopoulos (2016)
36	Waste production	Giannakis and Papadopoulos (2016)

37	Discrimination in the work	Tang and Nurmaya Musa (2011)
38	Unfair payments	Siegel (2012)
39	Too many working hours	Giannakis and Papadopoulos (2016)
40	Imbalance between work and life	Siegel (2012)
41	Lack of skilled or specialized human resources	Diabat et al. (2012)
42	Supplier bankruptcy risk	Diabat et al. (2012)

Step 2- This step is for screening and categorizing the criteria extracted from the literature using a single-stage fuzzy Delphi method. For this purpose, based on experts' opinions and Table 1, the top criteria were selected and categorized based on nature and similarities. Table 4 lists the final criteria for assessing sustainable supply chain risk management. The criteria are classified into five main criteria and 21 sub-criteria.

Table 4. Selected and categorized risk criteria

No.	Main criteria	Sub-criteria
1	operational risk	Machines and equipment risks Produce quality risk Change in technologies due to green activities Long product lead times for green products/materials Production capacity risk Inventory risks Restrictions on green processes
2	Human risk	Lack of skilled or specialized human resources Human errors Labor strikes labor disputes
3	Social risk	Discrimination in the work failure in social commitment work environment risk
4	financial risk	inflation rate Price fluctuations of raw materials
5	Environmental risks	greenhouse gas production Waste production Discharging wastes risks Lack of proper sewage infiltration Natural disasters

Step 3- This step is for implementing of fuzzy CRITIC method, and its purpose is to identify the weight of the objective weights of sustainable supply chain risk management indicators. First, based on the standard questionnaire of criteria-alternative and the qualitative and fuzzy values of Table 2, the opinions of experts were collected and aggregated. To aggregate the opinions of experts in the form of a matrix, a geometric mean was used in this study (Eq. (1)). The five alternatives, as mentioned earlier, are suppliers of packaging used by Kaleh Company and are named as follows: A1: Supplier of Mazandaran 1; A2: Supplier of Mazandaran 2; A3: Tehran Supplier 1; A4: Tehran supplier 2; A5: Golestan supplier. Table 5 shows the aggregated matrix:

Table 5. Part of aggregated matrix

	C1			**C2**			**C3**			**…**	**C20**			**C21**		
A1	2	4.03	7	3	5.17	9	3	5.44	7	…	2	3.14	5	3	5.51	9
A2	2	3.14	5	1	2.80	4	5	6.31	8	…	3	6.37	8	5	6.64	8
A3	0	1.58	3	2	3.26	6	5	6.60	9	…	5	6.48	8	5	6.15	8
A4	2	5.34	7	4	5.15	7	4	5.59	8	…	4	5.94	8	2	5.92	8
A5	3	4.64	6	1	3.17	5	2	3.77	7	…	3	5.21	9	1	4.18	8

The next step is to calculate the transforms of performance values and obtain index vectors. Based on the aggregated matrix and the type of criteria (positive or negative), the performance value of each criterion is determined. For this purpose, Eqs. (3) and (4) are used. When all criteria have a negative nature (due to their risk), only Eq. (4) was used. Criteria vectors are given in Table 6.

Table 6. Part of the matrix of criteria vectors

	C1			C2			C3			…	C20			C21		
A1	0.66	0.65	1	0.66	1	1	0.33	0.58	0	...	0	0	0	0.5	0.53	1
A2	0.66	0.41	0.5	0	0	0	1	0.89	0.5	...	0.33	0.96	0.75	1	1	0.5
A3	0	0	0	0.33	0.19	0.4	1	1	1	...	1	1	0.75	1	0.79	0.5
A4	0.66	1	1	1	0.99	0.6	0.66	0.64	0.5	...	0.66	0.83	0.75	0.25	0.70	0.5
A5	1	0.81	0.75	0	0.15	0.2	0	0	0	...	0.33	0.61	1	0	0	0

The next step is to calculate the standard deviation for each column (risk criteria) and form three symmetrical matrices. In this step, based on the matrix of criteria vectors constructed in the previous step, the first standard deviation of each criterion is determined. The intensity of the discrepancy between the numbers in each criterion is determined relative to each option. The upper, middle, and lower bounds of the indices are then separated in the criteria vector matrix and form three separate matrices. These three matrices are also based on comparing two-by-two vectors and calculating the linear correlation coefficient between the two vectors, forming three symmetric matrices 21 by 21. The purpose of calculating the linear correlation coefficient between two vectors is to examine the degree of incompatibility between them through the correlation coefficient. To calculate the correlation coefficient between the two vectors of G and K, the following equation was used (Diakoulaki et al., 1995).

$$r = \frac{G.K}{\|G\|\|K\|} \tag{22}$$

where the dot symbol represents the internal multiplication of two vectors. The denominator of the fraction also contains the multiplication of the dimensions of the two vectors in each other.

The next step is to calculate the weights of the criteria. In this step, stages are taken to extract the weights of the non-fuzzy significance of risk assessment criteria from the three matrices calculated above. In the first step, based on Eq. (6), the values of H for each row of the above three matrices are calculated. This value is known as the information criterion of each criterion. After that, the initial values of fuzzy weight (unsorted weight values) based on Eq. (7) are calculated. After determining the weights of the unsorted values of the criteria, based on Eqs. (8)−(10), these weights are arranged (sorted) as fuzzy numbers. These equations state that among the three weights, the smallest number is chosen as the lower bound, the most significant number as the upper bound, and the only remaining number as the middle bound. These fuzzy values are shown in Table 7.

Table 7. Sorted fuzzy values related to the weights of risk criteria

Criteria	Fuzzy initial weight		
1	0.031149	0.03692	0.037187
2	0.043283	0.05423	0.062741
3	0.03872	0.04663	0.0513
4	0.026446	0.03872	0.047718
5	0.030474	0.03929	0.054936
6	0.045599	0.04957	0.057948
7	0.046707	0.04862	0.054181
8	0.030753	0.03863	0.049541
9	0.037191	0.04589	0.051686
10	0.042013	0.05666	0.059514
11	0.044834	0.06011	0.06587
12	0.031959	0.04049	0.045107

13	0.044468	0.05836	0.074634
14	0.034497	0.03595	0.060584
15	0.038492	0.04326	0.055044
16	0.048453	0.05666	0.059156
17	0.049985	0.05502	0.06406
18	0.03756	0.05561	0.094052
19	0.044873	0.04615	0.057146
20	0.038665	0.04696	0.058984
21	0.026786	0.02938	0.042608

After calculating the initial fuzzy weights, based on Eq. (11), the final fuzzy weights of the risk criteria are determined. This formula is based on dividing each of the above fuzzy numbers by the sum and dividing them by 21. In this way, the above fuzzy numbers become normal. These values are shown in Table 8.

Table 8. Values of final fuzzy weights

Criteria	Fuzzy final weight		
1	0.543297	0.78864	0.960654
2	0.754946	1.158395	1.620796
3	0.675358	0.996053	1.325241
4	0.461276	0.82709	1.232711
5	0.531518	0.839265	1.419166
6	0.795336	1.058854	1.496994
7	0.814662	1.038561	1.399661
8	0.536391	0.825167	1.279798
9	0.648684	0.980246	1.335218
10	0.732796	1.210302	1.537444
11	0.781988	1.283997	1.701635
12	0.557426	0.864898	1.16526
13	0.775607	1.246615	1.928025
14	0.601697	0.76792	1.56508
15	0.671366	0.924068	1.421954
16	0.845118	1.210302	1.528198
17	0.871827	1.17527	1.654872
18	0.655111	1.187873	2.429659
19	0.782667	0.9858	1.476254
20	0.674397	1.003102	1.523738
21	0.467207	0.62758	1.10069

The final step in determining the objective weights of sustainable supply chain risk criteria is to defuzzification of the fuzzy numbers and ultimately normalize them.

Table 9. Objective weights of risk criteria

Criteria	Difference	Final weight
1	0.770308	0.035302
2	1.173133	0.053763
3	0.998176	0.045745

4	0.837041	0.03836
5	0.907303	0.04158
6	1.102509	0.050526
7	1.072862	0.049168
8	0.866631	0.039716
9	0.986099	0.045192
10	1.172711	0.053744
11	1.262904	0.057877
12	0.863121	0.039556
13	1.299216	0.059541
14	0.925654	0.042421
15	0.985364	0.045158
16	1.19848	0.054925
17	1.21931	0.055879
18	1.365129	0.062562
19	1.05763	0.04847
20	1.051085	0.04817
21	0.705764	0.032344

Step 4- As stated in Section 4, this step is to rank the suppliers using the fuzzy COPRAS method, calculate the subjective Weights of risk assessment criteria, and combine them with the objective weights of risk assessment criteria (calculated through the Fuzzy CRITIC). Table 10 shows the objective and subjective weights of the risks and final weight criteria calculated using Eq. (21).

Table 10. Weights of final importance of supply chain risk management criteria

	Main criteria	Sub-criteria	Objective weights	Subjective Weights	Final weights
1	operational risk	Machines & equipment risks	0.035	0.125	0.097
		Product quality risk	0.053	0.087	0.102
		Change in technologies due to green	0.045	0.028	0.028
		Long product lead times for green products/materials	0.038	0.059	0.050
		Production capacity risk	0.041	0.032	0.029
		Inventory risks	0.050	0.059	0.066
		Restrictions on green processes	0.049	0.079	0.085
2	Human risk	Lack of skilled or specialized human resources	0.039	0.044	0.038
		Human error	0.045	0.068	0.067
		Labor strike	0.053	0.052	0.061
		labor dispute	0.057	0.009	0.012
3	Social risk	Discrimination in the work	0.039	0.091	0.079
		failure in social commitment	0.059	0.003	0.004
		work environment risk	0.042	0.015	0.013
4	financial risk	inflation rate	0.045	0.022	0.021
		Price fluctuations of raw materials	0.054	0.043	0.051
5	Environmental risks	greenhouse gas production	0.055	0.031	0.039
		Waste production	0.062	0.011	0.015
		Discharging of wastes risks	0.048	0.060	0.064
		Lack of proper sewage infiltration	0.048	0.046	0.049

Natural disasters	0.032	0.025	0.18

Step 5- Then, using the steps of the fuzzy COPRAS method, suppliers are ranked based on experts' opinions and according to their level of ability in managing various risks, including sustainability issues. In this method, like the start of the fuzzy CRITIC method, the criteria-alternative matrix is used as the initial matrix. The formation of this matrix is the initial step in the fuzzy COPRAS method to rank the alternative. After that, this matrix is normalized and defuzzified with form Eq. (12). Table 11 shows the standard fuzzy matrix. We multiply the column elements of matrix 10, i.e,. the elements related to the scores of each alternative to each risk evaluation criteria, in the weight of that criteria. The result is shown in Table 12.

Table 11. Part of the normalized aggregated matrix

	C1	C2	C3	C4	….	C18	C19	C20	C21
A1	0.229	0.275	0.184	0.262	....	0.194	0.116	0.121	0.203
A2	0.178	0.130	0.225	0.202	.....	0.180	0.226	0.217	0.233
A3	0.082	0.179	0.239	0.200	.....	0.175	0.257	0.237	0.224
A4	0.264	0.262	0.204	0.216	.....	0.226	0.203	0.218	0.193
A5	0.245	0.152	0.145	0.117	.....	0.223	0.195	0.205	0.145

Table 12. Part of the weighted normalized matrix

	C1	C2	C3	C4	….	C18	C19	C20	C21
A1	0.022	0.028	0.005	0.013	.....	0.003	0.007	0.005	0.003
A2	0.017	0.013	0.006	0.010	......	0.002	0.014	0.010	0.004
A3	0.008	0.018	0.006	0.010	......	0.002	0.016	0.011	0.004
A4	0.025	0.027	0.005	0.010	......	0.003	0.013	0.010	0.003
A5	0.023	0.015	0.004	0.005	......	0.003	0.012	0.010	0.002

After this step, based on Eqs. (14) and (15), the positive and negative S_Js are determined. Then, based on these values and Eqs. (16) and (17), the values of Q and N for each alternative are specified. The top alternative has the largest Q and N. In this study, the criteria are all negative given that they are about risks. Therefore, the values for positive S_J for all alternatives are zero. Also, these quantities refer to the sum of positive criteria and the sum of negative criteria for each alternative. The final step is to identify the best alternative based on the criteria. Alternatives in the best position in terms of criteria are determined by Nj's highest degree of importance, which is 100% Nj. The total value of each criterion that is calculated is from 0 to 100%, which determines the best and worst alternatives within this range. Table 13 shows the final ranking of suppliers' performance in the field of sustainable supply chain risk management:

Table 13. Values for ranking alternative

Suppliers	Q_i	N_i	Rank
Mazandaran Supplier 1	0.1891	81.7776	3
Mazandaran Supplier 2	0.18708	80.9041	4
Tehran supplier1	0.21276	92.0098	2
Tehran supplier 2	0.17982	77.7624	5
Golestan supplier	0.23124	100	1

4. Discussion

Based on Delphi-CRITIC-COPRAS methods, this study result provides a framework for decision-making with multiple fuzzy criteria to evaluate supply chain risk management. In this study, five main criteria and 21 sub-criteria are proposed to assess the suppliers of the food packaging industry (especially dairy products). The results show that the most important factor in evaluating suppliers' risks in sustainable supply chain activities in the food packaging industry is operational risks. Also, the three sub-criteria with the highest weights are product quality risk, machines and equipment risks, and restrictions on green processes. Finally, the ranking provided to suppliers showed that Mazandaran supplier 1 had the best performance in the risk management of a sustainable supply chain. As Table 9 shows, the product quality risk with a weight of 0.102 is the most critical sub-criteria in the operational risk Index. In the human risk criteria, human errors weighing 0.067 as the most vital sub-criteria. In the social risk criteria, the sub-criteria of discrimination in work with a weight of 0.079 is the most critical. The sub-criteria of price fluctuations of raw materials with a weight of 0.051 is identified as the most important sub-criteria in the financial risk criteria. Also, in the environmental risk criteria, the risk of discharge of wastes with a weight of 0.064 is identified as the most important sub-criteria.

This study aims to develop a framework for sustainable supply chain risk management evaluation and provide a more optimal framework of multi-criteria decision-making methods in a fuzzy environment. Studies such as (Rostamzadeh et al., 2018) provided a favorable framework in this field. The present study result provides higher accuracy by replacing more optimal methods with traditional methods such as TOPSIS. The new methods reduce computational volume while providing higher accuracy in the obtained results. Significantly, recent studies have shown that it is necessary to develop studies and provide new frameworks to improve risk assessment approaches (Hofmann et al., 2014). Since effective risk assessment is one of the basic needs of managers and decision-makers to make decisions and implement effective measures, risk assessment is a fundamental step in managing supply chain risk (Hallikas et al., 2004). Without a comprehensive and effective risk assessment to rank risks, planning for the future, and adopting risk mitigation strategies is impossible. Supply chain risk management research has mainly mistreated the provision of risk assessment models (Dong and Cooper, 2016). This is especially true in the case of studies providing models for a particular industry. The primary need of the industry in managing its supply chain risk is first to identify these risks and then evaluate them to gain knowledge about the most important risks to focus and invest on reducing the probability of risk occurrence and addressing the important risks as well as reducing the consequences of these risks. Also, the effective use of risk management systems in organizations is highly dependent on the organization's ability to identify and evaluate the internal and external organizational risks associated with them (Gordon et al., 2009). Studies show that implementing an organizational risk management system has benefits, such as developing sustainable risk management processes in the organization (Aqlan and Lam, 2015), determining the range and the application of risk management in the organization (Olson and Dash, 2010), and the ability of the organization to make decisions based on the potential negative effects of risks (Manuj and Mentzer, 2008). Therefore, risk management systems based on risk assessment help develop the risk management capabilities of various organizational processes.

5. Conclusion

The food sector makes one of the most remarkable contributions to the gross domestic product of any country. The importance of the food industry and its dependence on the packaging industry has led to the increasing development of the food packaging industry and the growing complexity of the supply chain activities of this industry due to the increasing demand for healthy food products. Along with external pressures and intra-organizational needs, the phenomenon has led food packaging companies to achieve sustainable benefits. In line with such a strategic orientation, the risks associated with sustainable actions in the supply chain management process can increase. Although studies in risk management have provided valuable insights into this field, related research in the food packaging industry is still rare. In recent years, the interest in supply chain risk management by focusing on sustainability has increased.

Unfortunately, it is challenging to understand the meaning of risk management in a sustainable supply chain (the exact purpose) and what information needs to be controlled for risk management. Also, these ambiguities have led to uncertainty in managing these risks and reducing their consequences, which makes the design of control and management systems complex. The present study’s result contributes to the literature on sustainable supply chain risk management by providing a framework to identify and rank the most important risks and then evaluate suppliers based on these risks. In supply chain risk management, there are two fundamental interacted issues: one is the risk of the supply chain, and the other is the sustainability of the supply chain. Few studies have been observed in interaction with each other and are generally considered separate topics. With increasing market competition, improving customer knowledge, and ultimately developing the scopes of international corporate supply chain activities, we need to improve and enhance this sustainability's sustainability and risk management capabilities. Therefore, it is necessary to pay more attention to the issue of sustainability in the risk management of companies' supply chain activities.

In the present study, we tried to develop the relationship between the two concepts of supply chain risk management to increase the diversity of risk assessment approaches in sustainable supply chain risk management. However, further research is needed to focus more on this issue and develop existing models in terms of lesser computational volume and more accurate outputs. The topic of risk management of the food industry's sustainable supply chain is a cutting-edge issue and requires the development of its territories in various dimensions. Although researchers of this study have tried to provide a comprehensive model for sustainable risk assessment, future studies need to focus on identifying various risk factors in different industries, especially in other countries' packaging industries.

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