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Research Article

Multicriteria negotiation model for selecting sustainable suppliers' problem in the agribusiness

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Abstract

Paper aims: The objective of this research is to propose a multicriteria negotiation model for selecting a sustainable packaging supplier in the food industry. The model aims to minimize the environmental, social and economic impacts of the production process of plastic while ensuring the operational criteria of packaging.

Originality: Despite the high number of scientific research using multicriteria decision-making suggested to select a supplier, the proposed negotiation model is innovative as it includes green manufacturing as a criterion for negotiation, alongside price and delivery time, to promote sustainable supply chain management.

Research method: The research method involves three stages: pre-negotiation, negotiation (based on FITradeoff), and post-agreement. The proposed model is illustrated using a case study of a Colombian slaughterhouse that needs to select a sustainable packaging supplier for the next two years.

Main findings: The main findings indicate that the proposed model that uses the FITradeoff for negotiation solves the problem of selecting sustainable packaging suppliers while promoting sustainable supply chain management in the agribusiness sector.

Implications for theory and practice: The model has implications for both theory and practice. It encourages interdependent companies to collaborate and enhances efficiency in greener terms for supply chains, buyer and seller firms. The proposition of an original integrative negotiation protocol for selecting sustainable suppliers in agribusiness can provide enterprises with a set of negotiation parameters to achieve successful sustainable supply chain management.

Keywords

Multicriteria negotiation model. Decision support. Food supply chain. FITradeoff procedure.

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1. Introduction

In today's world, sustainability has become a significant concern for businesses (Camargo, 2023). One way businesses can promote sustainability is through their packaging supplier choices. Sustainable packaging supplier choices can help reduce waste and environmental impact while also improving the overall image of the company. Selecting a sustainable packaging supplier can be a challenging task as decision-makers (DM) need to consider several negotiation objectives.

Thus, the selection of sustainable food packaging is a critical problem faced by food chain leaders seeking to make their processes more environmentally friendly. The food packaging manufacturing process consumes a significant amount of water, energy, and materials, leading to the production of numerous wastes and pollutants (Testa et al., 2021). Moreover, the disposal of plastic waste in the environment is a growing problem, with an estimated 9.5 million tons of plastic waste disposed of until 2015 (Kan & Miller, 2022). Additionally, about 20% of the carbon emissions produced by the food industry are related to the use and production of industrial materials (Qin & Horvath, 2022). However, the use of plastic packaging is still inherent in food production due to its ability to preserve quality, prolong shelf life, and facilitate transportation and storage (Singh & Singh, 2005).

In this context, the selection of sustainable food packaging suppliers has become a complex problem for food chain leaders, and the assessment of sustainable suppliers is a key strategy in sustainable supply chain management (SSCM). The goal of SSCM is to reduce the misuse of environmental resources, non-green logistical activities in production and consumption, and the growing amount of industrial waste and pollutants (Banaeian et al., 2018; Tsai et al., 2021). Therefore, finding sustainable food packaging solutions is critical to the long-term sustainability of the food industry, and requires a multi-disciplinary approach that considers the environmental, social, and economic impacts of packaging materials and processes.

Supplier selection is a widely studied topic in academic literature, with numerous research articles published on the subject. Among the various approaches used, multicriteria decision-making/aiding (MCDM/A) is considered to be the most popular in this field due to its adaptability and ease of use by DMs (Viana & Alencar, 2012; Rodrigues et al., 2020; Hoseini et al., 2021). MCDM/A involves evaluating a group of contracted suppliers using a set of criteria to identify the best option and maintain a commercial relationship with the partner (Bhutta & Huq, 2002; Guarnieri & Almeida, 2015; Hoseini et al., 2021; Rodrigues et al., 2020).

In recent years, the issue of food packaging supplier selection has gained particular importance among researchers, given the direct impact of packaging on food safety. Several models for packaging supplier selection in the food industry have been proposed, with MCDM/A once again emerging as the most commonly used methodology due to its suitability for this type of problem (Banaeian et al., 2018; Frej et al., 2017; Ramos et al., 2020). For instance, Ramos et al. (2020) incorporate the food security as priority level to select suppliers using Fuzzy-AHP in a Brazilian food company.

In the field of supplier selection, MCDM/A methods can be categorized into compensatory and non-compensatory methods based on the DM's rationality for aggregating preferences (Macharis & Brans, 1998; Guarnieri & Almeida, 2015; Frej et al., 2017; Demir et al., 2018). Non-compensatory methods, such as ELECTRE and PROMETHEE, are characterized by outranking alternatives that fail to meet a particular criterion. However, these methods may not be suitable for negotiation processes that require concessions among criteria under negotiation.

To address this limitation, we suggest that the attributes used in supplier evaluation could be considered as negotiation objects to find a solution that benefits both parties. By taking a more dynamic and proactive approach, it may be possible to improve the performance of evaluated criteria and enhance the indicators of each provider, leading to a more successful and mutually beneficial commercial relationship.

In supplier selection, conflicts may arise between the seller and the buyer, also known as negotiators. Concessions are necessary between the objectives of negotiation, and a negotiation process can be an adequate methodology to solve the problem, deal with conflicts, and make tradeoffs between various negotiation issues to reach a mutual agreement. A negotiation process involves three general steps: pre-negotiation, negotiation, and post-negotiation. The pre-negotiation phase involves identifying the issues to be negotiated and defining the parties involved or negotiators. During the negotiation stage, offers and counteroffers are exchanged, and the concession magnitude function and counter-offer vector must be designed. This stage is the most complex phase of modeling, and the preferences of the involved parties must also be included in the negotiation protocol, according to (Frej et al., 2022). Finally, in the post-negotiation phase, the central issue is the contract that stipulates the responsibilities of each party (Thompson et al., 2010).

By including negotiation as a part of the supplier selection process, conflicts can be addressed, and tradeoffs can be made to reach a mutually beneficial agreement between the parties involved. Also, it is important to consider the preferences of all parties involved and to design a negotiation protocol that takes these preferences into account. Ultimately, the contract that is established in the post-negotiation phase should clearly outline the responsibilities of each party to ensure a successful and sustainable commercial relationship.

In the field of negotiation, criteria such as price, quality, and delivery time have traditionally been used as negotiation objects (Bichler et al., 2003; Fiedler, 2022). However, in cases where it is necessary to address other concerns, these objects may not suffice, and new objectives must be investigated. Frej et al. (2022) proposed a generic negotiation procedure based on a negotiation protocol that utilizes the FITradeoff method (Flexible and Interactive Tradeoff) (Almeida et al., 2016). The FITradeoff for negotiation procedure, which is an adaptation of the traditional Tradeoff procedure suggested by Raiffa (1982), was chosen for negotiation because it requires less cognitive effort from the DM and works with partial information rather than complete information. The FITradeoff method is a multicriteria approach that can be used for choosing (Almeida et al., 2016), ranking (Frej et al., 2019; Rodrigues et al., 2020), and sorting problems (Kang et al., 2020; Oliveira et al., 2022; Causil & Morais, 2023). Previous studies have used the FITradeoff method for supplier evaluation, ranking, and sorting in various contexts.

Considering current environmental concerns, supply chain management has suggested including sustainability criteria in the selection of packaging providers to minimize the greenhouse gases produced by this industry.

However, despite various negotiation protocols that have been proposed in the literature, particularly in the field of agribusiness, there is a gap in the literature that has not been addressed. The proposed procedure by Frej et al. (2022) can be adapted to the negotiation of sustainable suppliers in agribusiness by including sustainability criteria in the negotiation protocol.

Therefore, this paper presents a novel multicriteria negotiation model that is applied to a Colombian slaughterhouse. The model aims to select a sustainable supplier for the slaughterhouse's packaging needs over the next two years. In addition to conventional negotiation criteria such as price and delivery time, the model incorporates green manufacturing as a new and pertinent negotiation issue. Although the literature suggests various criteria for selecting suppliers, the authors have focused on green manufacturing due to its close relationship with sustainability (Lee et al., 2009; Nielsen et al., 2014). The findings indicate that the proposed model effectively addresses the challenge of selecting sustainable food packaging suppliers while also structuring the selection process in a suitable manner. Furthermore, the incorporation of green manufacturing as a negotiation topic yield benefits for both internal workers and society at large. This is achieved through the promotion of responsible practices, contributions to sustainable development, protection of the environment, and efficient utilization of natural resources.

The research article consists of five sections. The introduction (Section 1) addresses the problem statement. Section 2 covers the definition and strategies of the science of negotiation. The proposed model is detailed in Section 3. Section 4 describes the application of the model in a Colombian slaughterhouse case. Finally, the conclusion section (Section 5) discusses the findings, managerial implications, limitations, and possible future work.

2. Negotiation background

Negotiation is a process aimed at reaching an agreement between parties with a shared interest but differing perspectives. The literature offers various definitions of negotiation. For example, Kersten (2001) defines negotiation as a decision-making process involving two or more interdependent parties who cannot unilaterally reach a decision. Weiss (2017) conceptualizes negotiation as a field of forces comprising driving and restraining forces that facilitate the transformation of the current situation into a desired future outcome.

In terms of the number of involved parties and issues, Raiffa (1982) classified negotiation processes as either distributive or integrative. Distributive negotiation, also known as win-lose negotiation, is characterized by non-collaborative parties seeking to maximize their own outcomes at the expense of the counterparty, whom they view as an opponent. Typically, a single negotiation object is considered in this type of negotiation (Thompson et al., 2010). In contrast, Stoshikj (2014) describes integrative or win-win negotiation as involving parties that do not view each other as opponents. The primary objective of integrative negotiation is to maximize results for all parties involved. For an agreement to be reached in this type of bargaining configuration, at least two negotiation issues must be considered.

According to Raiffa (1982), distributive negotiations require the parties to have a common agreement zone for a successful negotiation outcome. This agreement zone can be achieved through two conditions. The first condition requires both parties to have a maximum initial value for trading the product. The second condition is that both parties must have a reserve value, which is the minimum value they are willing to accept for the product. During the negotiation process, the maximum values of the parties decrease in opposite directions until they reach the agreement zone. This agreement zone is the area where the buyer's reserve value is greater than or equal to the seller's reserve value. By meeting these conditions, a distributive negotiation can result in an agreement that is beneficial to both parties.

Negotiation is a complex process involving multiple parties, and the involvement of an analyst can help ensure the best agreement is reached. An analyst, who provides methodological support but does not intervene in decision-making, can be a valuable third party in the negotiation process. Silva et al. (2010) and Silva & Fontana (2021) have noted that analysts can assist DM in understanding the problem and defining negotiation objectives. By working closely with the parties involved, an analyst can help facilitate communication and identify areas of agreement, ultimately leading to a more successful negotiation outcome.

Bichler et al. (2003) noted that when discussing areas of activity, informatics and information systems are directly associated with tools, agents, and platforms used in the negotiation process. Conversely, negotiation strategies and tactics are related to the fields of economics, administration, and social sciences.

In the negotiation process, decision-making is carried out by individuals, which may result in subjectivities and inconsistencies. To address these issues, negotiation software agents (NSAs) have been developed. NSAs are intelligent systems that model decision-making with a degree of autonomy (Wang et al., 2013). In addition, the development of communication and computer systems has led to the creation of negotiation support systems (NSS) as office automation tools to assist negotiators in decision-making. Unlike NSS, e-NS (e-Negotiation System) is an online information system that leverages the Internet to enable merchants in different locations to conduct transactions.

Negotiation support systems have been constructed, which include negotiation software agents and negotiation protocols. These systems are composed of three activities: problem definition and establishment of points to be negotiated, a protocol for exchanging offers, and post-agreement. c proposed a negotiation protocol model to determine a set of products to be selected among several suppliers while considering the synergy effect between the products. This was followed by the proposal of a software agent by Yu & Wong (2015b) to support the negotiation process, which included trading strategies. Earlier, Faratin et al. (1998) presented three general negotiation strategies: independent of short or long term, resource-dependent tactics, and behavioral tactics.

Table 1 presents a summary of negotiation protocol found in the literature. The revision literature was made in the Web of Science, a well-known data base where the most recognized journals of operational research field are indexed. Negotiation, protocol, supplier selection and food industry were the terms used in the research.

Other agents have been proposed in the literature, particularly in the e-commerce area. Despite existing some negotiation protocol in the literature, currently, there is a gap related to negotiation models with a focus on agribusiness and specifically in food packaging supplier selection. Thus, we propose a negotiation model for selecting suppliers in the agribusiness field. The proposed negotiation model for food packaging supplier selection in agribusiness will be detailed in the next section.

3. Multicriteria negotiation model for selecting sustainable suppliers' problem in the agribusiness

This research proposes a multi-criteria negotiation model for supplier selection in sustainable packaging for food products. The model offers a solution to the challenge of making tradeoffs between several negotiation objectives while selecting a single supplier. The FITradeoff negotiation protocol is used to evaluate the performance of product requirements and evaluate the sustainability of suppliers while a single trading partner is selected. The proposed model aims to support the DM in selecting a sustainable packaging supplier for a food product.

The model allows DMs to seek improvements in several attributes, which are negotiation objectives, and compare the utility functions of the offers presented and exchanged in a package manner. The winning package is then recommended for maintaining a business relationship for some time. The proposed model comprises three stages: pre-negotiation, negotiation, and post-agreement. In the pre-negotiation stage, DMs identify negotiation objectives and gather information about potential suppliers. In the negotiation stage, the model compares the utility functions of the offers presented and exchanged in a package manner. In the post-agreement stage, the winning package is recommended for maintaining a business relationship for some time. Each step, as illustrate in Figure 1, is explained in detail in this study.

3.1. Pre-negotiation

In the initial phase, it is necessary to establish the negotiation issues and search for potential suppliers on the market. An initial triage must be carried out to ensure some minimum requirements, such as supplier operating certificates, and up-to-date government regulations, among others. Within the integrative context, as a novel subject of negotiation we propose green manufacturing (GM) for bargaining jointly to the price and delivery time.

Table 1. Negotiation protocol for bargaining found in the literature.

Authors	Research Objective
Faratin et al. (1998)	It presented a general negotiation approach which includes three types of strategies: independent of short or long term, resource-dependent tactics, and behavioral tactics.
Sim & Wang (2004)	Developed a negotiation agent using fuzzy rules.
Giannakis & Louis (2011)	Solved a multi-agent-based framework for supply chain risk management.
Yu & Wong (2015a)	Proposed a model for determining a bundle of products for selecting multi-product suppliers, taking into account the synergy effect between products.
Yu & Wong (2015b)	Proposed a Multi-Agent System (MAS)-supported protocol for the negotiation of multiple products in the supply chain of electronics gadget.
Haleema & Iyengar (2018)	Created a mathematical model with flexible negotiation strategies for agent-based negotiations which can be applied suitably in bilateral multi-issue negotiation environments
Salah et al. (2020)	proposed a multi-attribute negotiation process in the partner selection mechanism environment in order to enhance bids when there is only one competent partner.
Fiedler (2022)	Proposed a multi-agent system (MAS) to automate and facilitate the process of selecting the best possible financing options in the supply chain financial.

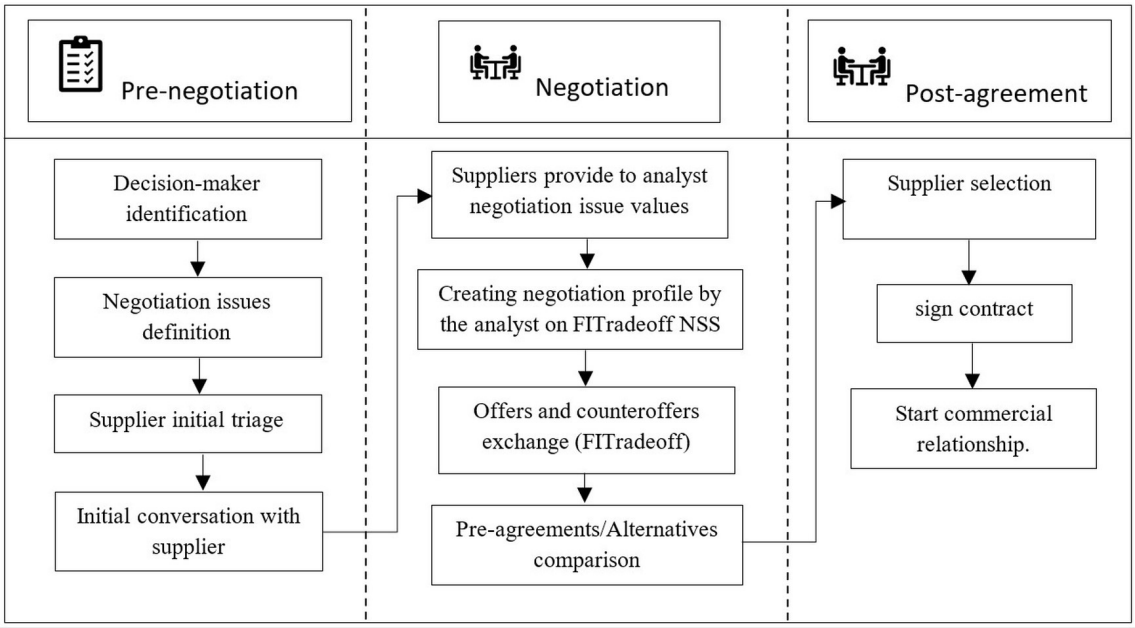


Figure 1. Proposed negotiation model scheme. Source: The authors (2022).

3.1.1. Negotiation criteria

As noted previously, this study identifies three negotiation issues to be addressed. To measure these issues, we employed the classification system proposed by Keeney (1992) which delineates three attribute types used to measure objectives: natural, constructed, and proxy attributes. For the negotiation issues of price and delivery time, we utilized a natural numerical scale. Price was measured by the economic value of each packaging unit, while delivery time was measured by the number of days elapsed from the moment of order placement. The overarching aim was to minimize price and reduce delivery time.

Green manufacturing, also known as sustainable manufacturing, refers to a series of strategies aimed at reducing environmental impacts and improving the well-being of a firm's stakeholders. These sustainable practices generate social and environmental benefits, such as the implementation of circular economy activities that involve reducing, recycling, recovering, or reusing inputs, components, or products in the value chain. This approach can result in cleaner production and value creation from waste materials. Furthermore, green manufacturing initiatives may also involve educational activities in local schools, generating benefits for the surrounding community where the company operates.

Constructed attributes are employed when a natural scale is inadequate to measure an objective. These attributes are specifically designed for a particular decision-making context Keeney (1992).

In order to negotiate green or sustainable activities, a constructed attribute scale will be utilized, comprising of four distinct levels, as indicated in Table 2. The constructed attribute scale assigns a higher-level number as the rate of ecological activities implemented by the supplier increases.

We defined green manufacturing as a friendly environment strategy set that could be adopted by firm suppliers to mitigate environmental impact. So, each supplier presents a determined initial level of green manufacturing, and this level can be improved in the bargaining process regarding the objective direction of each negotiation party. An improvement on the level implicates the supplier must add other environmental strategies in his operations. Aggregate new environment strategies by suppliers cause a rise in the green environment level of the company. An enhancement in the green level could be bargained with the price criterion. So, compensation is made among the mentioned criteria.

3.1.2. Sustainable parameters in the meat industry

The meat industry has a significant impact on the environment and society, so emphasis on sustainable parameters is crucial to reach an ecological meat supply chain. Here are some key green manufacturing activities or sustainable strategies that suppliers of meat industry should focus on.

Waste reduction: The meat industry can help reduce waste by minimizing overproduction, improving supply chain management, and utilizing more of the animal, such as using by-products for animal feed or other products.

Reducing greenhouse gas emissions: Animal agriculture is a significant source of greenhouse gas emissions. The meat industry can help reduce its environmental impact by implementing practices that reduce emissions, such as improving feed efficiency.

Resource Conservation: Sustainable practices aim to conserve natural resources and minimize waste. This includes reducing energy consumption, using renewable resources, and recycling and reusing materials.

Sustainable packaging: The meat industry can reduce its environmental impact by using sustainable packaging materials, such as biodegradable or compostable packaging. These materials help to reduce waste and conserve resources.

Consumer education: The meat industry can educate consumers on the importance of sustainable meat production and consumption. This can help to promote a more sustainable and ethical meat industry and encourage consumers to make more informed choices.

The Table 3 provides an overview of the sustainable parameters in order to reach these strategies.

These parameters are crucial to evaluating the sustainability of the supplier's products and practices. Through incorporating these parameters into the negotiation model, the Colombian slaughterhouse can select a supplier that not only meets traditional negotiation criteria like price and delivery time but also demonstrates a commitment to sustainable practices. Moreover, by focusing on these sustainable parameters, the meat industry can reduce its environmental impact, promote sustainable and ethical animal agriculture, and create a more sustainable and healthier food system (Smith et al., 2018)

3.2. Negotiation

Consists of two stages. In the first stage, pre-agreements must be made with different suppliers. For this, offers and counteroffers are exchanged by the negotiators. In offers and counteroffers, compensations are considered. Then, in the second step, a comparison of these pre-agreements must be carried out to select the supplier. Pre-agreements will be reached through the negotiation support system using FITradeoff for negotiation, a recent negotiation procedure proposed by Frej et al. (2022). The second sub-stage of the negotiation is carried out. In the second part, a final agreement is made after comparing the results of the pre-agreements reached. After comparing the decision maker's utilities, expressed with his/her preference, the last phase of the model must be carried out.

3.2.1. How does the FITradeoff for negotiation work?

To illustrate the FITradeoff for negotiation procedure, let consider a bilateral negotiation, that is, two negotiators d ($d=1,2$) and, also, we consider each negotiator has a finite negotiation issues a to be negotiated. ($j= 1, ..., a$). Then, the combination of all discrete values of the negotiation issues allows to create P negotiation packages ($i=1, ..., p$).

Table 2. Constructed scale to GM activities of the seller.

The constructed scale to green manufacturing negotiation issue	
Level	**Definition**
Level 4	This level constitutes a green manufacturing rate from 75% to 100%.
Level 3	This level constitutes a green manufacturing rate from 50% to 74%.
Level 2	This level constitutes a green manufacturing rate from 25% to 49%.
Level 1	This level constitutes a green manufacturing rate from 0% to 24%.

Table 3. Sustainable parameters in the food industry.

Parameters	Description	Objective
Energy	The amount of energy used during production and transportation	Minimize
Emissions CO_2	The amount of greenhouse gas emissions produced during production and transportation	Minimize
Water	The amount of waste generated during production and packaging	Minimize
Biodiversity	The positive impact on the surrounding biodiversity	Maximize
Social impact	The positive impact on local communities and workers	Maximize

Thus, based on the multi-attribute theory of value (MAVT), each alternative, in this case the generated packages, can be evaluated through an additive aggregation function, as formulated in Equation 1.

$$V^d(P_i) = \sum_{j=1}^{a} k_j^d v^d\left(p_{ij}\right) \quad (1)$$

Where, $V^d(P_i)$ represents the global function of package i for negotiator d. k_j^d represents the value of the scale constant of negotiation issue *j* for negotiator *d*, assuming that $\left(\sum_{j=1}^{a} k_j^d = 1\right)$. The last term of the expression, $v^d\left(p_{ij}\right)$ represents the normalized value, on a scale of 0-1, of the performance of criterion *j* for negotiator *d*.

In this approach, the FITradeoff for negotiation assumes that DMs/negotiators are not able to establish the exact value of the scale constant k_j^d, but can provide partial information. In this way, the elicitation of scale constants begins when each negotiator *d* establishes an order of negotiation issues considering his/her personal preferences. Then, for each trader an order of criteria is obtained with respect to his own preference, $\{k_1 \geq k_2, \ldots, \geq k_a\}$.

The elicitation process continues through a questioning process, performed by the negotiation support system, where the intention is to determine not a point of indifference between the two packages, but an interval that contains this point of indifference. To exemplify the procedure, let's consider just two packages *A* and *B* with two negotiation issues where *k1 > k2*. The question asked by the system considers that package *A* presents high performance in the first negotiation issue and the worst performances for all other subjects x_1^{up}. While package *B* presents the best performance in the second criterion and the worst performances in the other subjects x_1^{low}. Then, if the decision maker declares a preference for package *A*, it is concluded that the value of this package, denoted by Equation 1, is greater than the global value of package *B*, obtaining the inequality presented in Equation 2.

$$k_1^d v^d\left(x_1^{up}\right) > k_2^d \quad (2)$$

Otherwise, if the DM/negotiator prefers package *B*. The inequality that represents this situation is represented in Equation 3.

$$k_1^d v^d\left(x_1^{low}\right) < k_2^d \quad (3)$$

Inequality (Equations 2-3) can be generalized and expressed as the inequality Equation 4 and Equation 5, respectively.

$$k_j^d v^d\left(x_j^{up}\right) > k_{j+1}^d \quad (4)$$

$$k_j^d v^d\left(x_j^{low}\right) < k_{j+1}^d \quad (5)$$

As the DM/negotiator provides his/her preferences, linear programming models are generated between pairs of trading packages (*Pi, Pk*). Dominance systems are explored between these pairs of trading packages. The optimal solution of the model presented in Equation 6 determines whether there is a dominance relationship between the evaluated packages.

$$Max \sum_{j=1}^{a} k_j^d v^d\left(p_{ji}\right) - \sum_{j=1}^{a} k_j^d v^d\left(p_{jk}\right) \quad (6)$$

Based on the dominance relationships, a complete or partial order of the packages to be negotiated is generated. This order of packages becomes the main tool to support the offer and counteroffer of the FITradeoff for negotiation support system.

3.3. Pos agreement

Finally, in the last step of the proposed model, a contract must be signed by the negotiating parties. The document must contain all the information obtained in the pre-agreement, that is, product price, delivery times, and ecological practices included in the process. In addition, the penalties clause for non-compliance must be described in the contract. The document must be discussed and signed by the legal representatives of the companies involved in the business. The commercial relationship between both firms started from that moment.

4. Case study: application of the proposed model in a food company in northern Colombia

To evaluate the applicability of the model, a case study was conducted in a production and distribution fresh meat company. According to Law 905 of August 2, 2001, issued by the Ministry of Industry and Commerce of

the Republic of Colombia, the studied company is considered medium-sized. Products made in the company have been widely accepted by customers. Furthermore, some products are national sales leaders.

4.1. Pre-negotiation and problem description

The purchasing director (PD) has argued that given the high volume of production and the enormous popularity of their products, many food packaging suppliers send daily requests to initiate business relationships with the company. Additionally, since implementation of a quality and environmental management integral system that seeks to mitigate environmental impacts caused by the organization, the purchasing process has been obliged to start implementing sustainable criteria within the supplier selection process. The PD is a degree in administration with more than ten years of experience in the area. Then, the director, henceforth named buyer or DM, acts as the DM to face the problem of selecting sustainable suppliers. Also, the first author of this investigation, who possesses knowledge about MCDM/A, supported as the analyst and managed the negotiation process.

The price, delivery time, and GM were the negotiation issues. Negotiation issues were established by the buyer. With the analyst's support, the method of measurement was structured and then, once the problem was defined, the methodology was explained to the suppliers. Three potential suppliers agreed with the methodology and entered the negotiation process. An initial condition of minimum two action alternatives is required to execute the proposed model. Each supplier (hereinafter referred to as *Seller 1*, *Seller 2*, and *Seller 3*) was represented legally by a negotiator or counterparty with decision-making and negotiation capabilities. The pre-selection of candidates was carried out because their packaging has high-quality indices and high recognition in the field.

To start the offer and counteroffer exchange process, the analyst collected the necessary information (values of each negotiation subject for each seller) to create the negotiation packages. Before that, the analyst created a user for each seller and the buyer on FITradeoff NSS. This system works charge free and can be accessed by www.FITradeoff.org. When the user enters the system for the first time, an analysis of the trader's profile is performed. Both sellers and the buyer presented a collaborative profile. The information entered on the FITradeoff for negotiation NSS is summarized in Table 4. Basically, with the discrete values of the negotiation issues and target direction, the system generates "trading packages". For example, the seller, who presented 5 possible negotiation prices {*10, 9.5, 9, 8.5* and *8*}, 6 delivery time options {*15, 13, 11, 9, 7* and *5*}, and 4 levels of green manufacturing {*4, 3, 2* and *1*}, 120 trading packages were generated. 48 and 32 trading packages were generated, respectively, to *Seller 2* and Seller 3, respectively.

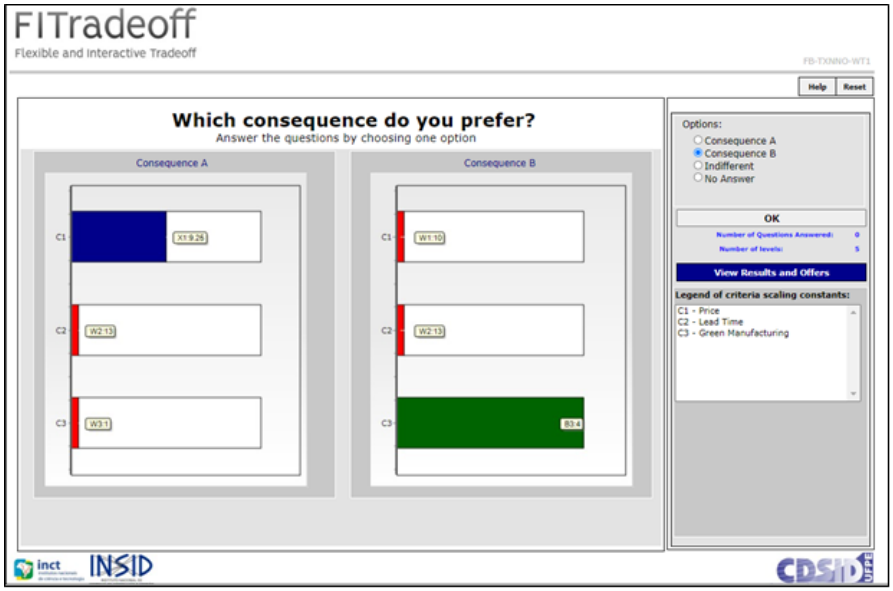
Table 4. Negotiation issues for each seller.

Negotiation issues				
		Price	Delivery time	Green manufacturing
Buyer	Objective	Minimize	Minimize	Maximize
		Price (COP*/Unit)	Delivery time (Days)	Green manufacturing (Level)
		10.0	15	4
		9.5	13	3
Seller 1	Discrete	9.0	11	2
		8.5	9	1
		8.0	7	
			5	
	Objective	Maximize	Maximize	Minimize
		Price (COP*/Unit)	Delivery time (Days)	Green manufacturing (Level)
		10.0	13	4
Seller 2	Discrete	9.5	11	3
		9.0	9	2
		8.5		1
	Objective	Maximize	Maximize	Minimize
		Price (COP*/Unit)	Delivery time (Days)	Green manufacturing (Level)
		12.0	12	4
Seller 3	Discrete	11.0	8	3
		10.0		2
		9.5		1
	Objective	Maximize	Maximize	Minimize

*COP is the official currency of the Republic of Colombia.

4.2. Negotiation

It consisted of offers and counteroffers exchanging packages between the DM and the representatives of each company individually. Before starting the bargaining process, each actor defined a single ranking of the packages based on the constant scale elicitation FITradeoff procedure. The elicitation was performed for the decomposition procedure, comparing supposed problem situations on the NSS. Figure 2 shows the elicitation process of the *Seller 2*. According to the figure, package negotiation N46 represents the best option for negotiating with this supplier.



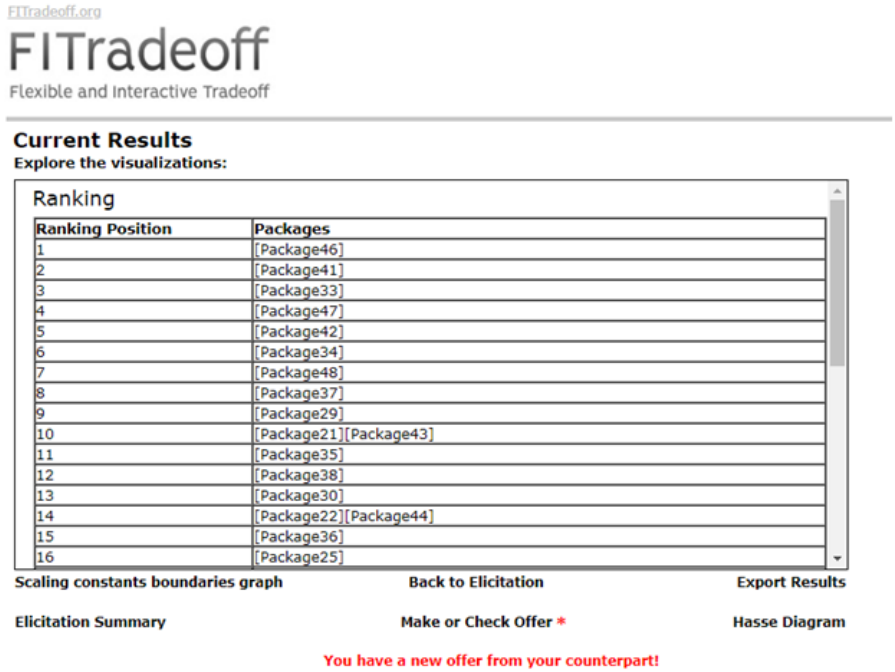
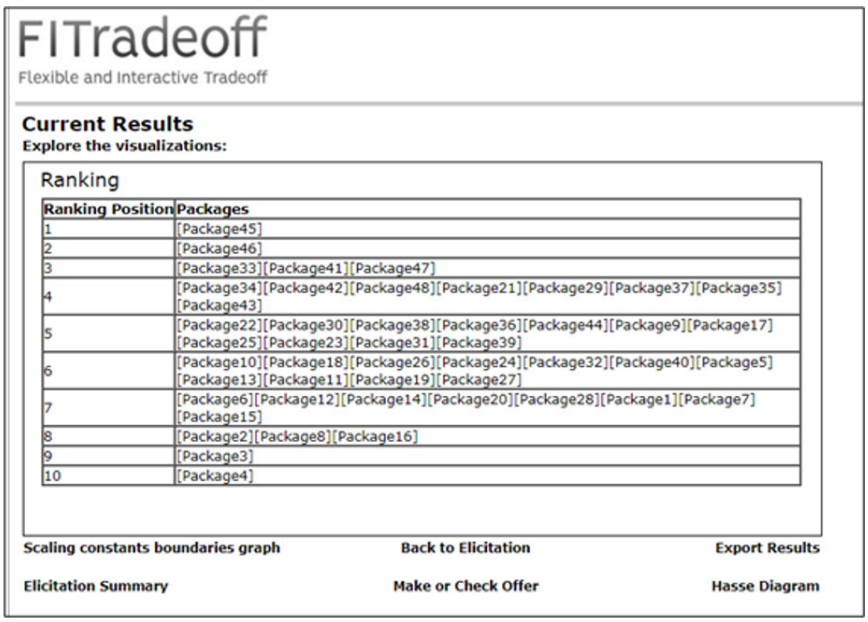
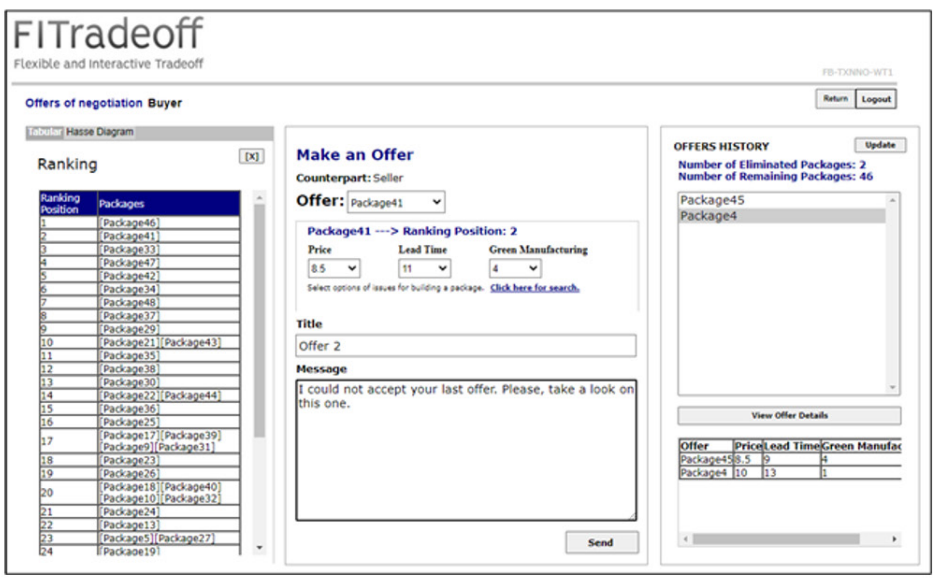


Figure 2. Scale constants elicitation process of the Seller 2. Source: FITradeoff negotiation system.

After that, each actor obtained its ranking in the negotiation packages. Next, the exchange of offers between parties {*Buyer* and *Seller 1*}, {*Buyer* and *Seller 2*} and {*Buyer* and *Seller 3*} began. The system in which Fitradeoff operates is interactive and has options for sending offers, returning to elicitation, and displaying eliminated packages, and potential negotiation packages. These options are shown on top of the Figure 3. Additionally, on bottom of the same Figure 3 shows the fourth negotiation round between *Seller 2* and the *Buyer*. Note that the *Seller 2* did not accept an offer offered by the *Buyer* and sent package N41 as a counteroffer. The N41 package consists of a price of 8.5, a delivery time of 11 days, and a green manufacturing level of 4.



3(a) Negotiation packaging ranking to send an offer between parties



3(b) Offer and counteroffer exchange between Seller 2 and buyer

Figure 3. Fourth negotiation round between buyer and seller 2. Source: FITradeoff negotiation system.

It took 6, 10 and 5 negotiations round to reach pre-agreements between the purchasing director and *Seller 1*, *Seller 2*, and *Seller 3*, respectively. A summary of the negotiation process with *Seller 1*, is shown in Figure 4. The system provides a detailed report of the packages of offers and counteroffers and the cumulative percentage of packages eliminated by decision making in each negotiation round.

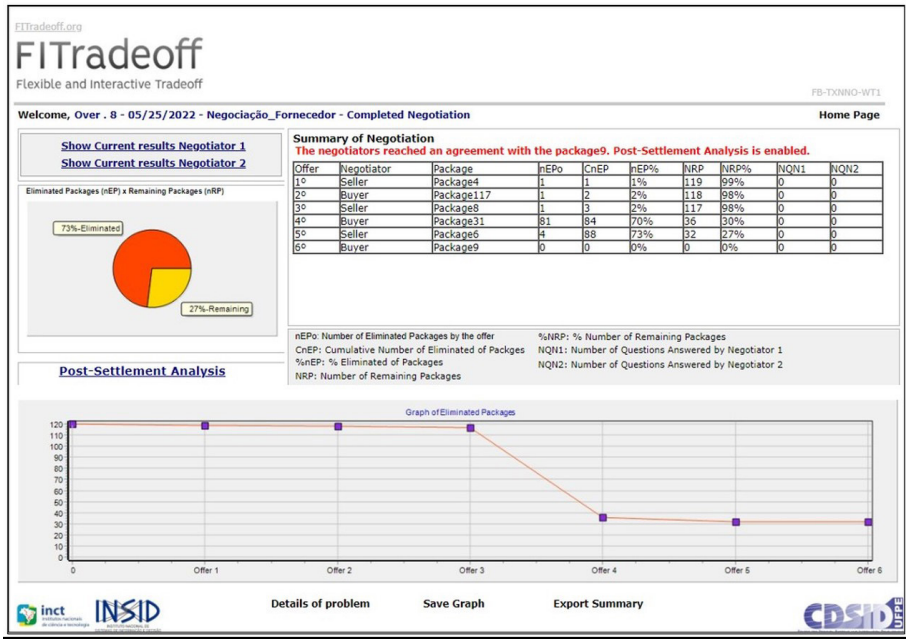


Figure 4. Summary of the negotiation process between *Buyer* and *Seller* 1. Source: FITradeoff negotiation system.

For example, from Figure 4 we conclude that in the fourth negotiation round, when the buyer rejects the last proposal sent by *Seller 1*, the seventy percent (70%), which is more than half of the packages, were eliminated from the negotiation process.

Finally, the three packages pre-selected by the buyer were {10, 11 and 4}, {8.5, 11 and 2} and {10,12 and 2}. In an interview with the analyst, the purchasing director confirmed that since his main objective is to maximize the level of sustainable activities of his suppliers, *Seller 1* would be the option that best represents his objectives, even if other options have the lowest price of the product.

The FITradeoff method allowed negotiators, by using incomplete information, to construct a linear programming model to determine the dominance relationship of the packages. In fact, as the exchange of offers took place, the linear programming equations were refined, and the dominance relationship became more precise and complete (to see Figure 3a). The FITradeoff protocol aims to reduce dominated packages, which are those that are of little interest to negotiators, facilitating the attainment of an agreement.

4.3. Post-agreement

After the decision-making is done, the purchasing department contacts the selected supplier's legal representative. A contract between the parties was drawn up, discussed, and signed. Thus, a new commercial relationship was initiated between the firms.

Conclusion and contributions of the study are presented in the next section.

5. Conclusion, contributions, limitations, and future works

This study has developed a multi-criteria negotiation model that facilitates the selection of a sustainable food packaging supplier. The model's effectiveness has been demonstrated through a case study conducted in

a Colombian agribusiness company. Traditional economic criteria, such as product price and delivery time, were employed to support the decision-making process. Furthermore, the study introduces the green manufacturing criterion as a novel component in the negotiation process. The incorporation of this new criterion ensures that sustainable strategies are adopted throughout the input manufacturing process. Consequently, the model contributes to greener supply chains by promoting sustainable practices among suppliers.

The proposed multi-criteria negotiation model offers a solution to the challenge of making tradeoffs between multiple negotiation objectives while selecting a single supplier. The FITradeoff negotiation protocol used in the model helps DMs evaluate the performance of product requirements and sustainability of suppliers and make tradeoffs between them. The model can assist DMs in selecting sustainable suppliers that align with their company's values and goals, promoting sustainability and reducing environmental impact.

The model comprises three stages: pre-negotiation, negotiation, and post-agreement. In the negotiation stage, that is, in the offers and counteroffers exchange process, using the FITradeoff for negotiation procedure. We select that approach because, initially, it reduces the chance of inconsistency in the decision process since instead of working with a strict point of indifference, it works with preference judgment. Second, the procedure operates within a negotiation support system easily to use.

Despite this model being applied to a specific case, this paper presents a significant contribution to the domain of slaughterhouse enterprises. Specifically, it presents a comprehensive approach for negotiating parameters that can facilitate the achievement of successful and sustainable supply chain management. Furthermore, the model advocates for the implementation of collaborative management practices between interdependent firms. The model also aims to enhance the efficiency of both the buyer and seller firms by incorporating a broader range of environmentally friendly strategies in the seller's operations. From a theoretical standpoint, introduces a novel approach to negotiating sustainable suppliers in agribusiness, thereby enriching the scientific literature on supplier negotiation and selection.

Due to its integrative nature, supply chain managers with primarily financial objectives may not readily embrace the model. Nonetheless, this limitation can be surmounted if these managers are made aware of the long- and medium-term advantages associated with the implementation of this methodology. These benefits include, but are not limited to, cleaner production processes, reduced pollution residue indices, and enhanced social impact on both the community and internal workforce. These benefits become apparent as soon as the changes in the management of a new organizational performance assessment are incorporated into the organization.

It is advised that future research endeavors explore the implementation of this study in various industrial sectors. Additionally, it is recommended that new criteria be established and tested to further promote green manufacturing practices. Furthermore, this research could serve as a benchmark for future studies in this field.

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