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A Static Negotiation Model of Electronic Commerce

Zhaoming Wang[1] *, Yonghui Ling[2]
[1]School of Business Administration, Jimei University,Xiamen 361021
[2] School of Maths and Info, Zhejiang Normal University, Jinhua 321004, P.R.China
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Abstract: To implement trade-off in automated negotiations is one of important aspects in the development of electronic commerce. And the precondition needs to establish a negotiation model. Introduced fuzzy set theory based on games theory; therefore, Introduced fuzzy set theory based on games theory, this paper puts forward a strategy model of the trade negotiations. In this model, firstly we complete the normalization for the weight vectors and payoff matrix of goals, secondly process the negotiation problem of multi-goals, lastly we will gain the optimum order in strategy sets during the process of negotiations. Furthermore, after discussing the negotiation mechanism based on the third party, the necessary condition is getting to fulfill the sustaining negotiations and the trade completion.

Key words: E-business; Negotiation; Fuzzy games; Negotiation mechanism

1 Introduction

With the increasing spread of the Internet technology, more and more commercial transactions are taking place on the Internet electronically. Electronic market places are becoming more important since they promise to greatly improve economic efficiency, reduce sales costs, and speed up complicated business transactions. To promote the development of electronic market, many automation mechanisms and technologies have been introduced currently. Therefore, it is very important that researchers are interested in the study of negotiation model.

Negotiation is a process by which a group of entities try and come to a mutually acceptable agreement on some matter [4]. Because of its ubiquity in everyday encounters, it is a subject that has been extensively discussed in the games theory, economic, and management science literatures [1,3,5]. Recently, however, there has been a surge of interest in automated negotiation systems that are populated with artificial Agent. This is due to both a technology push and an application pull [2,4]. The technology push is mainly from a growing standardized communication infrastructure which allows distributed and heterogeneous entities to interact flexibly. The application pull is from domains (e.g., virtual organizations and electronic trading systems) that require self-interested software entities, representing different stakeholders, to interact in a flexible manner. In these applications, conflicts often arise because the Agent represents distinct stakeholders with different perspectives and different preferences.

According to the cardinality and nature of the interaction, automated negotiation models can be classified into three main categories [4]. The first consists of many-to-one or many-to-many models in which multiple Agents negotiate with either a single or many other Agents. This category is predominantly handled using various auction-based models [8] and these models are widely used in the field of on-line retail (e.g. eBay). The second category consists of one-to-one models in which a pair of Agents negotiates directly with one another [6]. The third category consists of types of argument or persuasion-based models [7] in which

*Corresponding author. *E-mail address*: zmwang@jmu.edu.cn

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Agents use various types of argument, such as *threat*, *rewards* and *appeals*, to persuade their opponent to accept a deal they would not previously have countenanced.

In this paper, we concentrate on the one-to-one case and develop an automated and static (we are not consider the time constraint in the course of negotiation, so we call this is a static model) model for multi-object and incomplete information negotiation. In particular, we are interested in trading Agents in retail markets and so we cast our model in terms of buyer and seller Agents. Moreover, our model employs the games theory with the fuzzy sets theory and methods to discuss the course of negotiation, because the complexity and uncertainty are ubiquitous in this surrounding, and we will find that it is an effective approach to achieve the automated negotiation. Finally, this model will be applied to a negotiation mechanism which has the third-party arbitrator to intervene.

2 Fuzzy games theory-based negotiation model

In the traditional game theory [3,5], dealing with uncertainty in the mathematical tool used is the only probability and statistics. Whereas, in fact, the events of uncertainties have two different forms: one is the event whether or not t occurred, i.e. the randomness; the other one is the event itself-state of uncertainty, as fuzzy. From the perspective of the information, the randomness only relates to the amount of information, but the fuzzy related to the meaning of information. It can be said that the fuzzy is a more profound uncertainty than the randomness. Therefore, it has a more extensive practical significance while we make the traditional responses to the fuzzy game theory [1,10].

2.1 Basic assumptions

(1)Buyer and seller agents are rational and self-interested;

(2)Buyer and seller agents are opposite to the interests;

(3)The payoff matrix of the parties is common knowledge;

(4)Buyer and seller agents have their private information.

There are some notes we should know. Firstly, assumption (2) means that the one payoff is as same as the other one lost. Secondly, assumption (3) means that the strategy set and the utility function are known between two sides. Actually, although, it is very difficult to do it, they try their best to achieve approximately the reasonable conditions. Finally, assumption (4) means that the negotiation process between two sides is of incomplete information. In this paper, the private information includes object weight vectors and ranking function of fuzzy numbers.

2.2 The main components of this model

There are N objects in the course of the negotiation. Let them be as $g_1, g_2, \cdots, g_N$. Combining theory of games with theory of fuzzy sets (to simplify the analysis, we suppose the fuzzy numbers are all the fuzzy numbers of triangle in this paper), the negotiation strategy model in this paper is represented as $\Gamma = \{S_1, S_2, \{\tilde{A}^{(k)}\}_{k=1}^{N}, \tilde{\bar{\omega}}^{(1)}, \tilde{\bar{\omega}}^{(2)}, h_1, h_2\}$,

where:

• $S_1 = \{\alpha_1, \alpha_2, \cdots, \alpha_m\}$ is the strategy set of buyer agent in negotiating, in addition, denoted the probability as x_i when the buyer agent chooses the strategy $\alpha_i (i = 1, 2, \cdots, m)$ in a round of negotiation.

•$S_2 = \{\beta_1, \beta_2, \cdots, \beta_n\}$ is the strategy set of seller agent in negotiating, in addition, denoted the probability as y_j when the seller agent chooses the strategy $\beta_j (j = 1, 2, \cdots, n)$in a round of negotiation.

• $\tilde{A}^{(k)} (k = 1, 2, \cdots, N)$ is the kth payoff matrix with fuzzy of the buyer agent. We will know that the kth payoff matrix with fuzzy of the seller agent is $-\tilde{A}^{(k)}$ due to the assumption (2). In general, we have $\tilde{A}^{(k)} + (-\tilde{A}^{(k)}) \neq \tilde{O}$, where $\tilde{O}$ is zero matrix with fuzzy, and

$$\tilde{A}^{(k)} = \begin{pmatrix} \tilde{a}_{11}^{(k)} & \cdots & \tilde{a}_{1n}^{(k)} \\ \vdots & \ddots & \vdots \\ \tilde{a}_{m1}^{(k)} & \cdots & \tilde{a}_{mn}^{(k)} \end{pmatrix} \quad (k = 1, 2, \cdots, N)$$

•$\tilde{\bar{\omega}}^{(l)} = (\tilde{\bar{\omega}}_1^{(l)}, \tilde{\bar{\omega}}_2^{(l)}, \cdots, \tilde{\bar{\omega}}_N^{(l)})^T (l = 1, 2)$ respectively the fuzzy weight vectors of buyer and seller agent on these N objects, where $\tilde{\bar{\omega}}_k^{(l)} (l = 1, 2; k = 1, 2, \cdots, N)$ is the weight value on the kth objects g_k that $\tilde{\bar{\omega}}_k^{(l)} = (\underline{\omega}_k^{(l)}, \omega_k^{(l)}, \bar{\omega}_k^{(l)}) (l = 1, 2; k = 1, 2, \cdots, N)$.

•h_1, h_2 respectively denote the ranking function of fuzzy numbers which buyer and seller want to employ. These is the private information to them, the role is comparing to the size of fuzzy numbers.

2.3 Normalizing the weight vectors and payoff matrix

In the practical problems, due to the inconsistency in the backgrounds and dimensional unit of the various objects, we get it difficult to compare with the fuzziness of the weight. So, we need to standardize the object weight, and now are using the following formula to standardization:

$$\tilde{\omega}_k^{(l)} = \tilde{\bar{\omega}}_k^{(l)} \Big/ \sum_{k=1}^{N} \tilde{\bar{\omega}}_k^{(l)} \ (l = 1, 2; k = 1, 2, \cdots, N) \tag{1}$$

Then, through the formula (1), respectively we suppose the object weight vector of buyer and seller agent become

$$\tilde{\omega}^{(1)} = (\tilde{\omega}_1^{(1)}, \tilde{\omega}_2^{(1)}, \cdots, \tilde{\omega}_N^{(1)})^T, \tilde{\omega}^{(2)} = (\tilde{\omega}_1^{(2)}, \tilde{\omega}_2^{(2)}, \cdots, \tilde{\omega}_N^{(2)})^T$$

where $\tilde{\omega}_k^{(l)} (l = 1, 2; k = 1, 2, \cdots, N)$ are all the fuzzy numbers of triangle, i.e.

$$\tilde{\omega}_k^{(l)} = \left(\underline{\omega}_k^{(l)} \Big/ \sum_{k=1}^{N} \bar{\omega}_k^{(l)}, \omega_k^{(l)} \Big/ \sum_{k=1}^{N} \omega_k^{(l)}, \bar{\omega}_k^{(l)} \Big/ \sum_{k=1}^{N} \underline{\omega}_k^{(l)} \right) (l = 1, 2; k = 1, 2, \cdots, N).$$

As same as the object weight vectors, the object payoff matrix also needs to be standardized, so that the merit of all goals can be observed in the negotiations. Before do it, we firstly give a definition as follows:

Definition *For the fuzzy matrix games $\tilde{G}^{(k)} = \{S_1, S_2; \tilde{A}^{(k)}\}$ of the kth objects g_k, we choose the ranking function h of fuzzy numbers to sort the fuzzy numbers for all elements of the fuzzy payoff matrix $\tilde{A}^{(k)}$.If there exist $h(\tilde{a}_{i^*j^*}^{(k)}) = \max\{h(\tilde{a}_{ij}^{(k)})\}$, then we call $\tilde{a}_{i^*j^*}^{(k)}$ as the highest fuzzy payoff, to be represented as $\tilde{a}^{(k)} = (\underline{a}^{(k)}, a^{(k)}, \bar{a}^{(k)})$ $(k = 1, 2, \cdots, N)$.*

According to the above-mentioned definition, respectively, $\tilde{a}^{(k,l)} = (\underline{a}^{(k,l)}, a^{(k,l)}, \bar{a}^{(k,l)})$ is used to represent the highest fuzzy payoff of buyer and seller agent in the kth objects g_k. So we can use the following linear transformation formula to standardize:

$$\tilde{r}_{ij}^{(k,l)} = \tilde{a}_{ij}^{(k)} \Big/ \tilde{a}^{(k,l)} (l = 1, 2; k = 1, 2, \cdots, N; i = 1, 2, \cdots, m; j = 1, 2, \cdots, n) \tag{2}$$

Therefore, through the transformation formula (2), the buyer agent $(l = 1)$ can transform the payoff matrix $\tilde{A}^{(k)}$ into the corresponding new payoff matrix $\tilde{R}^{(k,1)} = (\tilde{r}_{ij}^{(k,1)})_{m \times n} (k = 1, 2, \cdots, N)$, and the seller agent $(l = 2)$ also can transform the payoff matrix $\tilde{A}^{(k)}$ into the corresponding new payoff matrix $\tilde{R}^{(k,2)} = (\tilde{r}_{ij}^{(k,2)})_{m \times n} (k = 1, 2, \cdots, N)$, where

$$\tilde{r}_{ij}^{(k,l)} = (\underline{a}_{ij}^{(k)} \Big/ \bar{a}^{(k,l)}, a_{ij}^{(k)} \Big/ a^{(k,l)}, \bar{a}_{ij}^{(k)} \Big/ \underline{a}^{(k,l)}) (l = 1, 2; k = 1, 2, \cdots, N; i = 1, 2, \cdots, m; j = 1, 2, \cdots, n)$$

Thus, the model $\Gamma = \{S_1, S_2, \{\tilde{A}^{(k)}\}_{k=1}^N, \tilde{\bar{\omega}}^{(1)}, \tilde{\bar{\omega}}^{(2)}, h_1, h_2\}$ changes into the new model
$\Gamma^* = \{S_1, S_2, \{\tilde{R}^{(k,1)}\}_{k=1}^N, \{\tilde{R}^{(k,2)}\}_{k=1}^N, \tilde{\omega}_1, \tilde{\omega}_2, h_1, h_2\}$.

2.4 Specifying the multi-objects negotiations

When the weight vectors and payoff matrix have been standardized, the next step is to address the consultations issue of multi-objects. The linear weight method will be used to finish transform in this paper, and then its solution is completed by making use of game theory matrix. It is worthy of mention that, the negotiation of the two sides being in the case of incomplete information, the model estimated matrix game will be gained by their private preference structure.

Actually, we can do a weighted linear transformation for the buyer agent:

$$\tilde{m}_{ij} = \sum_{k=1}^{N} \tilde{\omega}_k^{(1)} \tilde{r}_{ij}^{(k,1)} \ (i = 1, 2, \cdots, m; j = 1, 2, \cdots, n) \tag{3}$$

Then, we will transform the N objectives payoff matrix $\tilde{R}^{(k,1)} = (\tilde{r}_{ij}^{(k,1)})_{m\times n}$ into a new payoff matrix $\tilde{M} = (\tilde{m}_{ij})_{m\times n}$, where

$$\tilde{m}_{ij} = \left(\sum_{k=1}^{N} \frac{\underline{a}_{ij}^{(k)} \underline{\omega}_k^{(1)}}{\bar{a}^{(k,1)} \sum\limits_{k=1}^{N} \bar{\omega}_k^{(1)}}, \sum_{k=1}^{N} \frac{a_{ij}^{(k)} \omega_k^{(1)}}{a^{(k,1)} \sum\limits_{k=1}^{N} \omega_k^{(1)}}, \sum_{k=1}^{N} \frac{\bar{a}_{ij}^{(k)} \bar{\omega}_k^{(1)}}{\underline{a}^{(k,1)} \sum\limits_{k=1}^{N} \underline{\omega}_k^{(1)}} \right)$$

In the same way, we can do a weighted linear transformation for the seller agent:

$$\tilde{n}_{ij} = \sum_{k=1}^{N} \tilde{\omega}_k^{(2)} \tilde{r}_{ij}^{(k,2)} \ (i = 1, 2, \cdots, m; j = 1, 2, \cdots, n) \tag{4}$$

Therefore, we also can transform the N objectives payoff matrix $\tilde{R}^{(k,2)} = (\tilde{r}_{ij}^{(k,2)})_{m\times n}$ into another one payoff matrix $\tilde{N} = (\tilde{n}_{ij})_{m\times n}$, where

$$\tilde{n}_{ij} = \left(\sum_{k=1}^{N} \frac{\underline{a}_{ij}^{(k)} \underline{\omega}_k^{(2)}}{\bar{a}^{(k,2)} \sum\limits_{k=1}^{N} \bar{\omega}_k^{(2)}}, \sum_{k=1}^{N} \frac{a_{ij}^{(k)} \omega_k^{(2)}}{a^{(k,2)} \sum\limits_{k=1}^{N} \omega_k^{(2)}}, \sum_{k=1}^{N} \frac{\bar{a}_{ij}^{(k)} \bar{\omega}_k^{(2)}}{\underline{a}^{(k,2)} \sum\limits_{k=1}^{N} \underline{\omega}_k^{(2)}} \right)$$

Now, after the transformation of multi-objects negotiations problem being fulfilled, we have gotten the negotiation model based on single object. Next, we need to change the fuzzy payoff matrix into a precision payoff matrix, then, the multi-objects negotiations problem can be solved by use of the methods of matrix game.

Respectively, denote $H_1(\tilde{M}) = (h_1(\tilde{m}_{ij}))_{m\times n}$ and $H_2(\tilde{N}) = (h_2(\tilde{n}_{ij}))_{m\times n}$ as the precise payoff matrix gotten fuzzy payoff matrix on buyer and seller agent. Due to incomplete information (the buyer and seller agent choose different ranking functions of fuzzy numbers), the buyer agent thinks that their negotiation based on the model $\Gamma_1^* = \{S_1, S_2, H_1(\tilde{M}), h_1\}$ which the payoff matrix of buyer agent is $H_1(\tilde{M}) = (h_1(\tilde{m}_{ij}))_{m\times n}$. Whereas, the seller agent thinks their negotiation model is $\Gamma_2^* = \{S_1, S_2, H_2(\tilde{N}), h_2\}$ which the payoff matrix of buyer agent is $H_2(\tilde{N}) = (h_2(\tilde{n}_{ij}))_{m\times n}$, i.e. the seller agent own payoff matrix is $-H_2(\tilde{N})$. Consequently, we can obtain the linear programming model about the optimal strategy solutions of the model Γ_1^* is

$$\max\left\{w^{(1)}\right\}$$
$$(P_1)\begin{cases} \sum\limits_{i=1}^{m} h_1(\tilde{m}_{ij})x_i \geq w^{(1)} \ (j = 1, 2, \cdots, n) \\ \sum\limits_{i=1}^{m} x_i = 1 \\ x_i \geq 0 \ (i = 1, 2, \cdots, m) \end{cases}$$

$$\min\left\{v^{(1)}\right\}$$
$$(Q_1)\begin{cases} \sum\limits_{j=1}^{n} h_1(\tilde{m}_{ij})y_j \leq v^{(1)} \ (i = 1, 2, \cdots, m) \\ \sum\limits_{j=1}^{n} y_j = 1 \\ y_j \geq 0 \ (j = 1, 2, \cdots, n) \end{cases}$$

And, the linear programming model about the optimal strategy solutions of the model Γ_2^* is

$$(P_2)\quad \max\left\{w^{(2)}\right\} \begin{cases} \sum\limits_{i=1}^{m} h_2(\tilde{n}_{ij})x_i \geq w^{(2)}\ (j=1,2,\cdots,n) \\ \sum\limits_{i=1}^{m} x_i = 1 \\ x_i \geq 0\ (i=1,2,\cdots,m) \end{cases}$$

$$(Q_2)\quad \min\left\{v^{(2)}\right\} \begin{cases} \sum\limits_{j=1}^{n} h_2(\tilde{n}_{ij})y_j \leq v^{(2)}\ (i=1,2,\cdots,m) \\ \sum\limits_{j=1}^{n} y_j = 1 \\ y_j \geq 0\ (j=1,2,\cdots,n) \end{cases}$$

By solution for the above two pairs of dual programming problem with simplex algorithm or simplex method for dual, respectively, denote the optimal solution as

$$x^{(1)} = \left(x_1^{(1)}, x_2^{(1)}, \cdots, x_m^{(1)}\right)^T, y^{(1)} = \left(y_1^{(1)}, y_2^{(1)}, \cdots, y_n^{(1)}\right)^T$$

$$x^{(2)} = \left(x_1^{(2)}, x_2^{(2)}, \cdots, x_m^{(2)}\right)^T, y^{(2)} = \left(y_1^{(2)}, y_2^{(2)}, \cdots, y_n^{(2)}\right)^T$$

2.5 The model outcome

Now, we will discuss the size relations between the total actual fuzzy payoff and estimated fuzzy payoff when they get the optimal solution and utilize it to negotiate.

In the course of negotiations, the buyer agent will choose the optimal solution $x^{(1)}$, and consider that the seller agent will choose the optimal solution $y^{(1)}$, and then we can estimate the expected fuzzy payoff gotten on the object $g_k(k=1,2,\cdots,N)$ of the buyer agent is

$$\tilde{\delta}_{(k,1)} = (x^{(1)})^T \tilde{R}^{(k,1)} y^{(1)} \tag{5}$$

Similar to the buyer agent, the seller agent will choose the optimal solution $y^{(2)}$, and consider that the buyer agent will choose the optimal solution $x^{(2)}$ at the moment; hence, we also can estimate the expected fuzzy payoff gotten on the object $g_k(k=1,2,\cdots,N)$ of the buyer agent is

$$\tilde{\delta}_{(k,2)} = (x^{(2)})^T \tilde{R}^{(k,2)} y^{(2)} \tag{6}$$

However, the buyer and seller agent respectively taken the optimal solution is $x^{(1)}$ and $y^{(2)}$. So, we can obtain the actual expected payoff with fuzzy of buyer and seller agent are

$$\tilde{\delta}^*_{(k,1)} = \left(x^{(1)}\right)^T \tilde{R}^{(k,1)} y^{(2)} \tag{7}$$

$$-\tilde{\delta}^*_{(k,2)} = -\left(x^{(1)}\right)^T \tilde{R}^{(k,2)} y^{(2)} \tag{8}$$

respectively.

As mentioned above, two formulas of the following can be proved [1,9]:

$$\sum_{k=1}^{N} \tilde{\omega}_k^{(1)} \tilde{\delta}_{(k,1)} \leq \sum_{k=1}^{N} \tilde{\omega}_k^{(1)} \tilde{\delta}^*_{(k,1)} \tag{9}$$

$$\sum_{k=1}^{N} \tilde{\omega}_k^{(2)} \tilde{\delta}^*_{(k,2)} \leq \sum_{k=1}^{N} \tilde{\omega}_k^{(2)} \tilde{\delta}_{(k,2)} \tag{10}$$

Although the negotiation process of the buyer and seller agent is performed under condition of the incomplete information, the two formulas ((9) and (10)) showing, their original estimate optimal strategy for negotiations can be still adopted, and the ultimate outcome of the negotiation is executed to be none the worse than of estimate.

According to the negotiations, if we suppose that the buyer and the seller agent conform to the following principle, which the greater the strategy probability in optimal solution is, the better their own interests is, then the buyer and the seller agent could be obtain the best strategy priority in the course of negotiations:

Buyer's best strategy priorities: In the negotiation model $\Gamma_1^* = \{S_1, S_2, H_1(\tilde{M}), h_1\}$, the optimal solution $x^{(1)}$ of the buyer agent is sorted in accordance with order of decreasing powers, then the result is $x_{i_1}^{(1)}, x_{i_2}^{(1)}, \cdots, x_{i_m}^{(1)}$, where the $i_1, i_2, \cdots, i_m$ is an order of $1, 2, \cdots, m$. So, from the strategic options, the best strategy order of the buyer agent is $\alpha_{i_1}, \alpha_{i_2}, \cdots, \alpha_{i_m}$.

Seller's best strategy priorities: In the negotiation model $\Gamma_2^* = \{S_1, S_2, H_2(\tilde{N}), h_2\}$, the optimal solution $y^{(2)}$ of the seller agent is sorted in accordance with order of decreasing powers, then the result is $y_{j_1}^{(2)}, y_{j_2}^{(2)}, \cdots, y_{j_n}^{(2)}$, where the $j_1, j_2, \cdots, j_n$ is an order of $1, 2, \cdots, m$. Therefore, according to the principle of strategic options, the best strategy order of the seller agent is $\beta_{j_1}, \beta_{j_2}, \cdots, \beta_{j_n}$.

3 A third-party based negotiations mechanism for e-commerce

In the negotiation model established by using of the fuzzy games theory, the each round of negotiations between the seller and buyer agent is interactively completed through the strategy which is simultaneously taken by the two parties. In such a negotiations mechanism, it is an important problem whether the two sides can trust each other and truly abide by the rules of this interaction or not, and one of methods solved the problem is with the third-party achieving arbitration. On the other hand, known from the negotiation model, the respective models of the two parties are inconsistent with the strategies model of the actual negotiation, this inconsistency will directly lead to bring the instability in a process of negotiations between the two parties. In like manner, there exist the difference between the estimated payoff and the actual payoff during each round of negotiations for the two sides. Of course, the difference is obviously a key factor of whether the two sides successfully fulfill the each round of negotiations or not. So, in order to complete successfully the negotiations and trade-off, it is necessary to set some control principles on the negotiations, the principles can successfully guarantee to finish the negotiations, and the supervision and implement of the principles need to arbitrate through the third-party arbiter.

3.1 The negotiation mechanism's satisfiability conditions

The chief precondition is that the buyer and seller are willing to complete the deal so that they can fulfill negotiation. So, intuitively, in order to achieve each round of negotiations, we can suppose that if the difference between the estimated payoff and the actual payoff is restricted within a certain scope, then this round of negotiation could be considered to completed and the next negotiation be executed. In other words, if the maximum values in the payoff difference between the two parties is endued in advance to be λ_1 and λ_2 respectively(supposes λ_1 and λ_2 to be constant), known from the best strategy order of the two parties, while the two sides are entering the rth $(r = 1, 2, 3, \cdots)$ round of negotiation, the buyer will select the strategy at the same time, and the seller will select the strategy β_{j_r}. So, the actual payoff of the buyer agent is $\tilde{a}_{i_r j_r}$(the seller's actual payoff is $-\tilde{a}_{i_r j_r}$). In addition, the estimated payoff of the buyer agent is $\tilde{a}_{i_r j_r^*}$, the seller is $-\tilde{a}_{i_r^* j_r}$. So, when the formula (11) holding

$$\left| h_1(\tilde{a}_{i_r j_r}) - h_1(\tilde{a}_{i_r j_r^*}) \right| \leq \lambda_1 \tag{11}$$

The buyer agent regards that the round of negotiations can be completed and will continue for the $r + 1$th round of negotiations. Similar to the buyer agent, when formula (12) holding

$$\left| h_2(-\tilde{a}_{i_r j_r}) - h_2(- \tilde{a}_{i_r^* j_r}) \right| \leq \lambda_2 \tag{12}$$

The seller agent regards that this round of negotiations can be completed and will go on the $r + 1$th round of negotiations.

3.2 A negotiation mechanism with third-party

After discussing the conditions which the negotiation mechanism need to satisfy, we should consider it to be stand to reason for the buyer and seller how to decide the next progress according to the judgement conditions. Now, we suppose that the buyer and seller is processing in the rth $(r = 1, 2, 3, \cdots)$ round of negotiation, and then the three type conditions of negotiation mechanism are as follows:

(1)If formula (11) and (12) hold at the same time, then the two parties enter the $r + 1$th round of negotiations through the third party of arbitration.

(2)If formula (11) and (12) don't hold at the same time, then the negotiation will be terminated through the third party of arbitration.

(3)If only one of the formulas (11) and (12) hold, then suggests that the two sides enter the $r+1$th round of negotiations through the third party of coordinated.

For a special case of the condition (3), it is worthy of note that if certain times of the negotiations have been processed, where the one of two formulas always holds, but the other one of two formulas does not hold, then, a obvious fact is that the failure of negotiation must be brought after certain times being completed by the negotiation process based on the third party. Thus, in order to avoid this situation to happen, we introduce a factor $t_p (p = 1, 2)$ which reflects the tolerance degree of the two sides. As long as the times which formula (11) (or formula (12)) does not hold are more than t_1(or t_2), then, their negotiation will be terminated, otherwise, their negotiation will be processed continuously.

3.3 The trading mechanism's satisfiability conditions

Finally, we will discuss the deal mechanism's holding conditions when the negotiation has been completed. From formula (9), (10) and the two best strategy orders, we can conclude that the later using their strategy for the buyer and seller is, the worse their own benefit for the buyer and seller is. Therefore, when the intention to perform deal wants to inform the other side during one of the buyer and seller through third-party coordinator, the informed side should immediately response to the intention. For the reduction discussion, this response is restricted to two kinds: firstly, to accept the proposal of the other side; secondly, not to accept the proposal of the other side resulting in terminating the negotiation. Explained particularly content as following:

(1)Only the buyer and seller run out of their all strategies, can they complete the deal. Knowing from the strategy model, we will conclude that:

1)The deal must be completed when $m \equiv n$, and the result of negotiation is satisfying to the buyer and seller.

2)When $m \neq n$ (we assume that $n > m$), the deal is accomplished to be a satisfying result for the buyer, however, for the seller, if both the total actual payoff and the estimated payoff satisfy the following formula(13):

$$\left| \sum_{r=1}^{m} h_2(-\tilde{a}_{i_r j_r}) - \sum_{r=1}^{n} h_2(-\tilde{a}_{i_r^* j_r}) \right| \leq \lambda_2^* \tag{13}$$

then the deal can be completed, otherwise be failed. Where λ_2^* is the maximal difference value between the total actual payoff accepted by the seller and the total estimated payoff.

(2)If the two sides do not run out of their all strategies (we suppose they have done $s(s < \min(m, n))$ round of negotiations), we think that the deal can be in progress. For the seller and buyer, at the moment, only when the difference value between the total actual payoff and the estimated payoff is not more than the maximal value of the total difference payoff which can be accepted by the two sides, can the deal be completed. i.e.

$$\left| \sum_{r=1}^{s} h_1(\tilde{a}_{i_r j_r}) - \sum_{r=1}^{m} h_1(\tilde{a}_{i_r j_r^*}) \right| \leq \lambda_1^* \tag{14}$$

$$\left| \sum_{r=1}^{s} h_2(-\tilde{a}_{i_r j_r}) - \sum_{r=1}^{n} h_2(-\tilde{a}_{i_r^* j_r}) \right| \leq \lambda_2^* \tag{15}$$

If both formula (14) and formula (15) are at the same time holding, then the deal can be completed, or else be failed. Where λ_1^* is the maximal difference value between the total actual payoff accepted by the buyer and the estimated payoff.

4 Conclusions and future work

This paper developed a fuzzy games theory based model for bilateral, multi-object and incomplete information negotiations in a deal of e-commerce environment. The negotiation model presented in this paper is novel in four aspects:

(1)It exploits the related results of fuzzy games theory as the basic representation scheme;

(2)It enables negotiation to be carried out over multiple objects of a deal. This is more efficient than negotiation that is carried out over single point solutions;

(3)It guarantees that the outcome of negotiation is based on the case of incomplete information;

(4)It is applied on a third-party based negotiation mechanism, and obtain the conditions in the deal process should be satisfy.

There are, however, a number of issues that require further investigation. Firstly, we would like to investigate the effect when the basic assumptions in this model to be weakened, in particular, to weaken the basic assumption (3). Secondly, we would like to explore the situation of endowing the buyer and/or the seller agent with alternative negotiation strategies. Finally, since our negotiation model mainly discusses the static case which does not consider the time in the negotiating courses, it is natural that in the next step we will research the role when consider the time on the negotiation model.

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