Association for Information Systems
AIS Electronic Library (AISeL)

PACIS 2005 Proceedings

Pacific Asia Conference on Information Systems (PACIS)

December 2005

Study on the Automated Negotiation Methodology for Solving Multi Attribute Negotiation

Hyung Choi
Dong-A University

Hyun-Soo Kim
Dong-A University

Soongoo Hong
Dong-A University

Young-Jae Park
Dong-A University

Yong-Sung Park
Dong-A University

See next page for additional authors

Authors
Hyung Choi, Hyun-Soo Kim, Soongoo Hong, Young-Jae Park, Yong-Sung Park, and Dong-Yeol Yoo

Study on the Automated negotiation Methodology for Solving Multi attribute Negotiation

Hyung Rim Choi
Department of MIS, Dong-A University
840 Hadan-dong, Saha-gu, Busan 604-714,
South Korea
Tel: +82-51-200-7477
hrchoi@daunet.donga.ac.kr

Hyun Soo Kim
Department of MIS, Dong-A University
840 Hadan-dong, Saha-gu, Busan 604-714,
South Korea
Tel: +82-51-200-7478
hskim@daunet.donga.ac.kr

Soon Goo Hong
Department of MIS, Dong-A University
840 Hadan-dong, Saha-gu, Busan 604-714,
South Korea
Tel: +82-51-200-7488
shong@daunet.donga.ac.kr

Young Jae Park
Department of MIS, Dong-A University
840 Hadan-dong, Saha-gu, Busan 604-714,
South Korea
Tel: +82-51-200-7477
b990006@daunet.donga.ac.kr

Yong Sung Park
Department of MIS, Dong-A University
840 Hadan-dong, Saha-gu, Busan 604-714,
South Korea
Tel: +82-51-200-6538
ys1126@daunet.donga.ac.kr

Dong Yeol Yoo
Department of MIS, Dong-A University
840 Hadan-dong, Saha-gu, Busan 604-714,
South Korea
Tel: +82-51-200-7477
julliusy@donga.ac.kr

Abstract
The spread of the Internet and development of e-commerce technology have redefined commercial transactions, and a succession of attempts to embody actual transactions has proliferated in the e-commerce environment. Several studies have been continuously attempted to embody the function of negotiations in the e-commerce environment, since negotiations have been performed in most transactions except those at a fixed price. This study presents various alternative plans for the multiattribute negotiation between purchasers and sellers to embody the automated negotiation system in the e-commerce environment and proposes a method of creating and evaluating an optimum negotiation plan according to user characteristics.

Keywords: Negotiation; Multi attributes negotiation; Automated negotiation methods

1. Introduction

The rapid spread of the Internet and the progress of related technology have redefined existing commercial transactions. In particular, e-commerce transcends time and space barriers between sellers and consumers in actual commercial transactions. The scale grows rapidly along with the reduction of economic costs, enhancement of the convenience of use, and decrease in transaction costs (Se jin Oh et al, 2002; Ui sung Cho et al, 1999).

Most transactions except those at a fixed price are carried out through negotiations in actual transactions. In other words, negotiation is a main factor in commercial transactions. Studies to embody actual negotiations in e-commerce through agents have been conducted along with the expansion of the e-commerce market. Still, most existing studies on an automated negotiation, i.e., agents carrying out negotiations automatically, are insufficient since they deal with the negotiation support system as goods retrieval for e-commerce or comparative retrieval of the same goods.

Despite the importance of negotiation and spread of e-commerce, the automated negotiation system has yet to be realized fully owing to the difficulty of negotiation itself and negotiation automation (Carrie et al, 1997). This problem notwithstanding, an automated negotiation system is necessary for coping with environmental changes and complicated problems and carrying out various negotiations efficiently.

Activating negotiation in e-commerce will bring about other various negotiations at the same time; still, people alone can neither handle such various negotiations nor afford to wait for them to occur. Therefore, an automated negotiation system, i.e., negotiation is carried out automatically, is necessary to solve this problem.

This study defines the multiattribute negotiation using three negotiation items and examines the negotiation methodology from the seller's viewpoint. The negotiation process is classified into two parts: (1) the alternative plan of negotiation changed by entropy is formed at the seller's place

vis-à-vis production schedule, cost, and quality, and; (2) a negotiation plan is formed considering the penalty for delayed negotiation, seller's negotiation characteristic by utility function, and certainty of the success of the negotiation plan to make it cope with the negotiation plan of the other party.

The rest of this paper is organized as follows: Chapter 2 examines the present condition and limitations of the existing negotiation system; Chapter 3 defines multiattribute negotiation and formulates and evaluates a negotiation plan; Chapter 4 describes the drawing process of the negotiation plan by negotiation generator using the valuation results, and; Chapter 5 discusses the limitations, recommendations, and future research directions.

2. Review of Related Literature

Negotiation is a form of intention decision in search of a solution to realize a common aim by more than two participants (Rosenschein et al, 1994). After examining the existing negotiation studies, Jelassi (1989) and Forough (1995) presented a design for a negotiation system in support of negotiation with emphasis on human factors such as behaviorism, recognition difference, and negotiation theory. Nunamaker et al (1991) reported the results of an experiment using a negotiation support system to solve the negotiation problem regarding bilateral agreements. On the other hand, Sycara et al (1996) and Dajun et al (1996) designed protocols to exchange proposal and counterproposals between agents and developed the automated negotiation system called Bazaar based on such protocols. The Bayesian probability theory is used for learning in Bazaar. Sandholm et al (1995) proposed an upgraded version of the Contract Net Protocol for dispersed work allotment in the dispersion of Artificial Neural Networks. Chavez et al (1996) did a research on Kasbah or the negotiation market, negotiating with many people in the central market . Oliver (1996) applied the heredity algorithm as a learning to devise a negotiation strategy. On the other hand, the supporting transaction model was designed to support auction, bid, and transformed auction by the Michigan Internet AuctionBot (auction.eecs.umich.edu), Cathay Pacific (www.cathaypacifc.com), Onsale (www.osale.com), JEM Computers (www.jemcomp.com), and Koll-Dove (www.koll-dove.com). Studies supporting various negotiations by system were performed in various fields and could be classified into two parts: negotiation support system (NSS) and setting the final goal of perfect negotiation automation.

NSS supports the negotiation process instead of negotiation automation. This system provides the necessary decision-making information in the negotiation process and an electronic conversation channel. Unlike an automated negotiation agent, NSS depends on people for the input of restrictions, resolving early problems, and final decision making. NSS is divided into Solution-Driven NSS and Process Support NSS.

Solution-Driven NSS offers alternative plans and various methods. Social Judgment Theory Models, Hypergame Decision Models, Bargaining Models, and Multiobjective Linear Programming draw these plans, and an expert system is used. On the other hand, Process Support NSS supports various communication channels and bilateral agreements instead of presenting alternative plans. Most of the NSSs are Solution-Driven NSS, embodying the environment of group meeting (Yuan et al, 1998).

Finally, the ultimate goal of perfect negotiation automation is set. Automated negotiations are possible using a single computer or several mutually connected computers to emphasize that automated negotiations are carried out by computers without relying on people. Despite the complication of a face-to-face negotiation, the automated negotiation agents in existing studies did not demand a corresponding complicated process (Beam et al, 1996). Pattie et al (1994) stressed that some of the characteristics of mutually connected intellectual agents include their complicated environment and intellectual behavior compared to the simplicity of an individual agent.

Kasbah is an example of an automated negotiation agent that is not connected with the network (Chavez et al, 1996). As a center-based electronic market, Kasbah supports a transaction process using intellectual agents and a single-attribute negotiation agent using the price ascent strategy of the buyer and price relief strategy of the seller.

On the other hand, instrument learning is used for automated negotiation.

Oliver (1996) introduced an agent learning using the heredity algorithm to teach agents more effective ways of negotiation. Shaheen et al (2004) studied the formation of negotiation strategies and maintenance of balance to cope with the counterpart's strategy using the game theory.

Still, it is difficult to apply existing studies to actual transactions. This is because the method of substituting the people's role in the automated negotiation system, which still requires the intervention of people, has yet to be developed. For example, in case of negotiation, negotiation alternatives are created after determining the negotiation attribute and evaluated considering the environments and the counterpart's strategy. A negotiation plan is then presented according to the evaluation results.

Existing studies on automated negotiation failed to develop the method of substituting people's recognition system and discernment. Therefore, this study embodies people's recognition system and discernment in actual negotiations through the automated negotiation methodology.

Getting out of the existing automated negotiation system focusing on the price which is a single attribute, negotiation alternatives are created considering various attributes available for negotiation, and the evaluation and proposal of negotiation alternatives are investigated considering factors in actual negotiation such as the negotiation time, user's utility of negotiation substitutes, and possibility of success according to the counterpart.

3. Formation and Valuation of Negotiation alternatives

Decision makers evaluate negotiation attributes according to various standards of judgment and decide a preference order of the substitutes through such valuation. When negotiating with their counterparts, participants determine the environmental factors affecting the occurrence of negotiation as attributes. This chapter defines the negotiation environments and examines the solving process of negotiation. The formation and valuation of negotiation alternatives are also described.

3.1 Definition of negotiation environment

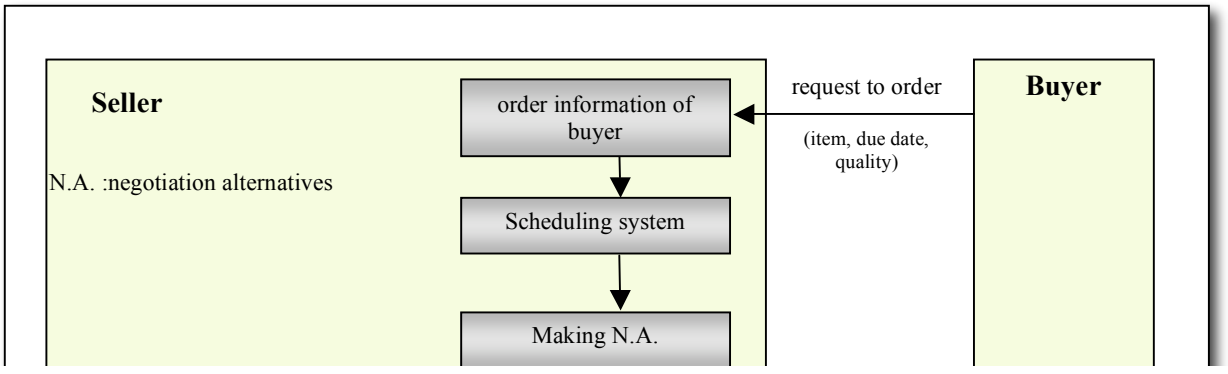
Sellers and buyers participating in the negotiation negotiate to maximize their profits. The negotiation attributes of participants selling and buying standardized goods include the goods, quantities of goods, and price of goods. In case of order negotiations, however, negotiation attributes include the price of goods, time limit for delivery, and quality. This is because a buyer wants to buy products with good quality and at a low price at his/her preferred date, whereas a seller wants to receive an order at a high price in the range of productive capacity. The profit sought by negotiation participants varies considerably according to the environment of negotiation. In this study, negotiation environment is defined as the negotiation environment between the seller and buyer in the order manufacture, since dealing with negotiation in the negotiation environment is difficult. The research range is limited to the negotiation environment of order manufacture. Since the production form of order manufacture is equipped for a system of various kinds and small production, production is decided by an order of a buyer. Most contracts are also concluded by negotiations. The environment of order manufacture is the most suitable environment for expressing negotiation. Negotiations occur in the order manufacture because a seller cannot accept the demand of a buyer completely, which, in turn, is either due to the difficulty of a seller to keep his/her appointed date owing to the limit of productive capacity or the rising price of goods as a result of keeping the appointed date. Negotiations of order manufacture refer to negotiations between a buyer and a seller regarding the ordered goods, and order splitting does not occur. This study assumes that the same goods are not repeatedly produced and assigns the price, time limit for delivery, and quality as negotiation variables. Transaction progresses through the bargaining method, and a negotiation plan is formed based on the price, time limit for delivery, and quality in a trade-off relationship.

3.2 Formation of negotiation substitutes

The main items of negotiation alternatives in the order manufacture include the price, time limit for delivery, and quality. Similarly, sellers make negotiation alternatives consisting of the price, time limit for delivery, and quality considering the existing production plan, production cost required to produce goods, and input cost changed by the alteration of quality. Finally, the order manufacture enterprise determines the range of negotiation based on the price, time limit for delivery, and quality through the production schedule system.

Park et al (2004) conducted a study on the formation of negotiation alternatives through the production schedule in the environment of order manufacture, and the performance of this methodology was verified through various experiments. This study applies the schedule methodology based on the heredity algorithm proposed by Park et al (2004) to the formation of negotiation substitutes. <Figure 1> shows the entire process of negotiation in the environment of order manufacture, which describes the process of negotiation starting from negotiating through a request to buy from the first buyer, setting up negotiation alternatives through the schedule system, and presenting an optimum negotiation plan through the evaluation of each negotiation substitute.

<Figure 1> Negotiations process



negotiation alternatives made from the schedule system is composed of attributes such as price, time limit for delivery, and quality, with the formation of negotiation alternatives using the schedule system resulting in the negotiation alternatives shown in <Table 1>. Each negotiation substitute of A_1~A_{21} is composed of attributes such as price, time limit for delivery, and quality in a trade-off relationship. The quality is grasped by quantitative factor of top, middle, and bottom and considered by cost factor in decision making. Therefore, the top as the highest quality shows an attribute value of the lowest, and the bottom as the lowest quality, an attribute value of the highest.

<Table 1> Generating negotiation alternatives

Negotiation Substitutes	Attribute of Negotiation Substitutes		
	C_1 (cost)	C_2 (time limit for delivery)	C_3 (quality)
A_1	40000	50	Top (75)
A_2	38200	55	Top (75)
A_3	36400	60	Top (75)
A_4	34600	65	Top (75)
A_5	32800	70	Top (75)
A_6	31000	75	Top (75)
A_7	29200	80	Top (75)
A_8	37300	58	Middle (80)
A_9	35500	63	Middle (80)
A_{10}	33700	68	Middle (80)
A_{11}	31900	73	Middle (80)
A_{12}	30100	78	Middle (80)
A_{13}	28300	83	Middle (80)
A_{14}	26500	88	Middle (80)
A_{15}	32800	55	Bottom (90)
A_{16}	31000	60	Bottom (90)
A_{17}	29200	65	Bottom (90)
A_{18}	27400	70	Bottom (90)
A_{19}	25600	75	Bottom (90)
A_{20}	23800	80	Bottom (90)
A_{21}	22000	85	Bottom (90)

Such value of the negotiation plan undergoes the process of evaluating the worth of negotiation alternatives using entropy measure and subjective weight.

3.3 Valuation of multiattribute negotiation alternatives using entropy measure

This study applied the Multiattribute Decision Making (MADM) method to the valuation method of negotiation substitutes. MADM standardizes the negotiation items with the measure of a different standard with the same standard, shows the valuation value of each substitute for the comparison of each substitute, and supports the identification of optimum substitutes by giving subjective weight to each item.

In applying MADM to this paper, the following signs are defined:

n: Number of the entire attribute
m: Number of the entire negotiation plan
A_i: Negotiation alternatives of i turn
C_j: j turn attribute of negotiation substitutes
x_{ij}: Attribute C_j value of negotiation plan A_i

$$D= \begin{array}{c} \\ A_1 \\ A_2 \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & C_3 \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \end{bmatrix} \end{array}$$

P_{ij}: Value standardizing valuation x_{ij} on the closed section [0, 1] by attributes
i=1, 2, ···, m, j=1, 2, ···, n
E_j: Entropy value of regularization value P_{ij} to attribute C_j, $0 \le E_j \le 1$, j=1, 2, ···, n
d_j: Diversity of the information offered by the valuation of attribute C_j,
$d_j = 1 - E_j$, j=1, 2, ···, n

s_j: Subjective weight set by a decision maker considering attribute $0 \le s_j \le 1$, j=1, 2, ···, n
w_j: Regularized weight calculated by diversity d_j, $0 \le w_j \le 1$, j=1, 2, ···, n
W^*_j: Each attribute's weight of negotiation alternatives calculated by entropy measure $0 \le W_j \le 1$
α_i: Sum of the product of multiplying P_{ij} of C_j to A_i by W^*_j calculated by entropy measure i=1, 2, ···, m, j=1, 2, ···, n
k: Negotiation round
δ_k: Negotiation penalty sustained by sellers in k round
V: Utility function of the seller's negotiation substitutes
CF: Certainty of success of negotiation alternatives according to a price in k round through the analysis of the negotiation alternatives by the negotiation counterpart (buyer)
$E(\alpha_{ik})$: Worth of the negotiation plan in k round applying the buyer's penalty for delayed negotiation
$U(\alpha_{ik})$: Utility of the negotiation plan applying utility function V to worth ($E(\alpha_{ik})$) of the negotiation plan in k round negotiation
$P(\alpha_{ij})$: Final worth of the negotiation plan considering the seller's utility of negotiation alternatives as the negotiation characteristic of the buyer in k round negotiation

Using the MADM method, the value of negotiation alternatives is calculated by the following formula:

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (1)$$

$$E_j = -k \sum_{i=1}^{m} p_{ij} \ln p_{ij} \quad (k = \text{constant}, 1/(\ln m)) \quad (2)$$

$$d_j = 1 - E_j \quad (3)$$

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \quad (4)$$

$$W^*_j = s_j w_j \quad (5)$$

$$\alpha_i = \sum_{j=1}^{n} P_{ij} W^*_j \quad (6)$$

When [illegible] alternatives as shown in <Table 1>, the negotiation substitute is compare[illegible]

Specifi[illegible] negotiation item need to be changed by the same standard using the entropy [illegible]on index, since the attributes, price, time limit for delivery, and quality l[illegible]

First, s[illegible] p_{ij} needs to be calculated when using the entropy method.

Calcula[illegible]n value p_{ij} of x_{ij} after replacing the attributes shown in <Table 1> with for[illegible] shown in (7).

$$P = \begin{bmatrix} 0.060866 & 0.034341 & 0.043732 \\ 0.068117 & 0.037776 & 0.043732 \\ 0.066378 & 0.041209 & 0.043732 \\ 0.062640 & 0.044643 & 0.043732 \\ 0.049901 & 0.048077 & 0.043732 \\ 0.047163 & 0.051511 & 0.043732 \\ 0.044424 & 0.054945 & 0.043732 \\ 0.066747 & 0.039836 & 0.046647 \\ 0.064009 & 0.043269 & 0.046647 \\ 0.061270 & 0.046703 & 0.046647 \\ 0.048532 & 0.050137 & 0.046647 \\ 0.045793 & 0.053571 & 0.046647 \\ 0.043055 & 0.057006 & 0.046647 \\ 0.040316 & 0.060440 & 0.046647 \\ 0.049901 & 0.037776 & 0.062478 \\ 0.047163 & 0.041209 & 0.062478 \\ 0.044424 & 0.044643 & 0.062478 \\ 0.041686 & 0.048077 & 0.062478 \\ 0.038947 & 0.051511 & 0.062478 \\ 0.036209 & 0.054945 & 0.062478 \\ 0.033470 & 0.058379 & 0.062478 \end{bmatrix} \quad (7)$$

By solving matrix P using formulas (2), (3), (4), and (5), E_j, d_j, w_j, s_j, and W^*_j (<Table 2>) related to the price and time limit for delivery can be derived.

<Table 2> The result of Calculated MADM

Division	C_1 (price)	C_2 (time limit for delivery)	C_3 (quality)
E_j	0.996306	0.996184	0.999054
d_j	0.003694	0.003816	0.000946
w_j	0.436859	0.451281	0.111860
s_j	0.4	0.3	0.3
W^*_j	0.508440	0.393919	0.097641

By replacing each attribute's weight of negotiation alternatives W^*_j with formula (6), worth α_i of each substitute can be derived. In <Table 3>, α_i shows the result of worth valuation related to negotiation alternatives derived using formula (6).

<Table 3> The results of value assessment on negotiation alternatives

Value of Negotiation Substitutes	Valuation Result of Negotiation Substitutes	Value of Negotiation Substitutes	Valuation Result of Negotiation Substitutes	Value of Negotiation Substitutes	Valuation Result of Negotiation Substitutes
α_1	0.048739	α_9	0.049059	α_{17}	0.045297
α_2	0.048699	α_{10}	0.049020	α_{18}	0.045257
α_3	0.048659	α_{11}	0.048980	α_{19}	0.045217
α_4	0.048620	α_{12}	0.048941	α_{20}	0.045178
α_5	0.048580	α_{13}	0.048901	α_{21}	0.045138

α_6	0.048541	α_{14}	0.048861		
α_7	0.048501	α_{15}	0.045376		
α_8	0.049099	α_{16}	0.045336		

The value of α_i of negotiation alternatives related to negotiation alternatives $A_1 \sim A_{21}$ as shown in <Table 3> is the valuation worth of the seller's negotiation substitutes, serving as basic data for choosing a negotiation plan. In negotiation alternatives with excellent valuation worth, negotiation favors the sellers. Still, sellers and buyers need to find a common ground in the negotiation alternatives to reach an agreement in negotiation since buyers will also negotiate for their own interest. Chapter 4 presents a negotiation plan between buyers and sellers considering the penalty for delayed negotiation, certainty of success of the negotiation plan, and risk preference of the negotiation result.

4. Multi attributes Automated negotiation Methodology

An automated negotiation requires the automatic creation of alternatives, suggestion of measures, evaluation of a negotiating partner's measure, and proposal of countermeasures for negotiation. This chapter introduces a method of automatic negotiation wherein the penalty for delayed negotiation, confidence for success, and negotiating types of buyers are applied to the negotiation alternatives discussed in Chapter 3.

4.1 Classification of negotiating partners by risk preference

A negotiation is composed of a series of proposals and counternegotiation measures that last until its conclusion or breakdown (Deutsch, 1973). The proposals made during negotiation may be classified by a few typical approaches. For instance, Thomas (1990) reported that competition, cooperation, compromise, alignment, and evasion are the approaches to general negotiations. Rahim (1983) approached negotiation from a more personal viewpoint and suggested the strategies of access, dominance, kindness, integration, compromise, and evasion. Fatima et al (2004) proposed a decision-making function in the forms of Conceder, Linear, and Boulware. According to the theory, a decision maker proposes a planned price as the negotiation progresses. The study carried out by Lee, Jong-Geon et al (2004) showed the consequences and differences in the results of the negotiation strategies chosen by each negotiation participant by conducting experiments. Through the existing studies on negotiation strategies, the types of negotiation participants may be classified according to the benefits to be obtained through the successful resolution of negotiation and risk level of negotiation failure. In this study, the types of negotiation participants are divided into "risk lover," "risk averter," and "risk-neutral person."

The participant who prefers taking risks puts more weight on the values expected to be gained when the negotiation is successfully concluded than on the risk of breakdown and tends to force the negotiating partner to yield even though his/her demands are very likely to be rejected. This type of participant does not expose his/her last bargaining chip until the final moment of negotiation, remaining intractable to the end even if the partner concedes. On the other hand, a risk averter puts the risk of failure on the front burner rather than the benefits of success; hence the tendency to give in to the partner if only to avoid breakdown. In other words, this type of negotiator tries to make a concession ahead of its partner in order to increase the possibility of conclusion of the negotiation. Furthermore, he/she strives to obtain the consent of the partner even if it means resorting to disclosing his/her ultimatum at the initial stage of the negotiation.

On the other hand, a risk-neutral person considers the benefits of agreement to be equal to the risk of breakdown. This type of negotiator makes concessions based on the possibility of failure in negotiation. In this study, the types of negotiators described above (risk lover, risk averter, risk-neutral person) are categorized into sellers and buyers.

The utility function of negotiation participants can be divided into various types of functions according to their level of risk preference: exponential function, logarithmic function, linear function, quadratic function, etc. Formulas (8), (9), and (10) deal with utility function "V" of the risk-neutral person, risk lover, and risk averter. The formulas are made randomly in the forms of linear function or quadratic function according to each type of negotiator.

$$V = \alpha_i \quad (8)$$

$$V = \alpha_i \quad (9)$$

$$V = -(\alpha_i - 1)^2 + 1 \quad (10)$$

More specific utility functions can be determined when negotiators determine the value of a negotiation measure and its consequent utility.

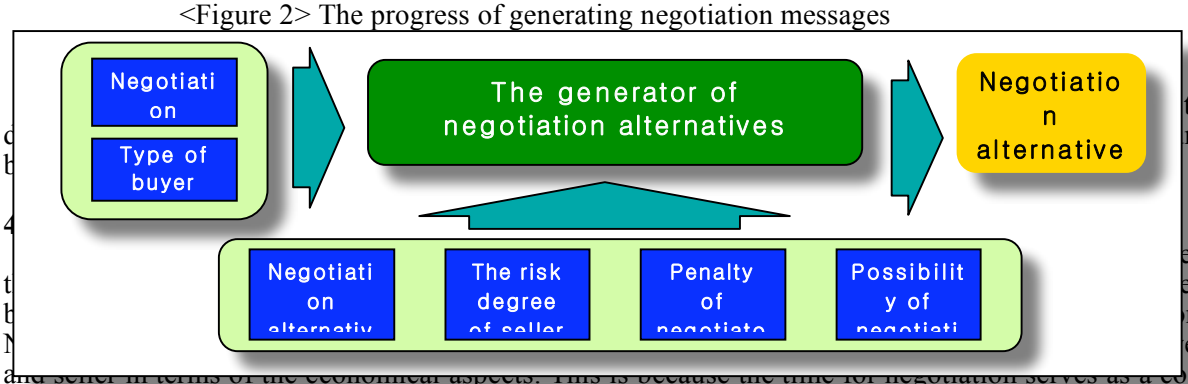
From the viewpoint of a seller as the focus of this study, the seller itself can obtain its utility function by inputting its utility values for itself; it does not know a buyer's utility function, however. The seller can make the negotiation move forward, presuming the type of the buyer by extrapolating its track record on trade or the degree of concession it makes during negotiation. In the absence of preliminary

information, or if judging the buyer's type is difficult while carrying out negotiation, the seller can assume the buyer to be a certain type of negotiator and speed up the progress of the talks.

4.2 Generator of negotiation measures

The flow chart below shows the process of generating negotiation measures (<Figure 2>). To create such measures, the information of the negotiator such as his/her negotiation measures and negotiating type and information of the seller including his/her alternative measures, risk preference, penalties for delay, and chance of success of the measure are inputted by the generator for negotiation measures, which in turn selects the best measure among the negotiation alternatives through the internal rules for generating negotiation measurers based on the inputted information and recommends the best alternative to the buyer.

<Figure 2> The progress of generating negotiation messages



factor for the negotiator. For instance, as the talks bog down, the opportunity cost for the possible chance of success in the other deal and loss are incurred due to the non-operating facilities. Therefore, the utility of a negotiation measure decreases alongside the time of postponement even if the negotiation is likely to be concluded. Against this backdrop, this study reflects a negotiator's economic loss owing to such delay by applying the penalty for delayed negotiation ("δ").

The value of the penalty for delayed negotiation ("δ") may vary according to negotiating environments and conditions. Formula (11) determines negotiation alternative $E(\alpha_{ik})$ *wherein the* penalty for delayed negotiation is considered by applying δ *to* α_{ik} as the alternative of K round. <Table 4> shows the results of applying the penalty for delayed negotiation in accordance with Formula (11).

$$E(\alpha_{ik}) = \alpha_{ik} \times (1-\delta_{ik})^{k-1} \qquad (11)$$

The values of round 1 in Table 4 are determined by standardizing the results of value assessment on a negotiation alternative of Table 3 into values ranging from 0 to 1. Such values do not reflect the penalty for delayed negotiation ("δ"). Penalty δ is applied starting from round 2, and the value of a negotiation alternative gradually decreases according to the application of delay penalties.

<Table 4> The results of reflecting the penalty for delayed negotiation

Round	δ	Negotiation Alternatives																				
		α_{21}	α_{20}	α_{19}	α_{18}	α_{17}	α_{16}	α_{15}	α_{7}	α_{6}	α_{5}	α_{4}	α_{3}	α_{2}	α_{1}	α_{14}	α_{13}	α_{12}	α_{11}	α_{10}	α_{9}	α_{8}
1	0	0.000	0.010	0.020	0.030	0.040	0.050	0.060	0.849	0.859	0.869	0.879	0.889	0.899	0.909	0.940	0.950	0.960	0.970	0.980	0.990	1.000
2	0.05	0.000	0.009	0.019	0.028	0.038	0.047	0.057	0.807	0.816	0.826	0.835	0.845	0.854	0.864	0.893	0.903	0.912	0.922	0.931	0.941	0.950
3	0.05	0.000	0.009	0.018	0.027	0.036	0.045	0.054	0.766	0.775	0.784	0.793	0.802	0.811	0.820	0.848	0.857	0.866	0.875	0.884	0.893	0.903
4	0.05	0.000	0.009	0.017	0.026	0.034	0.043	0.051	0.728	0.736	0.745	0.754	0.762	0.771	0.779	0.806	0.815	0.823	0.832	0.840	0.849	0.857
5	0.05	0.000	0.008	0.016	0.024	0.033	0.041	0.049	0.691	0.700	0.708	0.716	0.724	0.732	0.740	0.766	0.774	0.782	0.790	0.798	0.806	0.815
6	0.05	0.000	0.008	0.015	0.023	0.031	0.039	0.046	0.657	0.665	0.672	0.680	0.688	0.696	0.703	0.727	0.735	0.743	0.751	0.758	0.766	0.774
7	0.05	0.000	0.007	0.015	0.022	0.029	0.037	0.044	0.624	0.631	0.639	0.646	0.653	0.661	0.668	0.691	0.698	0.706	0.713	0.720	0.728	0.735
8	0.05	0.000	0.007	0.014	0.021	0.028	0.035	0.042	0.593	0.600	0.607	0.614	0.621	0.628	0.635	0.656	0.663	0.670	0.677	0.684	0.691	0.698
9	0.05	0.000	0.007	0.013	0.020	0.027	0.033	0.040	0.563	0.570	0.576	0.583	0.590	0.596	0.603	0.624	0.630	0.637	0.644	0.650	0.657	0.663
10	0.05	0.000	0.006	0.013	0.019	0.025	0.032	0.038	0.535	0.541	0.548	0.554	0.560	0.567	0.573	0.592	0.599	0.605	0.611	0.618	0.624	0.630
11	0.05	0.000	0.006	0.012	0.018	0.024	0.030	0.036	0.508	0.514	0.520	0.526	0.532	0.538	0.544	0.563	0.569	0.575	0.581	0.587	0.593	0.599
12	0.05	0.000	0.006	0.011	0.017	0.023	0.028	0.034	0.483	0.489	0.494	0.500	0.506	0.511	0.517	0.535	0.540	0.546	0.552	0.557	0.563	0.569
13	0.05	0.000	0.005	0.011	0.016	0.022	0.027	0.032	0.459	0.464	0.470	0.475	0.480	0.486	0.491	0.508	0.513	0.519	0.524	0.530	0.535	0.540
14	0.05	0.000	0.005	0.010	0.015	0.021	0.026	0.031	0.436	0.441	0.446	0.451	0.456	0.461	0.467	0.483	0.488	0.493	0.498	0.503	0.508	0.513

15	0.05	0.000	0.005	0.010	0.015	0.020	0.024	0.029	0.414	0.419	0.424	0.429	0.434	0.438	0.443	0.458	0.463	0.468	0.473	0.478	0.483	0.488

In Table 4, the same negotiation penalty (0.05) is applied to each round. Depending on the internal or external conditions of the negotiation, however, the penalty may be applied differently. The negotiation penalty determined in the method described above is applied to the utility function of the negotiator in order to obtain the seller's utility value for a negotiation alternative. The penalty also affects the certainty of success of the negotiation alternative (to be explained in the following section) as well as the selection of the final negotiation measure.

4.2.2 Certainty factor of a negotiation alternative

A negotiation participant proposes a bargaining measure to his/her negotiation partner, taking into account which measure would satisfy the partner. A proposed negotiating measure that goes beyond the mark stands almost no chance of success in the negotiation. On the other hand, when the negotiator proposes a measure whose value is akin to that of the partner, the possibility of success in the negotiation increases.

In addition, a negotiation participant tries to avoid prolonged delay in negotiation since it incurs consequential loss. Therefore, a negotiator should select the best strategy by factoring in the reasonable benefits and chance of success of a negotiation measure. There are several methods of analyzing the possibility of success for negotiation alternatives, including negotiation analysis with scant information of the game theory, Bayesian probabilistic model, and certainty. In this study, the method of certainty is employed to analyze the possibility of success.

The advantage of such certainty method is that success analysis can be conducted in a relatively easy manner using simple concepts such as the level of certainty and uncertainty (Shortliffe et al, 1975), unlike the abovementioned methods such as the game theory or probabilistic theory with many hurdles hindering their actual application such as complicated calculations, cumbersome estimation work for probabilistic values, requirement of satisfying the probabilistic axiom, etc.

Indicating the degree of confirmation, certainty is explained by the difference of belief and disbelief (Jae-Gyu Lee et al, 1996).

$$CF(H, E) = MB(H, E) - MD(H, E) \qquad (12)$$

Here, CF denotes the degree of confirmation of hypothesis (H) with given evidence (E), and MB, the measure of increased belief of H due to E. Finally, MD refers to the measure of increased disbelief of H due to E.

In this study, certainty factor (CF) is determined by deducting the uncertainty from the certainty of a specific negotiation alternative. Specifically, the value of CF varies since the certainty and uncertainty assigned to each negotiation alternative at the beginning of the negotiation increase or decrease over time.

Table 5 shows the degree of confirmation of each negotiation alternative at the start of negotiation.

<Table 5> The degree of confirmation for a negotiation alternative

Category		α_{21}	α_{20}	α_{19}	α_{18}	α_{17}	α_{16}	α_{15}	α_{7}	α_{6}	α_{5}	α_{4}	α_{3}	α_{2}	α_{1}	α_{14}	α_{13}	α_{12}	α_{11}	α_{10}	α_{9}	α_{8}
1st round	MB	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MD	0.00	0.00	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

As shown in the table above, the negotiation alternative with large value "α" comes first. Negotiation alternative "A_8" with the highest value for the seller is placed at the rightmost side, and "A_{21}" with the lowest value, at the leftmost side.

The degree of certainty (MB) of the seller for each negotiation alternative is 1 throughout round 1. Simply put, all alternatives are believed to succeed at the beginning of a negotiation. On the other hand, since a buyer did not reject any alternative yet, the degree of uncertainty (MD) is "0."

Therefore, all alternatives have a maximum value of 1 in terms of the degree of certainty (CF) of the seller at the start of a negotiation. Still, such initial certainty changes as the negotiation progresses, due largely to the type of buyer and rejected negotiation measures.

<Table 6> The changing degree of confirmation for a negotiation alternative

Category		α_{21}	α_{20}	α_{19}	α_{18}	α_{17}	α_{16}	α_{15}	α_{7}	α_{6}	α_{5}	α_{4}	α_{3}	α_{2}	α_{1}	α_{14}	α_{13}	α_{12}	α_{11}	α_{10}	α_{9}	α_{8}
2nd round	MB	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95
	MD	0	0.000	0.000	0.000	0.100	0.100	0.100	0.150	0.150	0.150	0.175	0.175	0.181	0.181	0.188	0.191	0.192	0.193	0.193	0.193	0.193
	CF	1.000	1.000	1.000	1.000	0.900	0.900	0.900	0.850	0.850	0.850	0.825	0.825	0.819	0.819	0.813	0.809	0.808	0.807	0.807	0.807	0.757

Table 6 shows the changed values of CF as a result of negotiation in round 1. CF is changed when the buyer rejects the seller's proposal "α_8."

Since the seller's α_8 alternative is rejected by the buyer, the MBs of α_8 alternative and negotiation alternative (with value higher than α_8) at the right side of the seller decrease, whereas the MDs of alternatives at the right side focusing on the α_{18} alternative offered by the buyer increase.

As an alternative gets further from alternative α_{18}, the range of MD expands. CF is calculated based on the decreased MB and increased MD, and CF serves as an important variable in the selection of the next negotiation measure.

4.2.3 Generation of a negotiation measure

A seller obtains "$U(\alpha_{ik})$" as the utility value of a negotiation alternative by substituting $E(\alpha_{ik})$, *which is determined by applying* the penalty for delay to a negotiation alternative, with V as the seller's utility function.

$$U(\alpha_{ik}) = V(E(\alpha_{ik})) \qquad (13)$$

Tables 7, 8, and 9 show the utility values determined by substituting $E(\alpha_{ik})$ wherein the penalty for delay is considered for V as the utility function of the seller. In other words, these tables indicate the utility values of alternatives according to each type of seller.

<Table 7> Utility value of Risk Lover on negotiation time

Round	Utility Value of Negotiation Alternatives (Risk Lover)																				
	$U(\alpha_{21})$	$U(\alpha_{20})$	$U(\alpha_{19})$	$U(\alpha_{18})$	$U(\alpha_{17})$	$U(\alpha_{16})$	$U(\alpha_{15})$	$U(\alpha_7)$	$U(\alpha_6)$	$U(\alpha_5)$	$U(\alpha_4)$	$U(\alpha_3)$	$U(\alpha_2)$	$U(\alpha_1)$	$U(\alpha_{14})$	$U(\alpha_{13})$	$U(\alpha_{12})$	$U(\alpha_{11})$	$U(\alpha_{10})$	$U(\alpha_9)$	$U(\alpha_8)$
1	0.000	0.000	0.000	0.001	0.002	0.002	0.004	0.721	0.738	0.755	0.773	0.790	0.808	0.826	0.884	0.903	0.922	0.941	0.960	0.980	1.000
2	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.650	0.666	0.681	0.697	0.713	0.729	0.746	0.797	0.815	0.832	0.849	0.867	0.885	0.903
3	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.587	0.601	0.615	0.629	0.644	0.658	0.673	0.720	0.735	0.751	0.766	0.782	0.798	0.815
4	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.530	0.542	0.555	0.568	0.581	0.594	0.607	0.650	0.663	0.677	0.692	0.706	0.720	0.735
5	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.478	0.490	0.501	0.513	0.524	0.536	0.548	0.586	0.599	0.611	0.624	0.637	0.650	0.663
6	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.432	0.442	0.452	0.463	0.473	0.484	0.495	0.529	0.540	0.552	0.563	0.575	0.587	0.599
7	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.389	0.399	0.408	0.417	0.427	0.437	0.446	0.477	0.488	0.498	0.508	0.519	0.530	0.540
8	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.351	0.360	0.368	0.377	0.385	0.394	0.403	0.431	0.440	0.449	0.459	0.468	0.478	0.488
9	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.317	0.325	0.332	0.340	0.348	0.356	0.364	0.389	0.397	0.406	0.414	0.423	0.431	0.440
10	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.286	0.293	0.300	0.307	0.314	0.321	0.328	0.351	0.358	0.366	0.374	0.381	0.389	0.397
11	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.258	0.265	0.271	0.277	0.283	0.290	0.296	0.317	0.324	0.330	0.337	0.344	0.351	0.358
12	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.233	0.239	0.244	0.250	0.256	0.261	0.267	0.286	0.292	0.298	0.304	0.311	0.317	0.324
13	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.210	0.215	0.220	0.226	0.231	0.236	0.241	0.258	0.264	0.269	0.275	0.280	0.286	0.292
14	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.190	0.194	0.199	0.204	0.208	0.213	0.218	0.233	0.238	0.243	0.248	0.253	0.258	0.264
15	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.171	0.175	0.180	0.184	0.188	0.192	0.197	0.210	0.215	0.219	0.224	0.228	0.233	0.238

<Table 8> Utility value of Risk-Neutral Person on negotiation time

Round	Utility Value of Negotiation Alternatives (Risk-Neutral Person)																				
	$U(\alpha_{21})$	$U(\alpha_{20})$	$U(\alpha_{19})$	$U(\alpha_{18})$	$U(\alpha_{17})$	$U(\alpha_{16})$	$U(\alpha_{15})$	$U(\alpha_7)$	$U(\alpha_6)$	$U(\alpha_5)$	$U(\alpha_4)$	$U(\alpha_3)$	$U(\alpha_2)$	$U(\alpha_1)$	$U(\alpha_{14})$	$U(\alpha_{13})$	$U(\alpha_{12})$	$U(\alpha_{11})$	$U(\alpha_{10})$	$U(\alpha_9)$	$U(\alpha_8)$
1	0.000	0.010	0.020	0.030	0.040	0.050	0.060	0.849	0.859	0.869	0.879	0.889	0.899	0.909	0.940	0.950	0.960	0.970	0.980	0.990	1.000
2	0.000	0.009	0.019	0.028	0.038	0.047	0.057	0.807	0.816	0.826	0.835	0.845	0.854	0.864	0.893	0.903	0.912	0.922	0.931	0.941	0.950
3	0.000	0.009	0.018	0.027	0.036	0.045	0.054	0.766	0.775	0.784	0.793	0.802	0.811	0.820	0.848	0.857	0.866	0.875	0.884	0.893	0.903
4	0.000	0.009	0.017	0.026	0.034	0.043	0.051	0.728	0.736	0.745	0.754	0.762	0.771	0.779	0.806	0.815	0.823	0.832	0.840	0.849	0.857
5	0.000	0.008	0.016	0.024	0.033	0.041	0.049	0.691	0.700	0.708	0.716	0.724	0.732	0.740	0.766	0.774	0.782	0.790	0.798	0.806	0.815
6	0.000	0.008	0.015	0.023	0.031	0.039	0.046	0.657	0.665	0.672	0.680	0.688	0.696	0.703	0.727	0.735	0.743	0.751	0.758	0.766	0.774
7	0.000	0.007	0.015	0.022	0.029	0.037	0.044	0.624	0.631	0.639	0.646	0.653	0.661	0.668	0.691	0.698	0.706	0.713	0.720	0.728	0.735
8	0.000	0.007	0.014	0.021	0.028	0.035	0.042	0.593	0.600	0.607	0.614	0.621	0.628	0.635	0.656	0.663	0.670	0.677	0.684	0.691	0.698
9	0.000	0.007	0.013	0.020	0.027	0.033	0.040	0.563	0.570	0.576	0.583	0.590	0.596	0.603	0.624	0.630	0.637	0.644	0.650	0.657	0.663
10	0.000	0.006	0.013	0.019	0.025	0.032	0.038	0.535	0.541	0.548	0.554	0.560	0.567	0.573	0.592	0.599	0.605	0.611	0.618	0.624	0.630
11	0.000	0.006	0.012	0.018	0.024	0.030	0.036	0.508	0.514	0.520	0.526	0.532	0.538	0.544	0.563	0.569	0.575	0.581	0.587	0.593	0.599
12	0.000	0.006	0.011	0.017	0.023	0.028	0.034	0.483	0.489	0.494	0.500	0.506	0.511	0.517	0.535	0.540	0.546	0.552	0.557	0.563	0.569
13	0.000	0.005	0.011	0.016	0.022	0.027	0.032	0.459	0.464	0.470	0.475	0.480	0.486	0.491	0.508	0.513	0.519	0.524	0.530	0.535	0.540
14	0.000	0.005	0.010	0.015	0.021	0.026	0.031	0.436	0.441	0.446	0.451	0.456	0.461	0.467	0.483	0.488	0.493	0.498	0.503	0.508	0.513
15	0.000	0.005	0.010	0.015	0.020	0.024	0.029	0.414	0.419	0.424	0.429	0.434	0.438	0.443	0.458	0.463	0.468	0.473	0.478	0.483	0.488

<Table 9> Utility value of Risk Averter on negotiation time

Round	Utility Value of Negotiation Alternatives (Risk Averter)

Round	$U(\alpha_{21})$	$U(\alpha_{20})$	$U(\alpha_{19})$	$U(\alpha_{18})$	$U(\alpha_{17})$	$U(\alpha_{16})$	$U(\alpha_{15})$	$U(\alpha_{7})$	$U(\alpha_{6})$	$U(\alpha_{5})$	$U(\alpha_{4})$	$U(\alpha_{3})$	$U(\alpha_{2})$	$U(\alpha_{1})$	$U(\alpha_{14})$	$U(\alpha_{13})$	$U(\alpha_{12})$	$U(\alpha_{11})$	$U(\alpha_{10})$	$U(\alpha_{9})$	$U(\alpha_{8})$
1	0.000	0.020	0.040	0.059	0.078	0.097	0.116	0.977	0.980	0.983	0.985	0.988	0.990	0.992	0.996	0.998	0.998	0.999	1.000	1.000	1.000
2	0.000	0.019	0.038	0.056	0.075	0.093	0.111	0.963	0.966	0.970	0.973	0.976	0.979	0.981	0.989	0.990	0.992	0.994	0.995	0.996	0.998
3	0.000	0.018	0.036	0.053	0.071	0.088	0.105	0.945	0.949	0.953	0.957	0.961	0.964	0.968	0.977	0.980	0.982	0.984	0.987	0.989	0.990
4	0.000	0.017	0.034	0.051	0.067	0.084	0.100	0.926	0.931	0.935	0.939	0.943	0.947	0.951	0.962	0.966	0.969	0.972	0.974	0.977	0.980
5	0.000	0.016	0.032	0.048	0.064	0.080	0.095	0.905	0.910	0.915	0.919	0.924	0.928	0.933	0.945	0.949	0.952	0.956	0.959	0.963	0.966
6	0.000	0.015	0.031	0.046	0.061	0.076	0.091	0.882	0.888	0.893	0.898	0.903	0.907	0.912	0.926	0.930	0.934	0.938	0.942	0.945	0.949
7	0.000	0.015	0.029	0.044	0.058	0.072	0.086	0.859	0.864	0.870	0.875	0.880	0.885	0.890	0.905	0.909	0.913	0.918	0.922	0.926	0.930
8	0.000	0.014	0.028	0.041	0.055	0.069	0.082	0.834	0.840	0.845	0.851	0.856	0.861	0.867	0.882	0.887	0.891	0.896	0.900	0.905	0.909
9	0.000	0.013	0.026	0.039	0.052	0.065	0.078	0.809	0.815	0.821	0.826	0.832	0.837	0.842	0.858	0.863	0.868	0.873	0.878	0.882	0.887
10	0.000	0.013	0.025	0.037	0.050	0.062	0.074	0.784	0.790	0.795	0.801	0.807	0.812	0.818	0.834	0.839	0.844	0.849	0.854	0.859	0.863
11	0.000	0.012	0.024	0.036	0.047	0.059	0.071	0.758	0.764	0.770	0.776	0.781	0.787	0.792	0.809	0.814	0.819	0.824	0.829	0.834	0.839
12	0.000	0.011	0.023	0.034	0.045	0.056	0.067	0.733	0.738	0.744	0.750	0.756	0.761	0.767	0.783	0.789	0.794	0.799	0.804	0.809	0.814
13	0.000	0.011	0.021	0.032	0.043	0.053	0.064	0.707	0.713	0.719	0.724	0.730	0.736	0.741	0.758	0.763	0.768	0.774	0.779	0.784	0.789
14	0.000	0.010	0.020	0.031	0.041	0.051	0.061	0.682	0.687	0.693	0.699	0.704	0.710	0.716	0.732	0.738	0.743	0.748	0.753	0.758	0.763
15	0.000	0.010	0.019	0.029	0.039	0.048	0.058	0.657	0.662	0.668	0.674	0.679	0.685	0.690	0.707	0.712	0.717	0.722	0.727	0.733	0.738

These are the utility values according to each type of seller. These results are gained by substituting a seller's utility function with equation 24, which is used to calculate the utility values of negotiation alternatives.

The seller applies CF to the utility value according to his/her risk preference type and selects the best alternative in each round to propose it to the buyer.

In case the buyer rejects the alternative and comes up with another alternative, the seller adjusts CF in the next round of negotiation and chooses the best alternative as a negotiating measure.

Using the utility value by each type of seller and CF of a negotiating measure considering the alternative offered by the buyer and obtained in the method described above automatically leads to selecting the optimum alternative to be proposed.

4.2.4 Negotiation experiment and results

This section takes a closer look at how a buyer and a seller actually carry out negotiation considering the utility value of a negotiation alternative as determined in the previous section plus the CF of a negotiation alternative that changes according to the negotiating measures proposed by the buyer and which kinds of negotiation measures help the buyer and the seller reach an agreement.

A seller can calculate final value $P(\alpha_{ik})$ of a negotiating alternative by multiplying $U(\alpha_{ik})$ as the utility value of a negotiation alternative determined by negotiator type as described above by CF as the chance of success of an alternative. Calculating the value of $P(\alpha_{ik})$ uses the same equation as Equation 25.

$$P(\alpha_{ik}) = U(\alpha_{ik} \times CF) \qquad (14)$$

Table 10 presents the process of negotiation of a risk-neutral seller and a risk averter. The final utility value of $P(\alpha_{ik})$ changes as the CF of the seller varies according to the buyer's response. The seller selects the negotiation alternative with the highest value of $P(\alpha_{ik})$ and makes the corresponding suggestion in each negotiation round. In this experiment, a seller's negotiating measure is assumed to be generated in conformity with the seller's own generation rules for negotiation measures. The process of selecting a negotiating measure is then applied randomly based on each buyer's type.

<Table 10> The process of negotiation of a risk-neutral seller and a risk-averting buyer

Round	$P(\alpha_{21})$	$P(\alpha_{20})$	$P(\alpha_{19})$	$P(\alpha_{18})$	$P(\alpha_{17})$	$P(\alpha_{16})$	$P(\alpha_{15})$	$P(\alpha_{7})$	$P(\alpha_{6})$	$P(\alpha_{5})$	$P(\alpha_{4})$	$P(\alpha_{3})$	$P(\alpha_{2})$	$P(\alpha_{1})$	$P(\alpha_{14})$	$P(\alpha_{13})$	$P(\alpha_{12})$	$P(\alpha_{11})$	$P(\alpha_{10})$	$P(\alpha_{9})$	$P(\alpha_{8})$
1	0.0000	0.0100	0.0200	0.0300	0.0400	0.0500	0.0600	0.8490	0.8590	0.8690	0.8790	0.8890	0.8990	0.9090	0.9400	0.9500	0.9600	0.9700	0.9800	0.9900	1.0000
2	0.0000	0.0095	0.0171	0.0256	0.0342	0.0404	0.0484	0.6856	0.6732	0.6811	0.6889	0.6915	0.6992	0.7016	0.7256	0.7305	0.7368	0.7438	0.7511	0.7588	0.7189
3	0.0000	0.0090	0.0180	0.0271	0.0325	0.0406	0.0487	0.6513	0.6589	0.6666	0.6545	0.6619	0.6643	0.6717	0.6893	0.6939	0.7000	0.7066	0.7135	0.6761	0.6379
4	0.0000	0.0086	0.0171	0.0257	0.0343	0.0429	0.0463	0.6551	0.6628	0.6333	0.6406	0.6288	0.6359	0.6381	0.6599	0.6618	0.6662	0.6719	0.6362	0.5999	0.5631
5	0.0000	0.0081	0.0163	0.0244	0.0326	0.0407	0.0489	0.6223	0.6297	0.6016	0.6085	0.5974	0.6041	0.6062	0.6269	0.6287	0.6329	0.5988	0.5644	0.5296	0.4942
6	0.0000	0.0077	0.0155	0.0232	0.0309	0.0348	0.0464	0.6569	0.5982	0.6052	0.6121	0.5847	0.5913	0.5803	0.6001	0.6019	0.5664	0.5324	0.4989	0.4651	0.4308
7	0.0000	0.0074	0.0147	0.0221	0.0294	0.0368	0.0441	0.6241	0.6314	0.5749	0.5815	0.5555	0.5617	0.5512	0.5701	0.5368	0.5028	0.4702	0.4379	0.4054	0.3725

As shown in Table 10, the buyer proposed negotiating measures *$P(\alpha_{21})$* to *$P(\alpha_{6})$ from the left side* from round 1 to 7. *On the other hand, the seller suggested measures $P(\alpha_{8})$* to *$P(\alpha_{6})$. After rejecting the negotiating measures proposed by the seller from round 1 to 6, the buyer made a concession over his/her measures to the seller considering those of the seller.*

On the part of the seller, he/she also gave in to the demand of the buyer in each round considering the penalties and change in CF. As a result, the gap between the measures of the two parties narrowed, finally concluding the negotiation in round 7 with measure $P(\alpha_6)$.

Tables 11 and 12 show the negotiation process of a risk-neutral seller and a buyer as well as of a risk-neutral seller and a risk-loving buyer, respectively.

<Table 11> The process of negotiation of a risk-neutral seller and a risk-neutral buyer

Round	$P(\alpha_{21})$	$P(\alpha_{20})$	$P(\alpha_{19})$	$P(\alpha_{18})$	$P(\alpha_{17})$	$P(\alpha_{16})$	$P(\alpha_{15})$	$P(\alpha_7)$	$P(\alpha_6)$	$P(\alpha_5)$	$P(\alpha_4)$	$P(\alpha_3)$	$P(\alpha_2)$	$P(\alpha_1)$	$P(\alpha_{14})$	$P(\alpha_{13})$	$P(\alpha_{12})$	$P(\alpha_{11})$	$P(\alpha_{10})$	$P(\alpha_9)$	$P(\alpha_8)$
1	0.0000	0.0100	0.0200	0.0300	0.0400	0.0500	0.0600	0.8490	0.8590	0.8690	0.8790	0.8890	0.8990	0.9090	0.9400	0.9500	0.9600	0.9700	0.9800	0.9900	1.0000
2	0.0000	0.0095	0.0171	0.0256	0.0342	0.0404	0.0484	0.6856	0.6732	0.6811	0.6889	0.6915	0.6992	0.7016	0.7256	0.7305	0.7368	0.7438	0.7511	0.7588	0.7379
3	0.0000	0.0090	0.0162	0.0244	0.0325	0.0406	0.0460	0.6513	0.6589	0.6470	0.6545	0.6569	0.6643	0.6665	0.6893	0.6939	0.7000	0.7066	0.7135	0.6940	0.6740
4	0.0000	0.0086	0.0171	0.0231	0.0309	0.0386	0.0463	0.6187	0.6260	0.6333	0.6217	0.6288	0.6311	0.6381	0.6548	0.6618	0.6662	0.6719	0.6530	0.6339	0.6145
5	0.0000	0.0081	0.0163	0.0244	0.0293	0.0367	0.0440	0.5878	0.5947	0.6016	0.5906	0.5974	0.5995	0.6062	0.6221	0.6263	0.6317	0.6140	0.5961	0.5780	0.5594
6	0.0000	0.0077	0.0155	0.0232	0.0309	0.0348	0.0418	0.5912	0.5650	0.5715	0.5781	0.5675	0.5739	0.5759	0.5955	0.5973	0.5789	0.5613	0.5438	0.5261	0.5082
7	0.0000	0.0074	0.0147	0.0221	0.0294	0.0368	0.0397	0.5617	0.5683	0.5430	0.5492	0.5391	0.5452	0.5471	0.5657	0.5465	0.5288	0.5119	0.4950	0.4780	0.4607
8	0.0000	0.0070	0.0140	0.0209	0.0279	0.0349	0.0419	0.5336	0.5219	0.4794	0.4665	0.4377	0.4238	0.4055	0.3996	0.3798	0.3616	0.3440	0.3265	0.3089	0.2910

<Table 12> The process of negotiation of a risk-neutral seller and a risk-loving buyer

Round	$P(\alpha_{21})$	$P(\alpha_{20})$	$P(\alpha_{19})$	$P(\alpha_{18})$	$P(\alpha_{17})$	$P(\alpha_{16})$	$P(\alpha_{15})$	$P(\alpha_7)$	$P(\alpha_6)$	$P(\alpha_5)$	$P(\alpha_4)$	$P(\alpha_3)$	$P(\alpha_2)$	$P(\alpha_1)$	$P(\alpha_{14})$	$P(\alpha_{13})$	$P(\alpha_{12})$	$P(\alpha_{11})$	$P(\alpha_{10})$	$P(\alpha_9)$	$P(\alpha_8)$
1	0.0000	0.0100	0.0200	0.0300	0.0400	0.0500	0.0600	0.8490	0.8590	0.8690	0.8790	0.8890	0.8990	0.9090	0.9400	0.9500	0.9600	0.9700	0.9800	0.9900	1.0000
2	0.0000	0.0085	0.0171	0.0256	0.0342	0.0404	0.0484	0.6856	0.6732	0.6811	0.6889	0.6915	0.6992	0.7016	0.7256	0.7305	0.7368	0.7438	0.7511	0.7588	0.7474
3	0.0000	0.0081	0.0162	0.0244	0.0325	0.0384	0.0460	0.6513	0.6396	0.6470	0.6545	0.6569	0.6643	0.6665	0.6893	0.6939	0.7000	0.7066	0.7135	0.7030	0.6920
4	0.0000	0.0077	0.0154	0.0231	0.0309	0.0364	0.0437	0.6187	0.6076	0.6147	0.6217	0.6240	0.6311	0.6332	0.6548	0.6592	0.6650	0.6713	0.6611	0.6508	0.6403
5	0.0000	0.0073	0.0147	0.0220	0.0293	0.0346	0.0415	0.5878	0.5772	0.5839	0.5906	0.5928	0.5995	0.6015	0.6221	0.6263	0.6317	0.6219	0.6120	0.6022	0.5920
6	0.0000	0.0077	0.0139	0.0209	0.0279	0.0348	0.0395	0.5584	0.5650	0.5547	0.5611	0.5632	0.5695	0.5715	0.5910	0.5950	0.5853	0.5758	0.5663	0.5567	0.5469
7	0.0000	0.0074	0.0132	0.0198	0.0265	0.0331	0.0375	0.5305	0.5367	0.5270	0.5331	0.5350	0.5411	0.5429	0.5614	0.5513	0.5419	0.5327	0.5236	0.5143	0.5048
8	0.0000	0.0070	0.0126	0.0189	0.0251	0.0314	0.0356	0.5039	0.5099	0.5006	0.5064	0.5083	0.5140	0.5158	0.5202	0.5104	0.5014	0.4926	0.4837	0.4748	0.4656
9	0.0000	0.0066	0.0133	0.0179	0.0239	0.0299	0.0358	0.4787	0.4844	0.4900	0.4811	0.4866	0.4883	0.4937	0.4817	0.4723	0.4636	0.4551	0.4465	0.4379	0.4291
10	0.0000	0.0063	0.0126	0.0170	0.0227	0.0284	0.0340	0.4548	0.4602	0.4655	0.4570	0.4622	0.4639	0.4576	0.4458	0.4367	0.4283	0.4201	0.4118	0.4035	0.3950
11	0.0000	0.0060	0.0120	0.0180	0.0216	0.0269	0.0323	0.4321	0.4372	0.4422	0.4342	0.4391	0.4299	0.4238	0.4123	0.4035	0.3954	0.3875	0.3795	0.3715	0.3633
12	0.0000	0.0057	0.0114	0.0171	0.0228	0.0256	0.0307	0.4346	0.4055	0.4004	0.3950	0.3767	0.3707	0.3613	0.3629	0.3509	0.3429	0.3350	0.3271	0.3192	0.3110
13	0.0000	0.0054	0.0108	0.0162	0.0216	0.0270	0.0324	0.4129	0.3992	0.3944	0.3657	0.3603	0.3425	0.3365	0.3346	0.3247	0.3161	0.3081	0.3003	0.2925	0.2846

Table 13 shows the negotiation process of a risk-averting seller.

<Table 13> The process of negotiation of a risk-averting seller and a risk-averting buyer

Round	$P(\alpha_{21})$	$P(\alpha_{20})$	$P(\alpha_{19})$	$P(\alpha_{18})$	$P(\alpha_{17})$	$P(\alpha_{16})$	$P(\alpha_{15})$	$P(\alpha_7)$	$P(\alpha_6)$	$P(\alpha_5)$	$P(\alpha_4)$	$P(\alpha_3)$	$P(\alpha_2)$	$P(\alpha_1)$	$P(\alpha_{14})$	$P(\alpha_{13})$	$P(\alpha_{12})$	$P(\alpha_{11})$	$P(\alpha_{10})$	$P(\alpha_9)$	$P(\alpha_8)$
1	0.0000	0.0199	0.0396	0.0591	0.0784	0.0975	0.1164	0.9772	0.9801	0.9828	0.9854	0.9877	0.9898	0.9917	0.9964	0.9975	0.9984	0.9991	0.9996	0.9999	1.0000
2	0.0000	0.0170	0.0339	0.0506	0.0671	0.0788	0.0941	0.8182	0.7971	0.7999	0.8025	0.7990	0.8013	0.7974	0.8032	0.8017	0.8016	0.8022	0.8029	0.8039	0.7549
3	0.0000	0.0180	0.0358	0.0534	0.0638	0.0794	0.0948	0.8035	0.8071	0.8104	0.7897	0.7928	0.7896	0.7923	0.7938	0.7929	0.7935	0.7946	0.7960	0.7482	0.7000
4	0.0000	0.0171	0.0340	0.0508	0.0674	0.0839	0.0902	0.8334	0.8375	0.7947	0.7984	0.7783	0.7816	0.7789	0.7879	0.7845	0.7840	0.7850	0.7378	0.6906	0.6434
5	0.0000	0.0162	0.0323	0.0483	0.0641	0.0798	0.0953	0.8143	0.8188	0.7774	0.7814	0.7622	0.7658	0.7636	0.7738	0.7709	0.7709	0.7245	0.6783	0.6321	0.5859
6	0.0000	0.0154	0.0307	0.0459	0.0609	0.0683	0.0907	0.8823	0.7988	0.7588	0.7181	0.6318	0.5898	0.5244	0.4860	0.4359	0.3852	0.3370	0.2899	0.2431	0.1962

The negotiation process of a risk-averting seller and a buyer clearly shows that the buyer proposed negotiation measures P(α_{21}) to P(α_7) at the left side, and the seller, measures P(α_8) to P(α_7) at the right side.

Despite turning down the measure proposed by the seller in rounds 1~5, the buyer also made a concession to the seller's demand. In addition, the seller gradually took a step backward from his/her initial stance, factoring in the penalty for delay, change in CF, and other factors. In round 5, the seller made a significant concession, thereby leading to the conclusion of the negotiation in round 6 with measure $P(\alpha_7)$.

Tables 14 and 15 show the negotiation process of a risk-averting seller and a risk-neutral buyer as well as of a risk-averting seller and a risk-loving buyer, respectively.

<Table 14> The process of negotiation of a risk-averting seller and a risk-neutral buyer

	$P(\alpha_{21})$	$P(\alpha_{20})$	$P(\alpha_{19})$	$P(\alpha_{18})$	$P(\alpha_{17})$	$P(\alpha_{16})$	$P(\alpha_{15})$	$P(\alpha_7)$	$P(\alpha_6)$	$P(\alpha_5)$	$P(\alpha_4)$	$P(\alpha_3)$	$P(\alpha_2)$	$P(\alpha_1)$	$P(\alpha_{14})$	$P(\alpha_{13})$	$P(\alpha_{12})$	$P(\alpha_{11})$	$P(\alpha_{10})$	$P(\alpha_9)$	$P(\alpha_8)$
Round 1	0.0000	0.0199	0.0396	0.0591	0.0784	0.0975	0.1164	0.9772	0.9801	0.9828	0.9854	0.9877	0.9898	0.9917	0.9964	0.9975	0.9984	0.9991	0.9996	0.9999	1.0000
Round 2	0.0000	0.0170	0.0339	0.0506	0.0671	0.0788	0.0941	0.8182	0.7971	0.7999	0.8025	0.7990	0.8013	0.7974	0.8032	0.8017	0.8016	0.8022	0.8029	0.8039	0.7748
Round 3	0.0000	0.0180	0.0322	0.0481	0.0638	0.0794	0.0896	0.8035	0.8071	0.7866	0.7897	0.7867	0.7896	0.7863	0.7938	0.7929	0.7935	0.7946	0.7960	0.7679	0.7397
Round 4	0.0000	0.0171	0.0340	0.0457	0.0607	0.0755	0.0902	0.7871	0.7631	0.7386	0.6904	0.6651	0.6336	0.6076	0.5798	0.5528	0.5225	0.4935	0.4650	0.4365	0.4083

Round 5	0.0000	0.0162	0.0323	0.0483	0.0577	0.0718	0.0858	0.7420	0.7187	0.6951	0.6481	0.6236	0.5929	0.5677	0.5411	0.5118	0.4837	0.4561	0.4286	0.4011	0.3735
Round 6	0.0000	0.0154	0.0307	0.0459	0.0609	0.0683	0.0816	0.7411	0.6745	0.6517	0.6284	0.5822	0.5580	0.5278	0.5080	0.4765	0.4477	0.4200	0.3928	0.3656	0.3385
Round 7	0.0000	0.0146	0.0292	0.0436	0.0579	0.0722	0.0776	0.6955	0.6740	0.6087	0.5861	0.5412	0.5177	0.4883	0.4692	0.4386	0.4105	0.3835	0.3569	0.3303	0.3038
Round 8	0.0000	0.0139	0.0277	0.0415	0.0551	0.0686	0.0820	0.6507	0.6299	0.5664	0.5446	0.5009	0.4781	0.4496	0.4311	0.4012	0.3738	0.3475	0.3216	0.2956	0.2698

<Table 15> The process of negotiation of a risk-averting seller and a risk-loving buyer

	$P(\alpha_{21})$	$P(\alpha_{20})$	$P(\alpha_{19})$	$P(\alpha_{18})$	$P(\alpha_{17})$	$P(\alpha_{16})$	$P(\alpha_{15})$	$P(\alpha_{7})$	$P(\alpha_{6})$	$P(\alpha_{5})$	$P(\alpha_{4})$	$P(\alpha_{3})$	$P(\alpha_{2})$	$P(\alpha_{1})$	$P(\alpha_{14})$	$P(\alpha_{13})$	$P(\alpha_{12})$	$P(\alpha_{11})$	$P(\alpha_{10})$	$P(\alpha_{9})$	$P(\alpha_{8})$
Round 1	0.0000	0.0199	0.0396	0.0591	0.0784	0.0975	0.1164	0.9772	0.9801	0.9828	0.9854	0.9877	0.9898	0.9917	0.9964	0.9975	0.9984	0.9991	0.9996	0.9999	1.0000
Round 2	0.0000	0.0170	0.0339	0.0506	0.0671	0.0788	0.0941	0.8182	0.7971	0.7999	0.8025	0.7990	0.8013	0.7974	0.8032	0.8017	0.8016	0.8022	0.8029	0.8039	0.7848
Round 3	0.0000	0.0162	0.0322	0.0481	0.0638	0.0750	0.0896	0.8035	0.7833	0.7866	0.7897	0.7867	0.7896	0.7863	0.7938	0.7929	0.7935	0.7946	0.7960	0.7778	0.7595
Round 4	0.0000	0.0154	0.0306	0.0457	0.0607	0.0713	0.0852	0.7871	0.7677	0.7714	0.7749	0.7724	0.7757	0.7729	0.7819	0.7815	0.7826	0.7843	0.7667	0.7492	0.7316
Round 5	0.0000	0.0146	0.0291	0.0434	0.0577	0.0678	0.0810	0.7691	0.7506	0.7546	0.7584	0.7564	0.7600	0.7577	0.7679	0.7680	0.7695	0.7524	0.7355	0.7188	0.7018
Round 6	0.0000	0.0154	0.0276	0.0413	0.0548	0.0683	0.0771	0.7500	0.7544	0.7365	0.7406	0.7390	0.7429	0.7410	0.7521	0.7526	0.7358	0.7194	0.7031	0.6870	0.6706
Round 7	0.0000	0.0146	0.0263	0.0393	0.0521	0.0649	0.0733	0.7299	0.7172	0.6826	0.6692	0.6500	0.6361	0.6163	0.6083	0.5903	0.5735	0.5571	0.5409	0.5247	0.5084
Round 8	0.0000	0.0139	0.0250	0.0373	0.0496	0.0617	0.0697	0.6924	0.6803	0.6467	0.6339	0.6154	0.6019	0.5828	0.5755	0.5581	0.5418	0.5260	0.5103	0.4947	0.4788
Round 9	0.0000	0.0132	0.0264	0.0355	0.0471	0.0587	0.0702	0.6555	0.6438	0.6319	0.5990	0.5864	0.5682	0.5549	0.5429	0.5261	0.5104	0.4951	0.4798	0.4647	0.4494
Round10	0.0000	0.0126	0.0250	0.0337	0.0448	0.0558	0.0668	0.6192	0.6080	0.5965	0.5647	0.5526	0.5350	0.5222	0.5108	0.4945	0.4793	0.4645	0.4498	0.4351	0.4202
Round11	0.0000	0.0119	0.0238	0.0356	0.0426	0.0531	0.0635	0.5838	0.5731	0.5620	0.5313	0.5195	0.5026	0.4902	0.4793	0.4635	0.4488	0.4345	0.4202	0.4060	0.3916
Round12	0.0000	0.0113	0.0226	0.0338	0.0450	0.0505	0.0604	0.5861	0.5391	0.5284	0.5175	0.4874	0.4758	0.4591	0.4534	0.4333	0.4191	0.4052	0.3914	0.3777	0.3637
Round13	0.0000	0.0108	0.0215	0.0322	0.0428	0.0533	0.0638	0.5515	0.5418	0.5318	0.4853	0.4745	0.4450	0.4335	0.4235	0.4064	0.3914	0.3774	0.3637	0.3501	0.3366

Table 16 shows the negotiation process of a risk-loving seller and a risk-averting buyer.

<Table 16> The process of negotiation of a risk-loving seller and a risk-averting buyer

	$P(\alpha_{21})$	$P(\alpha_{20})$	$P(\alpha_{19})$	$P(\alpha_{18})$	$P(\alpha_{17})$	$P(\alpha_{16})$	$P(\alpha_{15})$	$P(\alpha_{7})$	$P(\alpha_{6})$	$P(\alpha_{5})$	$P(\alpha_{4})$	$P(\alpha_{3})$	$P(\alpha_{2})$	$P(\alpha_{1})$	$P(\alpha_{14})$	$P(\alpha_{13})$	$P(\alpha_{12})$	$P(\alpha_{11})$	$P(\alpha_{10})$	$P(\alpha_{9})$	$P(\alpha_{8})$
Round 1	0.0000	0.0001	0.0004	0.0009	0.0016	0.0025	0.0036	0.7208	0.7378	0.7551	0.7726	0.7903	0.8082	0.8262	0.8836	0.9025	0.9216	0.9409	0.9604	0.9801	1.0000
Round 2	0.0000	0.0001	0.0003	0.0007	0.0013	0.0019	0.0028	0.5529	0.5494	0.5622	0.5752	0.5840	0.5972	0.6059	0.6479	0.6592	0.6720	0.6854	0.6993	0.7136	0.6830
Round 3	0.0000	0.0001	0.0003	0.0007	0.0012	0.0018	0.0026	0.4990	0.5108	0.5228	0.5192	0.5310	0.5389	0.5510	0.5848	0.5950	0.6064	0.6186	0.6311	0.6041	0.5757
Round 4	0.0000	0.0001	0.0003	0.0007	0.0012	0.0018	0.0024	0.4768	0.4881	0.4718	0.4827	0.4793	0.4901	0.4973	0.5318	0.5390	0.5483	0.5588	0.5345	0.5092	0.4828
Round 5	0.0000	0.0001	0.0003	0.0006	0.0011	0.0017	0.0024	0.4304	0.4406	0.4258	0.4357	0.4325	0.4423	0.4488	0.4800	0.4865	0.4949	0.4731	0.4506	0.4270	0.4025
Round 6	0.0000	0.0001	0.0002	0.0005	0.0010	0.0013	0.0022	0.4315	0.3976	0.4069	0.4163	0.4022	0.4113	0.4081	0.4365	0.4424	0.4207	0.3996	0.3783	0.3563	0.3334
Round 7	0.0000	0.0001	0.0002	0.0005	0.0009	0.0014	0.0019	0.3895	0.3987	0.3672	0.3757	0.3630	0.3712	0.3683	0.3939	0.3749	0.3548	0.3352	0.3155	0.2951	0.2738

Considering the negotiation outcome of a risk-loving seller and a risk-averting buyer, the buyer came up with measures $P(\alpha_{21})$ to $P(\alpha_{6})$ *at the left side of the table from round 1 to 7, whereas the seller proposed measures* $P(\alpha_{8})$ *to* $P(\alpha_{6})$ *at the right side of the table.*

The buyer rejected the measures proposed by the seller from round 1 to 6 before giving in to the demand of the seller. Similarly, the seller made a concession due to the delay penalty and change in CF; thus resulting in the agreement of both sides on negotiating measures and reaching a conclusion in round 7 with measure $P(\alpha_{6})$.

Tables 17 and 18 show the negotiation process of a risk-loving seller and a risk-neutral buyer as well as of a risk-loving seller and a buyer, respectively.

<Table 17> The process of negotiation of a risk-loving seller and a risk-neutral buyer

	$P(\alpha_{21})$	$P(\alpha_{20})$	$P(\alpha_{19})$	$P(\alpha_{18})$	$P(\alpha_{17})$	$P(\alpha_{16})$	$P(\alpha_{15})$	$P(\alpha_{7})$	$P(\alpha_{6})$	$P(\alpha_{5})$	$P(\alpha_{4})$	$P(\alpha_{3})$	$P(\alpha_{2})$	$P(\alpha_{1})$	$P(\alpha_{14})$	$P(\alpha_{13})$	$P(\alpha_{12})$	$P(\alpha_{11})$	$P(\alpha_{10})$	$P(\alpha_{9})$	$P(\alpha_{8})$
Round 1	0.0000	0.0001	0.0004	0.0009	0.0016	0.0025	0.0036	0.7208	0.7378	0.7551	0.7726	0.7903	0.8082	0.8262	0.8836	0.9025	0.9216	0.9409	0.9604	0.9801	1.0000
Round 2	0.0000	0.0001	0.0003	0.0007	0.0013	0.0019	0.0028	0.5529	0.5494	0.5622	0.5752	0.5840	0.5972	0.6059	0.6479	0.6592	0.6720	0.6854	0.6993	0.7136	0.7010
Round 3	0.0000	0.0001	0.0003	0.0007	0.0012	0.0018	0.0025	0.4990	0.5108	0.5074	0.5192	0.5270	0.5389	0.5468	0.5848	0.5950	0.6064	0.6186	0.6311	0.6201	0.6082
Round 4	0.0000	0.0001	0.0003	0.0006	0.0011	0.0017	0.0024	0.4504	0.4610	0.4718	0.4685	0.4793	0.4864	0.4973	0.5277	0.5390	0.5483	0.5588	0.5486	0.5380	0.5269
Round 5	0.0000	0.0001	0.0003	0.0006	0.0010	0.0015	0.0021	0.4064	0.4161	0.4258	0.4229	0.4325	0.4390	0.4488	0.4763	0.4846	0.4939	0.4851	0.4758	0.4661	0.4556
Round 6	0.0000	0.0001	0.0002	0.0005	0.0010	0.0013	0.0019	0.3884	0.3755	0.3843	0.3932	0.3904	0.3992	0.4050	0.4332	0.4390	0.4301	0.4213	0.4124	0.4030	0.3932
Round 7	0.0000	0.0001	0.0002	0.0005	0.0009	0.0014	0.0018	0.3505	0.3588	0.3468	0.3549	0.3523	0.3603	0.3655	0.3909	0.3816	0.3732	0.3650	0.3566	0.3478	0.3387
Round 8	0.0000	0.0000	0.0002	0.0004	0.0008	0.0012	0.0018	0.3163	0.3238	0.3130	0.3203	0.3180	0.3251	0.3299	0.3399	0.3312	0.3233	0.3156	0.3078	0.2996	0.2910
Round 9	0.0000	0.0000	0.0002	0.0004	0.0007	0.0011	0.0016	0.3172	0.2923	0.2991	0.3060	0.2956	0.3023	0.3000	0.2975	0.2895	0.2809	0.2731	0.2654	0.2576	0.2496
Round10	0.0000	0.0000	0.0002	0.0004	0.0006	0.0010	0.0014	0.2863	0.2931	0.2700	0.2762	0.2668	0.2632	0.2511	0.2580	0.2505	0.2425	0.2352	0.2281	0.2208	0.2134
Round11	0.0000	0.0000	0.0001	0.0003	0.0006	0.0009	0.0013	0.2584	0.2645	0.2707	0.2410	0.2380	0.2202	0.2162	0.2138	0.2067	0.1991	0.1921	0.1852	0.1782	0.1710

<Table 18> The process of negotiation of a risk-loving seller and a risk-loving buyer

	$P(\alpha_{21})$	$P(\alpha_{20})$	$P(\alpha_{19})$	$P(\alpha_{18})$	$P(\alpha_{17})$	$P(\alpha_{16})$	$P(\alpha_{15})$	$P(\alpha_{7})$	$P(\alpha_{6})$	$P(\alpha_{5})$	$P(\alpha_{4})$	$P(\alpha_{3})$	$P(\alpha_{2})$	$P(\alpha_{1})$	$P(\alpha_{14})$	$P(\alpha_{13})$	$P(\alpha_{12})$	$P(\alpha_{11})$	$P(\alpha_{10})$	$P(\alpha_{9})$	$P(\alpha_{8})$

Round 1	0.0000	0.0001	0.0004	0.0009	0.0016	0.0025	0.0036	0.7208	0.7378	0.7551	0.7726	0.7903	0.8082	0.8262	0.8836	0.9025	0.9216	0.9409	0.9604	0.9801	1.0000
Round 2	0.0000	0.0001	0.0003	0.0007	0.0013	0.0019	0.0028	0.5529	0.5494	0.5622	0.5752	0.5840	0.5972	0.6059	0.6479	0.6592	0.6720	0.6854	0.6993	0.7136	0.7101
Round 3	0.0000	0.0001	0.0003	0.0007	0.0012	0.0017	0.0025	0.4990	0.4958	0.5074	0.5192	0.5270	0.5389	0.5468	0.5848	0.5950	0.6064	0.6186	0.6311	0.6281	0.6245
Round 4	0.0000	0.0001	0.0003	0.0006	0.0011	0.0016	0.0022	0.4504	0.4475	0.4579	0.4685	0.4756	0.4864	0.4935	0.5277	0.5370	0.5473	0.5583	0.5554	0.5524	0.5489
Round 5	0.0000	0.0001	0.0002	0.0005	0.0010	0.0014	0.0020	0.4064	0.4038	0.4133	0.4229	0.4293	0.4390	0.4454	0.4763	0.4846	0.4939	0.4913	0.4885	0.4856	0.4821
Round 6	0.0000	0.0001	0.0002	0.0005	0.0009	0.0013	0.0018	0.3668	0.3755	0.3730	0.3816	0.3874	0.3962	0.4019	0.4299	0.4374	0.4348	0.4322	0.4294	0.4265	0.4232
Round 7	0.0000	0.0001	0.0002	0.0004	0.0008	0.0012	0.0017	0.3311	0.3389	0.3366	0.3444	0.3496	0.3575	0.3628	0.3879	0.3850	0.3824	0.3799	0.3772	0.3743	0.3711
Round 8	0.0000	0.0000	0.0002	0.0004	0.0007	0.0011	0.0015	0.2988	0.3059	0.3038	0.3108	0.3155	0.3227	0.3274	0.3415	0.3386	0.3361	0.3336	0.3310	0.3283	0.3252
Round 9	0.0000	0.0000	0.0002	0.0004	0.0006	0.0010	0.0014	0.2696	0.2760	0.2825	0.2805	0.2870	0.2912	0.2977	0.3004	0.2977	0.2952	0.2928	0.2903	0.2876	0.2847
Round10	0.0000	0.0000	0.0002	0.0003	0.0006	0.0009	0.0013	0.2434	0.2491	0.2550	0.2532	0.2590	0.2628	0.2687	0.2641	0.2615	0.2591	0.2568	0.2544	0.2518	0.2490
Round11	0.0000	0.0000	0.0001	0.0003	0.0005	0.0008	0.0012	0.2196	0.2248	0.2301	0.2285	0.2337	0.2372	0.2366	0.2320	0.2295	0.2273	0.2250	0.2227	0.2202	0.2175
Round12	0.0000	0.0000	0.0001	0.0003	0.0005	0.0007	0.0010	0.2099	0.2029	0.2077	0.2125	0.2109	0.2105	0.2082	0.2055	0.2013	0.1991	0.1970	0.1947	0.1924	0.1898
Round13	0.0000	0.0000	0.0001	0.0003	0.0005	0.0007	0.0011	0.1894	0.1939	0.1984	0.1872	0.1869	0.1805	0.1797	0.1803	0.1772	0.1747	0.1725	0.1703	0.1679	0.1655
Round14	0.0000	0.0000	0.0001	0.0002	0.0004	0.0007	0.0009	0.1899	0.1944	0.1751	0.1751	0.1645	0.1640	0.1579	0.1595	0.1567	0.1536	0.1511	0.1488	0.1465	0.1441

5.Conclusion

In this era where e-commerce is everywhere, selling and buying products through the Internet are no longer considered novel activities. Furthermore, even traditional produce markets strive to trade goods online by setting up Internet shopping malls. E-commerce overcame the time and space barriers of both sellers and consumers, sharply spreading and growing and taking advantage of the reduction in economic costs, convenience of use, easy access, and cost reduction in trade.

Alongside the growth of e-commerce, people have been trying to make available online the trade methods used in the traditional market such as auctioning, reverse auctioning, and haggling.

Nonetheless, an automated negotiation system that is good enough to be utilized online has yet to be realized.

A series of studies on various negotiation systems for application to the e-commerce market were conducted. Some of these studies have been realized as negotiation systems such as Kasbah, Tete-a-Tete, Jango, etc. Still, very few studies realize multiattribute negotiation wherein more than three negotiation items are considered and come up with the complete automation of negotiation.

In the e-commerce market, the involvement of people should be minimized since mindsets such as egocentricity and pride and limitations of time and space are difficult to control because of the very humanity of people. Against this backdrop, areas where humans are involved are very likely to be the bottleneck in the negotiation process.

This study approached the negotiation issue in the stance of a buyer and a seller based on specific bargaining environments called customized manufacturing in order to resolve the problems in multiattribute automated negotiation. Various attributes of negotiation required in the negotiation environments of customized manufacturing were defined. In addition, the weight of each attribute was analyzed using the entropy criteria, and each preference value for various negotiating measures, calculated.

In addition, to realize the decision-making process of a decision maker, the method of selecting the best negotiation alternative was researched by utilizing each negotiator's utility function, penalty for delay considering the negotiation circumstances, and CF of the negotiation. Such process of selecting negotiation measures can be explored in the study on automated negotiation methodology, which aims to materialize the cognition system of humans and judgment ability in each situation.

The generation of multiattribute negotiation alternatives and methods of selecting and proposing negotiating measures suggested in this study are expected to help develop a more sophisticated automated negotiation system later.

In the follow-up research, a method of carrying out negotiation that considers the various situations of a deal shall be developed.

A number of internal and external factors should be considered for negotiation. The negotiation situation varies according to the effect caused by each factor. Therefore, negotiation strategies befitting each negotiation situation are required in order to yield more fruit in a negotiation. This study failed to address the negotiation methods in the strategic aspect, however. Future studies are expected to supplement the research of negotiation strategies.

References

1) Sae Jin O, Oak Kyung Choi, and Sang Yong Han (2002). "Designing the e-marketplace based on a dynamic price negotiation agent that adapts to the changes in trade environments." Paper Archives of the Korea Business Associated Education, Vol. 2, No. 2.
2) Kang In Lee (2003). "Selection of preferred alternatives for the MADM problem using entropy criteria." Journal of the Korean Society of Industrial and Systems Engineering Vol. 26, No. 2,

pp.55-61.
3) Jae Kyu Lee, Hyung Rim Choi, Hyun Soo Kim, Min Soo Seo, Seok Jin Joo, and Won Chul Ji (1996). "Expert system: principle and development," pp.293-339, Beop-Young Co.
4) Jong Geon Lee and Heon Joon Park (2004). “Effects of negotiation strategies on negotiation results.” Research on the Management of Human Resources, Vol. 28, No. 2, The Korean Association of Personnel Administration.
5) Ui Seong Cho and Geun Sik Cho (1999). "Online staff system for automated negotiation with consumers in e-commerce." Paper Archives of the Korea Intelligence Information System Institute, Vol. 5, No.2.
6) Beam, C., Segwev, A., and Shanthikumar, J. G. "Electronic negotiation through Internet-based auction." CITM Working Paper 96-WP-1019.
7) Carrie Beam, Arie Segev, "Automated Negotiations: A Survey of the State of the Art", *Wirtschaftsinformatik*, 39 (1997) 3, pp. 263-268, 1997.
8) Chavez, A., and Maes, P., "Kasbah: An Agent Marketplace for Buying and Selling Goods", *Proceedings of the First International Conference on the Practical Application of Intelligent Agent and Muti-Agent Technology (PAAA' 96)*, London, UK, Apr. 1996.
9) D.G. Pruitt, Negotiation Behavior, Academic Press, New York, 1981.
10) Dajun, Z. and Sycara, K., "Bayesian Learning in Negotiation", Working Notes of the AAAI 1996 Stanford Spring Symposium Series on Adaptation, Co-evolution, and Learning in Multi agent Systems
11) Deutsch, M. "The Resolution of Conflict", New Haven, CT: Yale University Press, 1973
12) Foroughi, A., "A Survey of the Use of Computer Support for Negotiation", *Journal of Applied Business Research*, pp. 121-134, Spring 1995
13) H. Raiffa, The Art and Science of Negotiation, Harvard University Press, Cambridge, MA, 1982
14) Hobbs, B. F., "A Comparison of Weighting Methods in Power Plant Siting", *Decision Science*, 26(4) : 725-737, 1997.
15) Hwang, C. L. and Yoon, K. S., "Multiple Attribute Decision Making", *Lecture Notes in Economics and Mathematical Systems*, Springer-Verlag, New York, 1981
16) Jelassi, M. T. and Abbas, F., "Negotiation Support Systems: An Overview of Design Issues and Existing Software", *Decision Support Systems*, June 1989
17) Nunamaker, J. F. Jr., Dennis, A. R., Valacich, J. S. and Vogel, D. R., "Information Technology for Negotiating Groups: Generating Options for Mutual Gain", *Management Science*, October 1991.
18) Oliver, J. R., "A Machine Learning Approach to Automated Negotiation and prospects for Electronic Commerce", 1996.
19) Park B. J., Choi H. R., Park Y. S., "A Genetic Algorithm for Integrating Process Planning and Scheduling in a Dynamic Job Shop", *The 33rd International Conference on Computers and Industrial Engineering(COM&IE)*, 2004.
20) Pattie, M., "Modeling Adaptive Autonomous Agents", Artificial Life Journal, edited by C. Langton, MIT Press, Vol. 1, No. 1&2, pp.135-162, 1994.
21) R. Fisher, W. Ury, Getting to Yes: Negotiating Agreement without Giving in, Houghton Mifflin, Boston, MA, 1981
22) Rosenschein, J. and Zlotkin, G. , "Rules of Encounter: Designing Conventions for Automated Negotiation among Computers", MIT Press, 1994
23) Sandholm, T. and Lesser, V., "Equilibrium Analysis of the Possibilities of Unenforced Exchange in Multi agent System", *14 International Joint Conference on Artificial Intelligence(IJCAI '95)*, pp.694-701, 1995.
24) Shaheen S. Fatima, Nicholas R. Jennings, An agenda-based framework for multi-issue negotiation, *Artificial Intelligence*, 152(2004), 1-45
25) Shortliffe, E. H. and B. G. Buchanan, "A Method of Inexact Reasoning," *Mathematical Biosciences*, vol. 23, pp. 351~379, 1975.
26) Shaheen S. Fatima, Michael Wooldridge, Nicholas R. Jennings, "An agenda-based framework for multi-issue negotiation", *Artificial Intelligence*, 2004.
27) Sycara, K. and Dajun, Z., "Coordination of Multiple Intelligent Software Agents", *The International Journal of Cooperative Information systems*, 1996.
28) Yuan, Y., J. B. Rose and N. Archer, "A Web-Based Negotiation Support system", *Electronic Market*, Vol.8, No.3, pp.13-17, 1998.
29) Zeleny, M; Multiple Criteria Decision Making, Mcgraw Hill, New York, 1982.