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Khim-Yong Goh
University of Chicago

Hock-Hai Teo
National University of Singapore

Haixin Wu
National University of Singapore

Kwok-Kee Wei
National University of Singapore

COMPUTER-SUPPORTED NEGOTIATIONS: AN EXPERIMENTAL STUDY OF BARGAINING IN ELECTRONIC COMMERCE

Khim-Yong Goh
Graduate School of Business
University of Chicago
U.S.A.

Hock-Hai Teo
Haixin Wu
Kwok-Kee Wei
School of Computing
National University of Singapore
Singapore

Abstract

The expanding business-to-business (B2B) e-commerce market has created a need for firms to negotiate business deals online. Negotiation support tools are likely to play a more critical role in B2B e-commerce. Notwithstanding their importance, the impacts of negotiation support tools (especially automated bargaining agents) are not well understood. This research addresses this gap by conducting a series of laboratory experiments to investigate the impact of web-based electronic messaging, web-based negotiation support systems (NSS), and autonomous electronic bargaining agents (EBA) on the outcomes of a multi-issue, e-commerce negotiation. Two types of bargaining situation were investigated: integrative and distributive bargaining. Negotiation outcomes were assessed using joint profit/utility outcome, contract balance, and the closeness to the efficient/Pareto frontier and the Nash bargaining solution. Findings show that web-based NSS can significantly improve efficiency and fairness in remote integrative negotiations but not in distributive negotiations. EBA were found to achieve outcomes comparable to but not significantly better than unassisted human dyads. Implications for NSS and EBA implementation and research were drawn.

1. INTRODUCTION

Electronic commerce (e-commerce) on the Internet is fast expanding firms' markets beyond regional and national boundaries. While nascent e-commerce ventures focused predominantly on business-to-consumer markets, there is a growing recognition that the business-to-business (B2B) e-commerce arena to streamline supply chains provides greater potential opportunities and is likely to command a greater share of the e-commerce market in terms of revenue (Anderson 1997). Indeed, Merrill Lynch (Blodget and McCabe 2000) estimated that the B2B e-commerce market would grow to US$2.5 trillion dollars in 2003. With increasing pervasiveness of electronic markets linking B2B supply chains (e.g., GE Information Services' Trading Process Network[1] and Perfect.com[2]) (Magretta 1998; Vigoroso 1999), firms are increasingly negotiating business deals online. Hence, negotiation support tools are likely to play a critical role in B2B e-commerce.

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[1]URL of General Electric Information Services' Trading Process Network is <www.geis.com>.

[2]URL of Perfect.com is <www.perfect.com>.

B2B e-commerce markets are dynamic and characterized by multiple contract attributes, fluid pricing, and terms based on fluid back-and-forth negotiation between buyers and sellers. Unfortunately, competition on the electronic channel has also spawned a trend of price wars and chaos in some instances (Kuttner 1998). This need not be the case if negotiation support tools could create an opportunity to go beyond single-issue price wars by determining sellers' and buyers' preferences across multiple business issues and by encouraging negotiations which create possible joint gains for all trading partners. Given the increasing importance of negotiation support tools and the glaring paucity of negotiation studies in e-commerce (Kauffman and Walden 2000), there is a compelling need for research on computer-supported negotiation tools in B2B e-commerce. Indeed, the role and usefulness of negotiation support tools in supporting integrative ("expand-the-pie") and distributive ("fixed-pie") negotiations in B2B e-commerce warrant a thorough investigation.

Drawing from the bargaining, negotiation support systems (NSS), game theory, and social psychology literature, we conduct experiments to investigate the outcomes of multiple-issue, e-commerce negotiations supported by web-based electronic messaging (EM), web-based NSS (Kersten and Noronha 1999), and autonomous electronic bargaining agents (EBA) (Chavez and Maes 1996; Oliver 1997). In evaluating the negotiation outcome of various computer-supported negotiations, we also distinguish between integrative and distributive bargaining situations (Walton and McKersie 1965). Specifically, this study seeks answers to the following research questions: Can web-based NSS improve the outcomes of dyadic remote negotiation in integrative and distributive bargaining situations? Can dyadic EBA achieve outcomes comparable to those of the human negotiators in integrative and distributive bargaining situations?

The contributions of this research are twofold. From an academic perspective, we evaluate the negotiation outcomes of industrial buyers and sellers in a B2B e-commerce context in terms of two economic measures seldom documented in the IS negotiation literature—the distance to the efficient/Pareto frontier (Milter et al. 1996) and the distance to the Nash bargaining solution (Nash 1950, 1953)—and two traditional dependent measures used in NSS literature—joint profit/utility outcome and contract balance (e.g., Delaney et al. 1997; Foroughi et al. 1995). Such an integrative analysis can provide a rigorous, well-developed theoretical vantage point from which to assess negotiation support tools' contribution to e-commerce. From a practical perspective, this research benchmarks the outcome effectiveness of NSS and EBA against EM in a B2B e-commerce context and informs practitioners about the types of negotiation tools and the related design issues that are relevant for negotiations in e-commerce.

2. CONCEPTUAL FOUNDATIONS AND HYPOTHESES

2.1 Theoretical Perspectives and Improving Negotiation Outcomes in E-Commerce

The study of two-party negotiation behaviors and outcomes has been approached from many disciplines, notably sociology, psychology, organizational behavior, economics (game theory), information systems (NSS), and computer science (distributed artificial intelligence, evolutionary computation).

Descriptive theories of negotiation in sociology, psychology, and organizational behavior have mostly emphasized contextual characteristics of negotiation and negotiators' cognition and interaction processes (Bazerman and Carroll 1987; Pruitt and Rubin 1986). These descriptive theories examine the influence of individual differences (Hausken 1997; Thompson 1990), situational determinants (Pruitt and Rubin 1986; Thompson 1990) and cognitive processes on judgment, behavior, and outcomes in negotiation (Bazerman and Carroll 1987; Thompson 1990). In evaluating the outcome of negotiations, descriptive negotiation theorists measure elements of social perception such as negotiators' perceptions of the bargaining situation, the bargaining opponent, and themselves (Thompson and Hastie 1990).

Given the increasing zero-sum nature of perfectly competitive markets on the Internet (Anderson 1997; Kuttner 1998), we are primarily interested in the magnitude of conflict in business negotiations. Walton and Mckersie (1965) made the important distinction between *distributive* (high conflict) bargaining in which parties bargain over a fixed pie, and *integrative* (low conflict) bargaining in which parties may "expand the pie" through problem-solving, creativity, and identification of differences in priorities and/or compatibility of interests.

In contrast to descriptive theories of negotiation in social psychology and organizational behavior, normative, game-theoretic models of negotiation (Nash 1950, 1953; Rubenstein 1982) tend to assume rationality and focus on the outcome that should emerge from these rational actions by all negotiating parties. Because of its explicit assumptions of individual rationality and normative analyses of negotiation behavior, game theory has been simultaneously a goal and a foil against which much descriptive experimental research has been directed (Dawes 1988; Kahneman et al. 1982). However, normative models of negotiation have advanced the understanding of conflict behavior by providing compelling analyses of optimal or rational behavior in competitive situations.

Economic measures of negotiation performance (e.g., Gupta and Livne 1988; Kalai and Smorodinsky 1975; Nash 1950, 1953) represent the most well-formulated specifications and benchmarks of optimal negotiation performance in terms of efficiency and fairness. Typical measures of negotiation outcome used in most negotiation studies include joint profit/utility outcome, contract balance (difference between negotiators' total utility scores achieved), and the number of contracts/offers proposed (e.g., Delaney et al. 1997; Neale and Bazerman 1985). However, some researchers have criticized that joint outcome is not a sensitive measure of negotiation efficiency and contract balance is not a standardized measure of negotiation fairness (Lax and Sebenius 1987; Tripp and Sondak 1992). Consequently, some researchers have proposed to measure negotiation outcomes in terms of the distance to the efficient/Pareto frontier and the distance to the Nash bargaining solution (Lim and Benbasat 1992; Milter et al. 1996) as complementary measures to joint outcome and contract balance respectively. The efficient frontier represents the locus of achievable joint evaluations from which no joint utility gains are possible. The Nash bargaining solution specifies the maximum of the product of two parties' utility gains. In informal terms, it is a solution from which no party has the incentive to deviate (Nash 1950, 1953).

While the theoretical objective of the above perspectives is to predict the processes and outcomes of negotiation, the practical goal is to help people negotiate more effectively (Raiffa 1982). Very frequently, past research and our common experiences demonstrate that even in simple negotiations, people often settle on sub-optimal agreements, thereby "leaving money on the table" (e.g., Camerer 1990; Rangaswamy and Shell 1997). To this end, information systems can help tremendously in supporting negotiation processes and improving negotiation outcomes by either assisting human negotiators or serving as negotiation participants. Information systems in the former case have been much studied in the area of NSS research while those in the latter are often referred to as automated negotiation software agents or EBA. With developments in NSS and EBA research, there is now a significant opportunity for e-commerce technologies to help people and firms achieve superior settlements in multiple-issue, e-commerce negotiations.

2.2 Negotiation Support Systems

The challenges of negotiation and the cognitive limitations of human negotiators have led researchers to pursue computer support of negotiations in the form of NSS. By incorporating computer-based decision tools to assist negotiating parties reach an agreement, NSS offer the potential to enhance the analytically complex problem-solving process and help alleviate cognitive and socio-emotional stumbling blocks to successful negotiation (see, for example, Anson and Jelassi 1990; Jelassi and Foroughi 1989). Foroughi (1998), Lim and Benbasat (1992), and Rangaswamy and Shell (1997) provide comprehensive surveys of the empirical NSS research literature.

Empirical research in NSS has indicated that NSS effectiveness is likely to be moderated by the type of negotiation situation or the amount of conflict between the negotiators. In particular, Jones (1988), Foroughi et al. (1995), and Delaney et al. (1997) showed that in integrative negotiations, compared to dyads with no computer support, NSS-supported dyads achieved higher joint outcomes and better contract balances (fairer outcomes). However, in distributive bargaining situations, Jones found comparable joint outcomes for both groups. Thus, NSS may not be particularly useful in distributive negotiation situations where negotiating parties tend to "split the difference" in coming up with a reasonably efficient and fair settlement by using a satisficing strategy (Erickson et al. 1974; Raiffa 1982). Rangaswamy and Shell also showed that negotiators using NSS achieved better outcomes than those using an e-mail messaging facility for negotiation. Hence, for our implementation of NSS that includes both decision and electronic messaging support, our hypotheses for NSS-supported negotiations are summarized in Table 1.

Table 1. Summary of Research Hypotheses for NSS-Supported Negotiations

	Measures of Negotiation Outcome			
Type of Bargaining Situation	*Joint Outcome*	*Contract Balance*	*Distance to Efficient Frontier*	*Distance to Nash Solution*
Integrative	Hypothesis 1.1 NSS > EM	Hypothesis 1.2 NSS < EM	Hypothesis 1.3 NSS < EM	Hypothesis 1.4 NSS < EM
Distributive	Hypothesis 2.1 NSS = EM	Hypothesis 2.2 NSS = EM	Hypothesis 2.3 NSS = EM	Hypothesis 2.4 NSS = EM

EM: Electronic Messaging Support only NSS: Decision Support + Electronic Messaging Support

2.3 Electronic Bargaining Agents

Although powerful and effective, NSS still require near-constant human input and communications. Recent studies of autonomous software agents in distributed artificial intelligence and evolutionary computations disciplines have opened up exciting possibilities for automated negotiation (e.g., Guttman and Maes 1998; Oliver 1997; Sandholm 1999) in e-commerce whereby the negotiation roles of human buyers and sellers are performed by electronic bargaining agents (EBA). Unlike NSS supporting human negotiators, EBA negotiation involves two or more EBA (employing artificial intelligence techniques) in a virtual environment governed by computational rules. Examples of computational techniques include a concession model that hard-codes a general strategy of concession in multiple-issue negotiations (Matwin et al. 1991), a case-based reasoning to planning and support of negotiations (Sycara 1990), and artificial adaptive agents using a genetic algorithm-based learning technique (Oliver 1997).

EBA have the potential to save human negotiators' time and find better deals in combinatorially and strategically complex settings. Thus, for reasons similar to NSS-supported negotiations, we hypothesize that in *integrative*, multiple-issue negotiations, the distance to efficient frontier (joint profit outcome) will be shorter (higher) for EBA dyads than that for human dyads using EM. Similarly in *distributive* negotiations, the distance to efficient frontier (joint profit outcome) will be no different for EBA dyads and for human dyads with EM support. EBA do not have concerns for fairness as human negotiators do. They are often self-interested and thus not necessarily interested in helping or hurting other agents. Thus, it would be unusual for EBA to share more information than minimally necessary. We thus hypothesize that in *integrative* negotiations, the distance to Nash bargaining solution (contract balance) will be longer for EBA dyads than that for dyads with EM support. Similarly in *distributive* negotiations, the distance to Nash bargaining solution (contract balance) will be no different for EBA dyads and for dyads using EM.

Table 2. Summary of Research Hypotheses for EBA-Supported Negotiations

	Measures of Negotiation Outcome			
Type of Bargaining Situation	*Joint Outcome*	*Contract Balance*	*Distance to Efficient Frontier*	*Distance to Nash Solution*
Integrative	Hypothesis 3.1 EBA > EM	Hypothesis 3.2 EBA > EM	Hypothesis 3.3 EBA < EM	Hypothesis 3.4 EBA > EM
Distributive	Hypothesis 4.1 EBA = EM	Hypothesis 4.2 EBA = EM	Hypothesis 4.3 EBA = EM	Hypothesis 4.4 EBA = EM

EM: Electronic Messaging Support only EBA: Automated Decision Support only

3. RESEARCH METHODOLOGY

3.1 Experimental Design

Three series of controlled laboratory experiments were performed to investigate the impact of NSS and EBA on negotiation outcomes. Each series examined one type of computer negotiation support: EM, NSS, or EBA. Experiments sessions of EM-supported dyads served as the control group and were used as the baseline comparisons to evaluate the impact of NSS and EBA. Within each series of experiment sessions, we also compared two types of negotiation situations: integrative or distributive bargaining. We did not employ a 2 x 3 factorial design because there is no theoretical basis to compare NSS and EBA effectiveness. Table 3 shows the number of dyads in each treatment. Subjects were recruited from our undergraduate MIS degree program. Our design initially consisted of 72 dyads (144 subjects). However, only 69 dyads were used for final data analyses because three dyads were found to collude among themselves based on our log file analysis.

3.2 Independent Variables

In the ***integrative bargaining*** treatments, the assigned weights for negotiation issues were different. When the priorities of negotiators differ, the potential for mutually beneficial tradeoffs exists and the relationship might be characterized as one of low conflict. In the ***distributive bargaining*** treatments, negotiation issues for both buyer and seller were weighted similarly (i.e., assigned approximately equal utility points). This resulted in a zero-sum or high conflict bargaining situation where one party's gains were almost equal to the other party's losses.

Table 3. The Number of Dyads in Each Treatment Group (Male-Male/Female-Female Dyads in Parentheses)

Type of Bargaining Situation	Type of Negotiation Support		
	EM	*NSS*	*EBA*
Integrative	12 (6/6)	12 (6/6)	12 (6/6)
Distributive	11 (5/6)	11 (6/5)	11 (5/6)

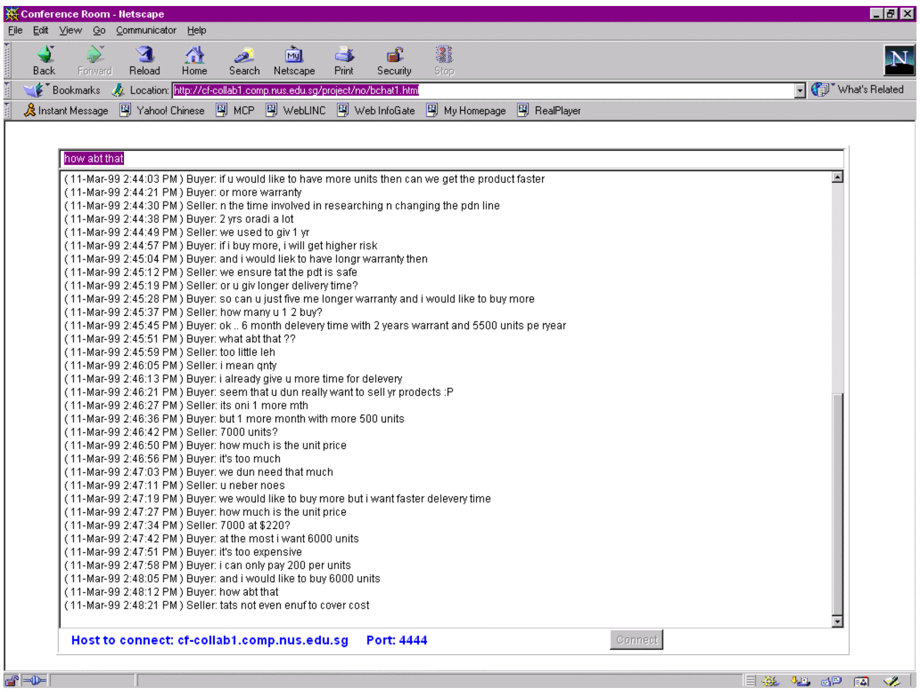

Figure 1. Screen Capture of Electronic Messaging (EM) Interface

Computer negotiation support was manipulated by implementing three types of tools in the form of EM, NSS, and EBA. These tools were written in the JAVA language (as JAVA applets) and could be easily accessed through popular web browsers such as Netscape Navigator. In the ***EM treatment*** groups, dyads negotiated with each other only through a *text-based, electronic messaging* facility (see Figure 1).

In the ***NSS treatment*** groups, three computer tools were provided (see Figure 2): a text-based, electronic messaging facility (on the lower right), an alternative evaluator (on the upper right), and an alternative generator (on the left). The *alternative evaluator* (Foroughi et al. 1995) was specially developed to support alternative contract evaluation based on the preset preference scores of the negotiator. The negotiator could plug in alternative contracts to determine the total score that could be achieved. The *alternative generator* (Delaney et al. 1997) was used to support alternative generation and possible concessions and/or solutions suggestions. Based on the preset (one's own) and estimated (the other party's) point structure of the negotiating parties, it generated all of the 784 contract alternatives and displayed the best three for consideration by the negotiator.

In the ***EBA treatment*** groups, two computer tools were provided (see Figure 3): an agent tailor and an event viewer. The *agent tailor* (on the top) allowed the negotiator to specify his/her contract preferences: highest acceptable price, maximum purchase quantity, shortest acceptable warranty period, and longest acceptable delivery schedule. Using the *event viewer* (on the bottom), the negotiator could track his/her bargaining agent operation and performance. Our implementation of EBA contains a concession-based algorithm similar to that of Matwin et al. (1991) and into which the preset preference scores of the negotiator are built. Based on these scores and the negotiator requirements, the EBA generates all possible alternatives, ranks them in descending order on total score, and proposes the alternative with the highest score to its opponent agent as its first offer. If the offer is accepted, the two agents clinch an agreement; if rejected, the opponent agent comes back with a counter-offer. This offer and counter-offer routine continues until the agents come to an agreement or one of the agents exhausts its possible alternatives and sends a quit message. Within the bargaining cycle, the EBA employs some specific ecaying function on total score to determine which proposal to put forward next.

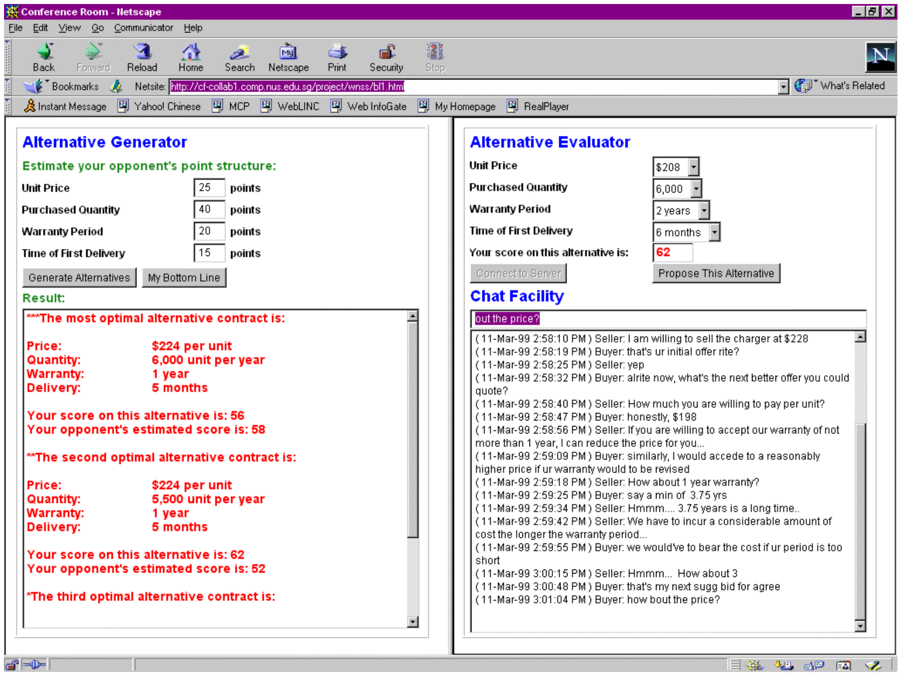

Figure 2. Screen Capture of Negotiation Support System (NSS) Interface

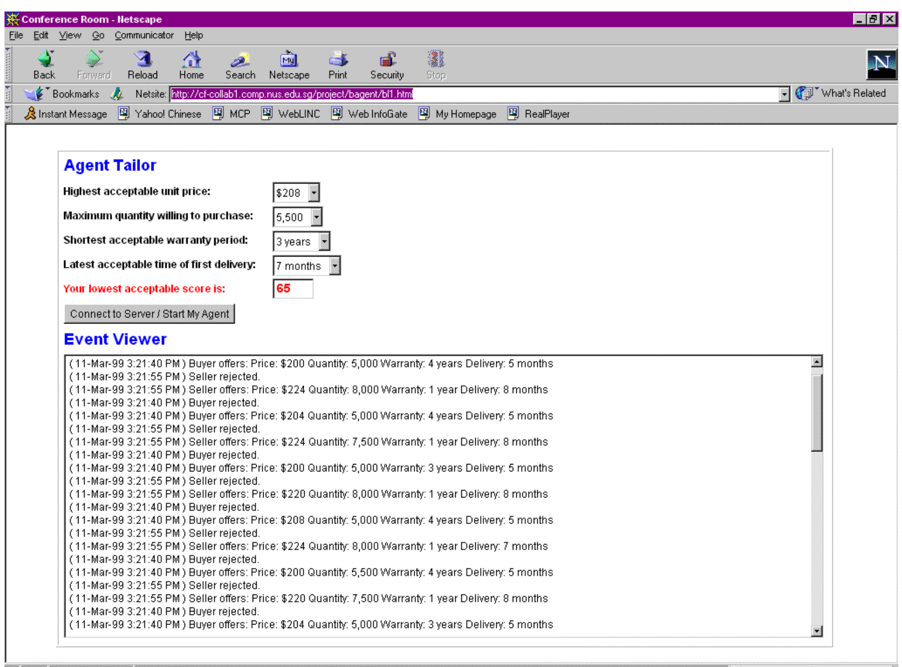

Figure 3. Screen Capture of Electronic Bargaining Agent (EBA) Interface

3.3 Dependent Variables

The dependent variables are joint outcome, contract balance, the distance to the efficient/Pareto frontier, and the distance to the Nash bargaining solution. *Joint outcome* is measured by the sum of total, multi-attribute utility scores of the buyer and the seller for the final agreement. Before the utility scores can be computed, point sheets as used in Jones (1988) and Delaney et al. (1997) are constructed to assign importance utility weights to all negotiation issues. The more important a negotiation issue is to the negotiator, the higher the utility assigned. The utilities of the individual values are then used to calculate a total, multi-attribute utility score.

Contract balance is computed by the absolute value of the difference between the total utility scores achieved by each negotiator. It is zero for a balanced contract and a higher number for an unbalanced one. *The distance to the efficient frontier* measures the efficiency of the final agreement. All efficient solutions on the efficient frontier must be determined before the distance can be calculated. D_1, the distance to the efficient frontier, is then computed as:

$$D_1 = \min_{i=1}^{n} \left(\sqrt{(F_b - E_{b_i})^2 - (F_s - E_{s_i})^2} \right)$$

where F_b, F_s and E_{b_i}, E_{s_i} denote buyer's and seller's utility scores for the final agreement and for efficient solution i respectively. Here l is the sequential index into efficient solutions, and n is the total number of efficient solutions.

The distance to the Nash bargaining solution measures the fairness of the final agreement. The Nash bargaining solution is a settlement that maximizes the product of the utilities of the two bargainers. The Nash solution is identified before the distance can be calculated. D_2, the distance to the Nash bargaining solution, is then computed as:

$$D_2 = \sqrt{(F_b - N_b)^2 + (F_s - N_s)^2}$$

where F_b, F_s and N_b, N_s denote buyer's and seller's utility scores for the final agreement and for the Nash bargaining solution respectively.

3.4 Control Variables

Other pertinent variables not studied in this research are kept consistent to ensure adequate control and internal validity of this study. Table 4 lists the control variables.

Table 4. Operationalization of Control Variables

Control Variable	Operational Measure
Personality of subjects	Random assignment of role, dyad, and treatment group
Negotiation experience	Random assignment of role, dyad, and treatment group
Gender effects	Equal division of male-male and female-female dyads
Negotiator relationship	No history and future possibility of dyadic negotiation
Motivation of subjects	Cash rewards based on negotiation performance
Number of bargaining periods	Continuous, ongoing negotiation for two hours
Non-institutional interaction	Explicit separation of subjects, no interactions allowed

3.5 Experimental Task and Procedures

The experiment task was adapted from Jone's study, which involves negotiation between a buyer (Roberts Enterprise, Inc.) and a seller (Simo Parts Distributor) over four issues—*unit price*, *purchased quantity*, *time of first delivery*, and warranty period—of a purchase agreement for turbochargers (an engine sub-component).

In *integrative* negotiations, the buyer's most important issue was quantity, followed by delivery time. The two least important issues were warranty period and price. For the seller, price was the most important issue, followed by warranty period. Delivery time and quantity were the least crucial issues. In *distributive* negotiations, the four issues were weighted similarly for the two parties. Price was given the most weight, followed by quantity. The two least important issues were delivery time and warranty period. A BATNA (Best Alternative to a Negotiated Agreement—i.e., an alternative offer from another company) was provided to both parties. This gave subjects a minimum point level to achieve in the negotiation. BATNA is crucial to computing the Nash solution and motivating the subjects to achieve superior agreements in the negotiations.

All experiment sessions lasted two hours and were carried out by the same experiment administrator who followed standardized guidelines and instructions.[3] In each session, subjects were randomly assigned the role of buyer or seller. This would determine their seating positions, which were separated by partitions to prevent verbal interactions and opportunities for collusion. All subjects were given ample time to read and understand the experiment case. Point sheets were given to the subjects after the case had been read. Subjects were asked to do an exercise computing the utility score of an agreement to ensure that they knew how to compute utility scores for contracts. Subjects then completed a pre-negotiation questionnaire of personal information and outcome expectations.

At each session's start of negotiations, subjects were explicitly told that cash rewards based on their negotiation performance would be given at the end. All subjects underwent training in using EM, NSS, or EBA before starting negotiations. A computer log file was used to capture all electronic interactions of the negotiators. Upon settlement, subjects completed a post-negotiation, feedback questionnaire. At the end of each session, subjects were paid according to their negotiation performance measured by their total score. They were warned explicitly not to reveal the experimental details to others.

4. DATA ANALYSES AND RESULTS

Two different questions were examined in this study. First, can web-based NSS improve the outcomes of dyadic remote negotiation in integrative and distributive bargaining situations? Second, can dyadic EBA achieve outcomes comparable to those of the human negotiators in integrative and distributive bargaining situations?

Prior to statistical testing, control checks on gender and negotiation experience (both data recorded in the pre-negotiation questionnaire) in each treatment group were performed. ANOVA tests of gender and negotiation experience across six different treatment groups showed no significant differences.

Statistical analyses of the experiment results were performed using a two-way ANOVA model for the dependent measures of joint outcome, contract balance, distance to the efficient frontier, and distance to the Nash bargaining solution. The analysis of each outcome measure began with a two-way ANOVA using the type of negotiation support and bargaining situation as the main effects. Differences in mean values of each dependent measure were identified. For each measure and each type of bargaining situation, a one-way ANOVA was performed, followed by a series of planned comparisons among the three types of computer negotiation support tool.[4]

The planned comparisons of means were carried out using a multiple-comparison t-test (Tukey's HSD test) with an alpha of 0.05 for a one-tailed test. The alpha was modified to adjust for the three types of negotiation support. As a check, non-parametric tests were also used for these planned comparisons. The results were essentially similar to the planned multiple-comparison tests of Tukey's HSD Test. The results of the hypotheses tests are presented in Table 5. Figures 4 and 5 show the mean levels of joint outcome, contract balance, distances to the efficient frontier and the Nash bargaining solution.

[3]Due to space constraints, experiment instructions are not included but are available from the authors on request.

[4]We replicated this analysis procedure using MANOVA and obtained similar results for multivariate effects.

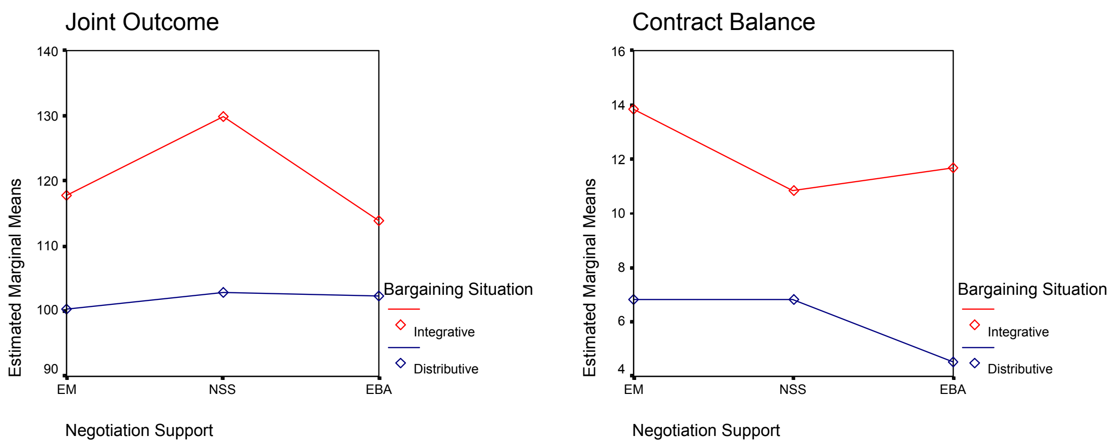

Figure 4. Joint Outcome and Contract Balance Across All Treatment Groups

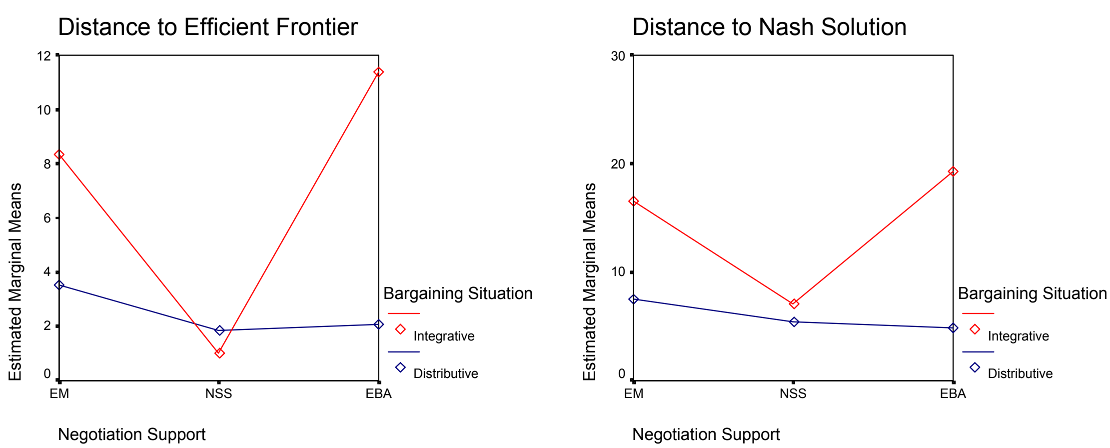

Figure 5. Distance to Efficient Frontier and Nash Solution Across All Treatment Groups

5. DISCUSSIONS AND IMPLICATIONS

5.1 Results for Negotiations with NSS support

In integrative negotiations, compared to EM-supported dyads, NSS-supported dyads were able to achieve significantly higher joint outcomes. This result concurs with Delaney et al.'s (1997) and Jones's (1988) findings. NSS-supported dyads were also able to achieve significantly more efficient agreements (in terms of the distance to the efficient/Pareto frontier). When fairness of negotiation agreements is measured by contract balance, unlike Delaney et al.'s and Foroughi et al.'s (1995) results, there were no significant differences. However, when fairness of settlements is measured by the distance to the Nash bargaining solution, NSS-supported dyads achieved significantly fairer negotiation outcomes. Therefore, we can conclude that our web-based NSS can significantly improve outcomes of remote negotiation in integrative bargaining situations.

In distributive negotiations, results show that our hypotheses were justified. Similar to Jones's findings in distributive negotiations, there were no significant differences in negotiation outcomes of NSS-supported dyads and EM-supported dyads. Therefore, unlike the case of Foroughi et al.'s study, our web-based NSS proved not to be very useful in achieving superior settlements in remote, distributive negotiations.

Table 5. Summary of Statistical Tests and Hypothesis Tests

Dependent Variables	Type of Bargaining Situation	Type of Negotiation Support Mean (Standard Deviation)			Hypothesis	Level of Sig.	Hypothesis Supported
		EM	*NSS*	*EBA*			
Joint Outcome	*Integrative*	117.83 (12.15)	129.83 (4.51)	113.83 (10.72)	H1.1 NSS > EM	p < 0.013	Yes
					H3.1 EBA > EM	p < 0.576	No
	Distributive	100.27 (5.33)	102.82 (2.04)	102.36 (2.11)	H2.1 NSS = EM	p < 0.222	Yes
					H4.1 EBA = EM	p < 0.356	Yes
Contract Balance	*Integrative*	13.83 (11.83)	10.83 (6.95)	11.67 (12.66)	H1.2 NSS < EM	p < 0.776	No
					H3.2 EBA > EM	p < 0.875	No
	Distributive	6.82 (7.99)	6.82 (4.96)	4.55 (3.93)	H2.2 NSS = EM	p < 0.999	Yes
					H4.2 EBA = EM	p < 0.641	Yes
Distance to Efficient Frontier	*Integrative*	8.33 (8.57)	1.01 (2.39)	11.40 (8.19)	H1.3 NSS < EM	p < 0.039	Yes
					H3.3 EBA < EM	p < 0.535	No
	Distributive	3.52 (3.65)	1.87 (1.36)	2.09 (1.41)	H2.3 NSS = EM	p < 0.254	Yes
					H4.3 EBA = EM	p < 0.352	Yes
Distance to Nash Bargaining Solution	*Integrative*	16.59 (8.07)	7.06 (6.35)	19.31 (6.94)	H1.4 NSS < EM	p < 0.007	Yes
					H3.4 EBA > EM	p < 0.625	No
	Distributive	7.46 (4.83)	5.42 (3.35)	4.84 (2.06)	H2.4 NSS = EM	p < 0.391	Yes
					H4.4 EBA = EM	p < 0.220	Yes

A key result obtained in this study is that our web-based NSS helped subjects in integrative negotiations improve both outcome efficiency and fairness of settlements significantly. Subjects without NSS support tended to "satisfice," i.e., stopped negotiating when a satisfactory solution had been reached. Additional information provided by decision aids of NSS had the effect of raising negotiators' expectations. It gave negotiators direction on how to go about searching for efficient and fair agreements. Our log file shows that time to reach agreements was longer for NSS-assisted dyads than that for EM-supported dyads. This suggests that, in situations where integrative solutions were possible, negotiating parties considered their options more thoroughly to achieve more efficient and fairer settlements.

The implications of our web-based NSS findings for practice are clear. There is potential for web-based NSS to benefit business negotiators involved in integrative remote decision-making activities by supporting alternative generation and evaluation as well as suggesting contracts that optimize values and make available joint gains. In view of the flourishing number of B2B e-commerce portals such as EC Portal,[5] Bz2Biz.com,[6] and Perfect.com, the inclusion of web-based NSS in such e-commerce portals can help

[5]URL of EC Portal is <www.ecportal.com>.

[6]URL of Biz2Biz.com is <www.biz2biz.com>.

remote buyers and sellers engage in more optimal and efficient multiple-issue business negotiations. In these B2B portal sites, buyers are able to submit RFQs while sellers are also able to submit RFPs online. These sites act as the intermediaries between buyers and sellers by standardizing the multiple dimensions (e.g., warranty, delivery, and financing) of business contracts so as to facilitate automated auctioning and online negotiation. The potential of web-based NSS is thus especially pertinent for online supplier-manufacturer and manufacturer-retailer/wholesaler dyads (Frazier and Rody 1991; Wilson et al. 1991) in industrial procurement negotiations.

5.2 Results for Negotiations with EBA Support

There were no significant differences in negotiation outcomes between EBA dyads and EM-supported dyads in both integrative and distributive negotiations. Contrary to our hypotheses for integrative negotiations, EBA dyads only achieved comparable negotiation outcomes (in terms of joint outcome, contract balance, distances to the efficient frontier and Nash bargaining solution) compared to EM-supported dyads. Therefore, we conclude that our dyadic EBA can achieve negotiation outcomes comparable to those of the human negotiators in both integrative and distributive bargaining situations. This finding is similar to Oliver's (1997) results, which showed that EBA do not perform significantly better or worse than human dyads in terms of negotiation efficiency and the ability to make integrative tradeoffs.

As part of the *post hoc* statistical tests, we also compared the negotiation outcomes of EBA dyads and NSS-supported dyads. In distributive negotiations, there were no significant differences. However, in integrative negotiations, EBA dyads obtained significantly lower joint outcomes ($p < 0.001$) and significantly less efficient agreements (in terms of the distance to the efficient/Pareto frontier) ($p < 0.003$) than NSS-supported dyads. In terms of contract balance, there were no significant differences in fairness of agreements achieved by both dyadic groups. However, in terms of the distance to the Nash bargaining solution, NSS-supported dyads achieved significantly fairer negotiation outcomes ($p < 0.001$) than EBA dyads. Thus, we conclude that a concession-model implementation of EBA did not perform as well as the human negotiators assisted by NSS in integrative negotiations.

There are several plausible reasons why EBA dyads did not outperform the human dyads with only EM support (i.e., without NSS) in integrative negotiations. The lack of communication channels between buyer and seller in EBA-supported dyads may have impeded information sharing and joint-problem solving possibilities. Indeed, Sebenius (1992) proposes that "to generate gainful options, it is normally helpful for information to be shared openly, communication enhanced, creativity spurred, joint-problem solving emphasized, and hostilities productively channeled."

The fixed strategy of concession adopted by EBA may be too simple, lacking sophisticated machine learning abilities. Particularly, the implementation of EBA strategy in terms of evaluating total score (joint outcome) perpetuates the *fixed-pie bias*—a tendency for negotiators to assume that their own interests directly conflict with those of the other party (Bazerman and Carroll 1987; Thompson and Hastie 1990). This bias may have interfered with EBA's abilities to discover mutually beneficial tradeoffs.

Several implications for practical application of EBA can be drawn. First, using EBA saves time and efforts of human negotiators without jeopardizing the outcomes of negotiations. Hence, EBA are suitable for supporting negotiations in e-commerce, which often take place across different time zones in a global, distributed manner. Second, the strategies of concession adopted by EBA have a huge impact on their performance. EBA developers should keep in mind the importance of bargaining strategies as well as their flexibility. Ideally, such bargaining strategies should lead to negotiation outcomes comparable to, if not better than, that of human negotiators assisted by NSS.

6. CONCLUSIONS

Given the increasing importance of negotiation support tools in B2B electronic market portal sites and the glaring paucity of negotiation studies in e-commerce, there is a compelling need for research on negotiation tools in B2B e-commerce. In this research, we investigate the comparative performance of three types of e-commerce negotiation support tools (EM, NSS, and EBA) in either an integrative or distributive bargaining context. Our findings show that web-based NSS can significantly improve negotiation efficiency and fairness in remote integrative negotiations but not in distributive negotiations. Although EBA do not significantly outperform human negotiators in both integrative and distributive bargaining, such agents are able to achieve negotiation outcomes comparable to unassisted human dyads.

The majority of previous empirical studies on computer negotiation support used joint outcome and contract balance to measure the efficiency and fairness of negotiation outcomes respectively. The present study normalized these measures based on the wellestablished Nash bargaining theory and compared negotiation outcomes in terms of the distances to the efficient/Pareto frontier and the Nash bargaining solution. Our results show that contract balance as an unnormalized measurement of the fairness of negotiation outcomes may not be a sensitive dependent measure, in contrast to Delaney et al.'s (1997) argument. On the other hand, we also find that joint outcome and the distance to efficient frontier are negatively correlated (r = -0.373, p = 0.002).

We recognize that our research results above are subject to some limitations. Our research methodology of laboratory experimentation may have precluded some levels of realism in real-world negotiations while the use of student subjects may also have limited the findings' generalizaility. Our implementation of EBA algorithm in terms of a concession strategy may not have been the most optimal one and is subject to further improvements in future research. Our findings open several avenues for future research. First, we are interested to pursue further research into investigating the negotiation process dynamics of dyads assisted by different tools of EM, NSS, and EBA. This can be achieved by analyzing our log files of all experiment sessions and by plotting out the "negotiation dances" (Milter et al. 1996) of all intermediate offers and counter-offers of negotiating parties. Second, based on our data from experiment questionnaires, we intend to study the social-psychological measures of negotiation processes and outcomes. This is especially pertinent because negotiators' perceptions may differ substantially from objective economic analyses (Thompson and Hastie 1990). Future research in these directions would be able to provide us with deeper insights into the economic effectiveness and psychological value of negotiation support tools in B2B e-commerce.

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