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Bilateral Price Negotiations by Software Agents – A Model for Measuring Marketplace-Related Negotiation Behavior

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ABSTRACT

Software agents are seen as a promising technology for automating economic transactions as they can act autonomously on behalf of their human owners. In open, decentralized markets with incomplete information and possibly non-cooperative behavior, bilateral price negotiations have been shown as an adequate mechanism for balancing out the individual interests and for achieving coordination. Automating bilateral price negotiations and embarking on a strategy require inherent knowledge of the environment, e.g. of the typical negotiation leeway or behavior on the respective marketplace.

Based on findings on negotiation theory, this contribution introduces a measuring system for quantifying marketplace-related negotiation behavior which can be used as a base for automated decision-finding in price negotiations and realizing a concrete strategy. The measuring system has been implemented in software agents and evaluated within a prototypical electronic marketplace. Results show the effectiveness of the measuring system and that coordination of the market can be achieved.

Keywords

Software agent, price negotiation, marketplace-related behavior, coordination.

STRATEGICAL SIGNIFICANCE OF MARKETPLACE-RELATED NEGOTIATION BEHAVIOR

An automation of bilateral price negotiations by software agents requires a formal, microeconomic-based model for decision-finding and action-choosing. An estimation of the respective market environment, particularly of the marketplace-related negotiation behavior, is a requisite for a suitable selection of bargaining strategies in bilateral price negotiations. Without such knowledge, the realization of negotiation strategies becomes impossible: If a merchant adds a flat-rate surcharge of 20% to his (realistic) aspiration, he can be regarded as a profiteer on one marketplace, whereas with this strategy he appears as a lucrative victim on another.

While several formal concepts for the management of bilateral negotiations exist, there is a lack of appropriate concepts for the preceding negotiation opening phase, both in theory and in practice. The knowledge of marketplace-related negotiation behavior is typically assumed as given in theory (e.g. as a game theoretical pay-off matrix), whereas in practice it has to be pre-determined by the human actor himself (e.g. *Market Maker* (Maes *et al.* 1999) or *Avalanche* (Eymann 2000)).

Since the recognition of marketplace-related negotiation behavior has not yet been automated, it constitutes a gap for the complete automation of economic transactions, the significance of which increases constantly with progressive networking, miniaturization and mobility of the components of information systems. The measuring of marketplace-related negotiation behavior thereby becomes an important issue for the opening of negotiations in open, decentralized marketplaces with incomplete information and possibly non-cooperative behavior. Without solving this problem, it is not possible to adequately make any strategic decisions. The measuring method presented and its integration into the negotiation strategy of software agents presents a first step in closing this gap.

This contribution is compiled as follows: In the first section, a measuring model for quantifying market-related negotiation behavior for commodity goods is presented based on statistical reference points of bilateral price negotiations. In the second section, this method is integrated into a microeconomic model which is implemented into software agents. The evaluation is performed in the third section with experiments in a prototypical electronic marketplace. Both the effectiveness of the measuring method and the adaptability of the software agents' negotiation behavior are demonstrated and it is shown that coordination of the market can be achieved with its implementation.

QUANTIFYING MARKETPLACE-RELATED NEGOTIATION BEHAVIOR

Parameters for Quantifying the Opening of a Negotiation

Price negotiations can generally be subdivided into two phases which require separate examination. The first phase is the opening of the negotiation as part of the initiation phase of economic transactions. The second phase is the negotiation proper as part of the contract optimization or the agreement phase (Schmid 1993). A complete automation of bilateral price negotiations is only possible when a formal, microeconomic-based model for their decision-finding and action-choosing can be implemented in both phases.

The opening requires the fixing of the initial offers of both transaction partners, through which the extent of the negotiation leeway and the concrete form of the chosen strategies for the following price negotiation are determined. The fundamental basis for this is the software agent's aspiration¹ as well as information about the concrete negotiation partner² and the respective transaction environment, such as the previous marketplace's events or the negotiated prices (Lewicki *et al.* 1997). The respective initial offers should be adjusted to the typical negotiation leeway of the respective transaction environment and turn out differently, depending on whether small margins are negotiated or whether the negotiation takes place on a kind of "oriental bazaar".

As promising parameters for a measuring system, static reference points of price negotiations, such as reservation price, aspiration or the partner's initial offer, are suitable. The consideration of these static reference points when determining an initial offer is positively linked with the negotiation outcome (Poucke/ Buelens 2001) and feature in competitive price negotiations (Lewicki *et al.* 1997). Poucke and Buelens show in their experimental study that as much as 60% of the standard deviation of the negotiation results can be explained by static reference points, which are already fixed before the negotiation takes place. This result is of special significance for the automation of bilateral price negotiations because static reference points are easy to quantify and allow a reduction of complexity for its integration into microeconomic decision models.

The measuring method for marketplace-related negotiation behavior and leeway proposed in this contribution is thus based on historical, objectively quantifiable data of the respective marketplace, in particular on the initial offers and the realized transaction prices. Reviewing this data with statistical methods allows the actors (on the assumption that the market is relatively stable) a helpful forecast of the negotiation behavior to be expected in the future. A further advantage is that it does not require complete information but can be used decentrally, based solely on the individual experiences made by particular actors.

Measuring of the Marketplace-Related Negotiation Leeway

While the absolute negotiation leeway during a concrete negotiation is of central importance, the quantification of marketplace-related negotiation behavior proposed here is based on relative quantities. The relative negotiation leeway L_i^X of the negotiation i is calculated *ex post* for both negotiation partners ($B = \text{buyer}$, $S = \text{seller}$) according to definition (1) and gives information about the deviation between initial offer $p_i^{I,X}$ and realized transaction price $p_i^T \triangleq 100\%$.

$$L_i^X \equiv \frac{|p_i^{I,X} - p_i^T|}{p_i^T} \quad \text{with } X \in \{B, S\} \quad (1)$$

If the economic plausible condition $p_i^{I,S} \geq p_i^T \geq p_i^{I,B}$ is satisfied, it results in a relative negotiation leeway of the seller $L_i^S \geq 0$ and of the buyer $1 \geq L_i^B \geq 0$.

¹ The aspiration constitutes *the* central determinant for negotiation success and is therefore the focus of negotiation theory. This connection has been evaluated by several studies and proven as significant for instance by the "Streaker" experiment in (Raiffa 1982) or (Poucke/ Buelens 2001).

² For anonymous negotiation methods typically found in markets, it is not possible to relate previous actions to individual actors. In the information phase of transactions, therefore, only indirect methods for information recovery can be used (Kersten/ Lo 2001).

The introduced ‘negotiation leeway’ quantity always relates to a singular, concrete negotiation. However, the aggregation of the negotiations carried out on a marketplace characterizes the negotiation behavior typical of a marketplace. With its *ex post* measured relative negotiation leeway, each single negotiation then represents a single parameter value and can be used with statistical methods for a characterization of the marketplace as a whole. From an economics aspect, on the assumption that all actors are acting rationally and that the deviation of the transaction prices is small,³ interdependency between the marketplace-related negotiation leeway and the market price is expected to exist. Thus, a measuring method for quantifying the marketplace-related negotiation leeway should take this into account because it involves interesting information for the estimation of concrete negotiation situations.

A first approximation for quantifying this interdependency is given by a linear function $y = b + m x$. The seller’s negotiation leeway \bar{L}^S dependent on the transaction price p^T can be calculated according to definition (2a) and analogously for the buyer \bar{L}^B according to definition (2b).

$$\bar{L}^S \equiv b_1 + m_1 p^T \quad (2a)$$

$$\bar{L}^B \equiv b_2 + m_2 p^T \quad (2b)$$

Both parameters of the regression curve are calculated with the least-squares method.⁴ Taking the range of the individual negotiation leeway into account, the regression curves L^S and L^B are limited within the following values:

$$L^S = \max\{0, \bar{L}^S\} \quad (3a)$$

$$L^B = \max\{0, \min\{\bar{L}^B, 1\}\} \quad (3b)$$

These *ex post* calculated parameter values for sellers’ relative leeway are shown in figure 1 where each dot represents a successfully concluded transaction and its corresponding relative negotiation leeway L_i^S . The buyers’ relative negotiation leeway L_i^B is shown in figure 2.⁵ The regression curves representing the marketplace-related negotiation behavior in the form of the negotiation leeway of the sellers L^S and of the buyers L^B conditional upon the transaction price are additionally plotted.

The presented measuring of the marketplace-related negotiation behavior is designed as an independent generic module, which can basically be considered in every microeconomic negotiation model and negotiation strategy. On the basis of this simple calculation method, the measuring system is suitable for the aspired automation of bilateral price negotiations and for the implementation into software agents. Furthermore, the measuring system could be implemented as a basic service on electronic marketplaces for giving new software agents an idea about the marketplace-related negotiation behavior.

³ On markets for commodities with high market transparency, the deviation of transaction prices is usually small.

⁴ For calculating the regression curve the software agents need at least two different transaction prices.

⁵ All figures are based on a sample of parameter values presented in detail in (Sackmann 2003).

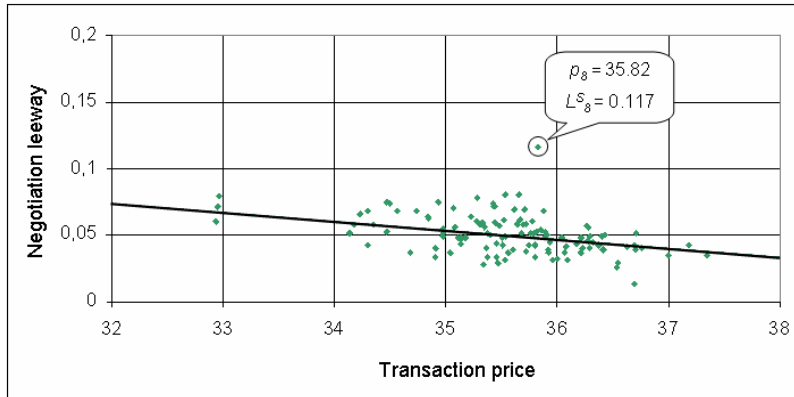


Figure 1. Marketplace-related negotiation leeway (seller)

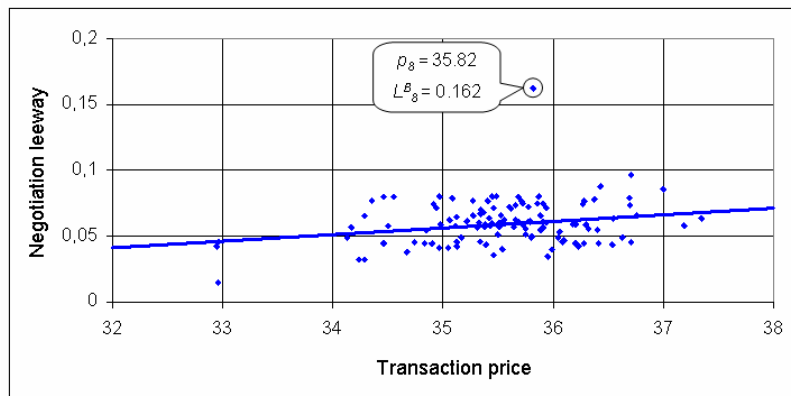


Figure 2. Marketplace-related negotiation leeway (buyer)

INTEGRATING THE MEASURING SYSTEM INTO NEGOTIATION STRATEGY

The measuring method for quantifying marketplace-related negotiation leeway has been developed with the aim of formally describing the essential characteristics of marketplaces and thus providing a prognosis tool for decision-finding in price negotiations. Based on the assumption that the negotiation behavior on a marketplace is not completely unaffected by previously observed negotiation behavior, the *ex post* calculated parameter values can be used at the beginning of a concrete negotiation for the prognosis of the negotiation behavior expected and therefore as a basis for the determination of the initial offers and the concrete negotiation.

The database for the measuring method are the previously realized transactions on the respective marketplace and, for its use, it is primarily immaterial where this information comes from.⁶ In the following heuristic behavior model, the problem of information procurement is not expounded upon and the availability of data is seen as given, at least from the actor's own negotiation history.

⁶ Whether a previous transaction on a marketplace has at all taken place is normally of minor significance in practice. (Raiffa 1982) shows that even in such cases agreements can be usually reached. Simulations furthermore show that software agents with randomly chosen reservation prices are able to negotiate successfully as long as a positive negotiation leeway exists (Eymann *et al.* 2003).

In this section, a microeconomic decision model for price negotiations is presented which firstly comes from an actor behaving in accordance with the respective marketplace. Any number of variations can be derived from this 'prototypical' strategy. A seller becomes able to fix a high initial offer by multiplying the difference between his aspiration and the calculated initial offer typical of the marketplace. Though for such an operation he needs a concrete idea of the marketplace-related negotiation behavior.

Initial Offer

The opening of a bilateral price negotiation as a rule occurs by communicating an initial offer. The fundament for the determination of its value is formed by the introduced prognosis-tool for the marketplace-related negotiation behavior or, to be precise, by using the estimated regression curves. By transforming definition (1), the initial offers can be calculated as follows:

$$p^{I,S} \equiv I^S = p^T(1 + L^S) = (1 + b_1)p^T + m_1 \cdot p^{T^2} \quad (4a)$$

$$p^{I,B} \equiv I^B = p^T(1 - L^B) = (1 - b_2)p^T - m_2 \cdot p^{T^2} \quad (4b)$$

The initial offer corresponding to the marketplace-related negotiation behavior can then be calculated by equating the transaction price with the *ex ante* fixed aspiration $p^{A,S} \stackrel{!}{=} p^T$ ($p^{A,B} \stackrel{!}{=} p^T$) and putting into the equation for calculating the marketplace-related negotiation leeway (3).

Counter-Offer versus Termination

After receiving an initial offer, the opposing actor has to decide whether he should enter into negotiation or search for an alternative negotiation partner. This decision depends on the interpretation of the initial offer received, which depends on the interpreting actor's preferences, reservation price, aspiration and idea of the marketplace-related negotiation behavior. In this section, different possibilities for using the marketplace-related negotiation behavior for interpreting initial offers are discussed and suitable reactions in accordance with the pursued strategy are shown.

After receiving an initial offer, it has to be decided whether to accept it immediately, whether to break off the negotiation or whether to open the negotiation by communicating an initial counter-offer. The easiest case is given when the initial offer received is better than the actor's aspiration, i.e. when the condition $p^{I,B} \geq p^{A,S}$ ($p^{I,S} \leq p^{A,B}$) is satisfied. For the other cases, an interpretation of the initial offer received is necessary. For the calculation of the expected opposing static reference points, the regression curves are reverted to and the step 'calculating an initial offer' is firstly inverted, i.e. the quadratic equation (4) formally solved for the expected transaction price. The seller calculates the expected transaction price p^{T*} and the expected aspiration of his opponent $p^{A,B*}$ on the basis of definition (5) and conditional upon the received initial offer of the buyer $p^{I,B}$.⁷

$$p^{T*} \equiv p^{A,B*} = -\frac{1-b_2}{2 \cdot (-m_2)} \pm \sqrt{\left(\frac{1-b_2}{2 \cdot (-m_2)}\right)^2 - \frac{p^{I,B}}{m_2}} \quad (5)$$

Depending on the aspiration, the buyer can distinguish between three economic-related cases:

Case 1: $p^{I,S} \leq p^{A,B}$: The initial offer of the seller is lower than the buyer's aspiration. The buyer should directly accept the seller's offer.

Case 2: $p^{A,S*} \leq p^{A,B}$: The expected seller's aspiration is lower than the buyer's aspiration. A simple negotiation can be expected in which both negotiation partners can reach a price better than their aspiration. The negotiation should be opened with a counter-offer.

Case 3: $p^{A,S*} > p^{A,B}$: The expected seller's aspiration is higher than the buyer's aspiration. A hard negotiation can be expected in which a successful transaction can only be reached if at least one of the negotiation partners deviates from his

⁷ The buyer can calculate the expected values accordingly. From an economics view, only those solutions are valid that are higher than the initial offer received (Raiffa 1982) and satisfy the condition $p^{I,B} \leq p^{A,B*}$.

original aspiration. In this case, a decision is necessary as to whether the negotiation should be broken off or if a counter-offer should be made. This decision can only be made in relation to the concrete transaction environment and requires a corresponding analysis and evaluation. One suitable formal method therefore is given by the measuring of the marketplace-related negotiation behavior and the reference points derived from it. While the measuring method can be used for the analysis of the marketplace-related negotiation behavior independent of the actor's concrete strategy, its consideration in the decision for a concrete negotiation is no longer possible independent of strategy.

The measuring of the marketplace-related negotiation behavior offers no explicit strategy recommendation but can be used within different strategies for fixing the value of the counter-offer. Hence, it is not possible to demonstrate the method in general. Therefore, it is illustrated by the very well-known 'tit for tat' strategy (Axelrod 1984): With a 'tit for tat' reaction on a received initial offer, the counter-offer that corresponds to the expected transaction price (aspiration) is sought after. The calculation of the counter-offer is based on the equation (6):

$$\frac{p^{T^*} - p_i^{I,B}}{p_i^{I,S} - p_i^{I,B}} = \frac{b_2 + m_2 \cdot p^{T^*}}{b_1 + b_2 + (m_1 + m_2) \cdot p^{T^*}} \quad (6)$$

The expected transaction price p^{T^*} is then equated with the aspiration $p^{A,X}$ (with $X \in \{S, B\}$). The counter-offer is calculated as follows:

$$p^{I,S} = p^{A,S} + \frac{b_1 + m_1 \cdot p^{A,S}}{b_2 + m_2 \cdot p^{A,S}} \cdot (p^{A,S} - p^{I,B}) \quad (7a)$$

$$p^{I,B} = p^{A,B} - \frac{b_2 + m_2 \cdot p^{A,B}}{b_1 + m_1 \cdot p^{A,B}} \cdot (p^{I,S} - p^{A,B}) \quad (7b)$$

There are a number of other strategies for fixing the value of counter-offers that differ in their particular consideration of the marketplace-related negotiation behavior and also require an appropriate examination of the attainability of a satisfactory negotiation outcome.

EVALUATION OF THE MEASURING SYSTEM WITH A MULTI-AGENT SYSTEM

The evaluation of the measuring method proposed has been carried out by its integration into software agents in the form of a heuristic negotiation strategy and by sending them onto a prototypical electronic marketplace. The software used for the simulations carried out is based on the multi-agent system 'B2BOS'⁸ that has been developed at the Institute of Computer Science & Social Studies at the University of Freiburg. It has been introduced with several publications, e.g. (Eymann 2002), (Padovan *et al.* 2002).

The software agents implemented for the evaluation of the measuring method have a heuristically-adaptive strategy for their price-finding which is oriented on the work of (Cliff 1997), (Preist/ Tol 1998) and on the so-called 'variation-imitation-decision' model of (Brenner 1999). This strategy offers several starting points for an integration of the measuring method presented.⁹ For checking and adapting the idea of current market prices, the software agents use any price information they can get through successfully terminated or abandoned negotiations. The adaptation is then realized by a modified 'derivative-following' strategy (Greenwald/ Kephart 2001). Thus, the software agents adopt their idea of the actual market price after successful negotiations by equating the realized transaction price with the idea of the actual market price assuming that this price can be realized again. In the case of abandoned negotiations, the last counter-offer at which the transaction could have been successfully terminated enters the actual market price concept, weighted with a factor fixed in the software agent's strategy. This kind of adaptation corresponds to a 'trial and error' action and performs an incremental change of the parameter value after each negotiation.

For evaluating the functionality and consequences of the measuring method, the execution of several simulation series is described in the following sections. The quality of the measuring system is analyzed and evaluated within the intentionally simply kept simulation environment. Firstly, the simulation of a reference scenario without use of the measuring method is described. Secondly, the functionality of the measuring system is checked by its implementation in a single agent and thirdly

⁸ <http://b2bos.sourceforge.net>.

⁹ The used strategic parameters are described in (Eymann 2002).

the consequences of using the measuring system by all software agents on the coordination of the whole system are investigated.

Reference scenario without use of measuring method

The reference scenario is set up as follows: Twelve software agents are brought in on each side of the market, fixing their initial offers moderately above their concept of the market price. Buyers are started with the idea of buying for 30 units, sellers with an idea of selling for 40 units. The reservation prices of the buyers, just as sellers, are chosen in such a way that for each negotiation a positive leeway exists. Figure 3 shows an exemplary simulation run. Every dot represents a successfully terminated transaction (713 transactions were successfully terminated, the average transaction price came to 35.21 units with a standard derivation of 0.98).

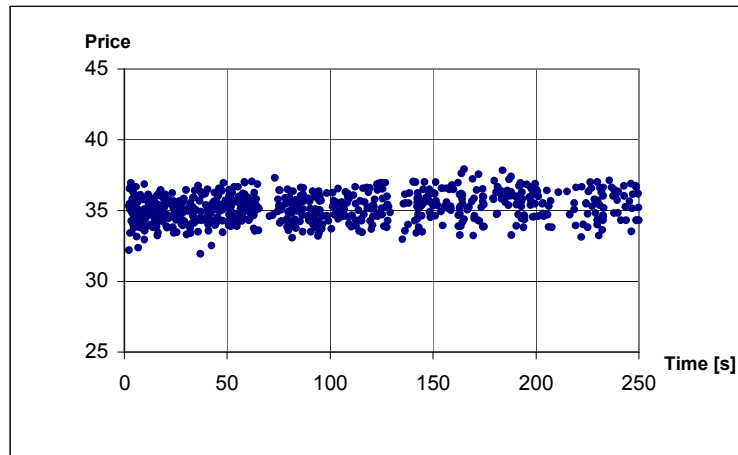


Figure 3. Development of the price (reference scenario)

All simulations carried out have shown that on a macroeconomic level the expected coordination of the system can be reached and occurs emergently from the sole direct interaction of the software agents. It is not promoted by any central component.

Integration of the Measuring Method into Software Agents

In a second step, the functionality of the measuring system itself and its integration into the negotiation behavior of the software agents is evaluated. This evaluation is made on the basis of three scenarios. Firstly, it is shown that the measuring system can be used decentrally without fully informed software agents and that it reflects the real negotiation behavior observed on the macroeconomic level. Secondly, it is shown that, by using the implemented measuring system, a single software agent is able to adapt its negotiation behavior to a formerly unknown marketplace-related negotiation behavior and can thus increase its economic success. Thirdly, it is shown that the coordination on the marketplace can still be reached when all software agents use the measuring system and that this does not result in a break-down of coordination.

Decentralized use of the Measuring System

The first simulation run for reviewing the functionality of the measuring system by using it decentrally and without fully informed software agents corresponds in its configuration to the introduced reference scenario. Merely one of the 12 buyer agents uses the measuring system. This software agent acts as long as the other software agents until it has enough transaction experience for calculating the regression curve. After that, it changes its negotiation behavior in two aspects: Firstly, the initial offers are calculated by the method introduced above. Secondly, the value of the counter-offer is no longer independent of the initial offer received. The received initial offer also influences both the reaction and the fixing of the counter-offer.

If the available data is exclusively derived from the transaction history of a single buyer agent,¹⁰ it is not possible to directly estimate the marketplace-related total negotiation behavior of the buyers through one single buyer and thus this side of the market cannot be adequately estimated without additional information.¹¹ However, the opposite side of the market can be estimated directly. Figure 4 shows three ‘snapshots’ which represent the estimated regression curve regarding the negotiation behavior of the sellers by a buyer. The unbroken line is calculated by taking all negotiations on the marketplace into account. The slashed line represents the negotiation behavior and is based exclusively on buyers’ own negotiation history. The clear approximation of the results of the decentralized measurement with incomplete information to the results of the centralized measurement was observable in all simulation runs carried out.

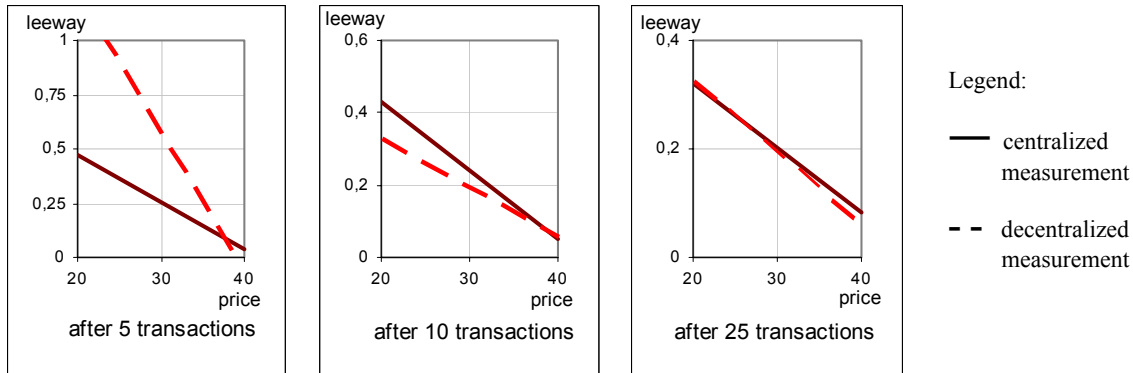


Figure 4. Decentralized versus centralized measurement of the marketplace-related negotiation leeway

The measurement method proposed consequently offers the possibility to conclude from the aspiration of the partner and the transaction price to be expected from an initial offer received. The estimation of the transaction price to be expected and its consideration in the individual negotiation strategy lead to a positive effect on the software agents negotiation effort, thus significantly less negotiations are abandoned and less negotiation is needed for reaching successful agreements.

Adaptation of the Negotiation Strategy by Using the Measurement Method

For the second simulation run, two software agents with differing parameter settings are started with the aim of evaluating their adaptation behavior. These software agents enter a marketplace with a ‘wrong’ idea of marketplace-related negotiation behavior,¹² though one software agent is started with the measuring system integrated, while the control agent is started without it.

In figure 5, a further simulation run is shown.¹³ The dark points represent the transaction prices realized on the marketplace. The bright points directly below represent the initial offers of the ‘typical’ buyers. The initial offers of the modified software agent using the measuring system are marked in with black triangles. The initial offers of the control agent are marked in with grey rhombuses. At the beginning, the behavior of the modified software agents is identical and there is no difference in the size of their initial offers. After 50 seconds, the modified software agent has collected enough (at minimum two) parameter values and starts to use its ‘measured idea’ of the marketplace-related negotiation behavior for adapting its own negotiation behavior and for setting its initial offers.

¹⁰ All following findings can be transferred analogously to seller agents.

¹¹ The negotiation behavior of the other buyers can only be indirectly observed and estimated. For a more detailed discussion of the arising lock in-effects and possible countermeasures, see (Sackmann 2003).

¹² In the simulation, the marketplace-related negotiation leeway is 15%. The buyer agents with the ‘wrong’ idea take 55% as their starting point and are thus fixing their initial offers ‘extremely’ low in comparison with the other buyers.

¹³ The stabilization of the market price occurs on different levels depending on the simulation run. This can be explained by the heterogeneity of the software agents’ parameter settings regarding their concessions and also by the ‘extreme’ initial offers (Sackmann 2003).

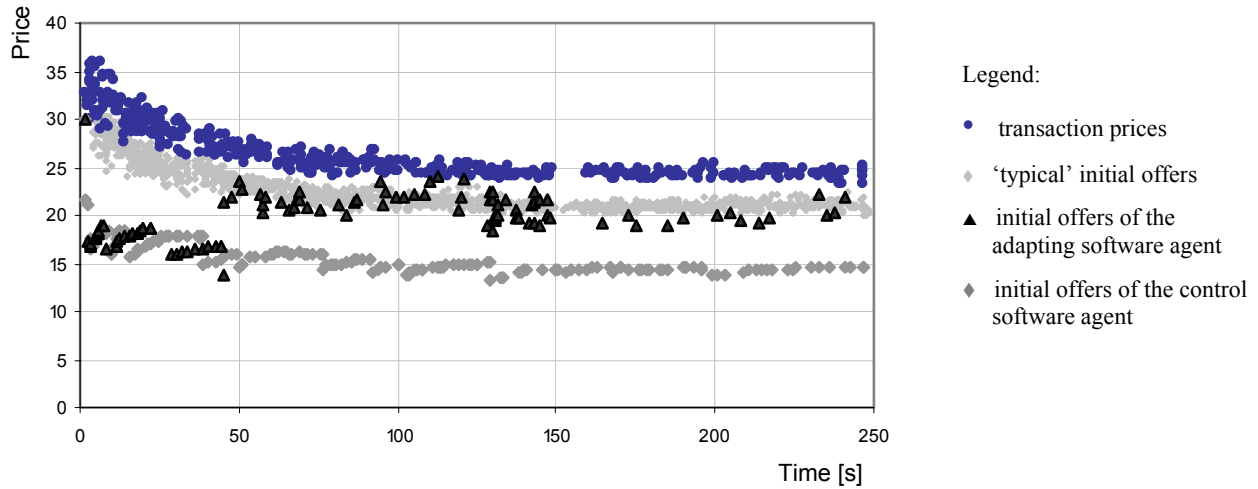


Figure 5. Adjustment of initial offers to the marketplace-related negotiation leeway

The analysis of the simulation runs furthermore shows that the modified software agent requires less negotiation steps and successfully concludes more transactions than the control agent. Thus, the simulation results anticipate that the use of the proposed measuring system also offers a possibility of realizing an automated estimation of the transaction environment for software agents or services in open systems.

Integration of the Measuring System into all Software Agents

In the last simulation run, the focus is directed on the macroeconomic level. The effect the use of the measuring system has on the coordination of an electronic marketplace when *all* software agents are using it is evaluated. The simulations carried out generally show that also in this scenario the coordination of the software agents also occurs emergently and that the software agents get used to each other's way of negotiation and therefore generate a marketplace-related negotiation behavior only by their bilateral interaction.

A further example of the self-coordination of the software agents is shown in figure 6. This simulation has been carried out with the same parameter setting as the simulation above. On the basis of its first executed transactions, one of the buyer forms a 'wrong' estimation of the marketplace-related negotiation behavior and hence starts to fix 'untypical' initial offers. After several failed trials, it succeeds both in correcting its estimation and adapting its negotiation behavior to that of the other software agents. With ongoing simulation, a stable marketplace-related negotiation behavior ensues.

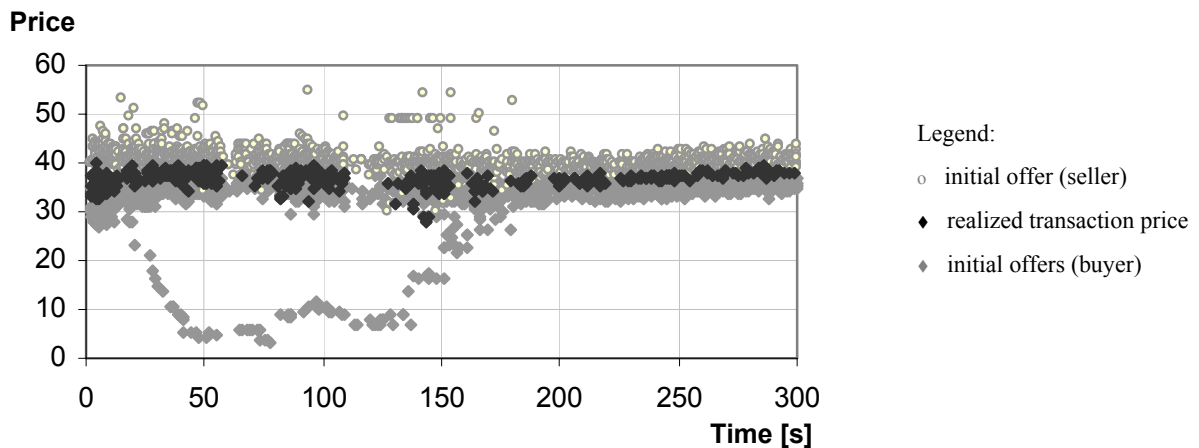


Figure 6. Example of self-coordination

The simulation results anticipate that with the consideration of marketplace-related negotiation behavior by the software agents, the coordination of the electronic marketplace is not at risk. Furthermore, the provision of the information about the marketplace-related negotiation behavior could be offered as a service of the marketplace itself and therefore give new software agents a chance for a faster adaptation of their negotiation behavior and a chance to realize their individual negotiation strategy.

Simulation Results and Interpretation

The simulations presented show that the proposed measuring method can be used decentrally and without full information for the estimation of the marketplace-related negotiation behavior of the opposite side of the market. It also offers the possibility of automated recognition of the negotiation behavior on an electronic marketplace and with respective consideration, the negotiation behavior of software agents can be adapted to the marketplace-related negotiation behavior.

CONCLUSION

The automated execution of bilateral price negotiations by software agents requires a general concept that includes both the conducting of negotiations and an automated adaptation of the negotiation strategy to the concrete transaction environment. The measuring system presented constitutes an independent modular unit for automatically measuring the 'typical' negotiation behavior of a marketplace and can be integrated into every negotiation strategy. It can be implemented into software agents and allows them to quantify the marketplace-related negotiation behavior. The integration of the measuring method into a microeconomic behavior model is exemplified with a heuristically-adaptive negotiation strategy.

The experimental results presented are strictly seen as no formal proof of the interdependence between the integration of the measuring method and the economic success of the software agents but it is to be expected that it improves the possibilities of software agents' use in open systems. The recognition of marketplace-related negotiation behavior and the adaptation of the negotiation strategy are of special significance especially in the context of mobile use of information technology because the transaction environment can constantly change through a change in location of the services offered and demanded. On the basis of the relatively simple calculation and thus the low additional demands on the arithmetic capacity required, the measuring method is predestined for use in the context of mobile information technology with its limited capacities of end-devices.

The requests arising through the technical development for an automated execution of economic transactions and the presented results of the experimental simulations give cause for further research. The next step would be a testing outside the experimental environment and to evaluate its reliability. Therefore, it is planned to integrate the independent measuring

module into other negotiation strategies and to use it in practical application as part of the *CatNet* and *EMIKA* projects.¹⁴ Last but not least, the transferability of the measuring method onto other market-based coordination mechanisms, e.g. for measuring the marketplace-related bidding behavior in auctions, is a possible subject of further research.

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¹⁴ The *CatNet* project is supported by the EU and evaluates the decentralized coordination of software agents in dynamic application layer networks (<http://www.telematik.uni-freiburg.de>). The *EMIKA* project is supported by the German Research Foundation and evaluates decentral coordination with software agents in hospitals in real-time (Sackmann *et al.* 2002).