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Modelling and Analysis of Bargaining Process for E-Procurement of Large Enterprise Group [1]

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Abstract: To solve the bargaining problems of centralized procurement in the environment of e-commerce, we propose a visible tool named as Bargaining Process Chart to support bargaining process. By mapping any bargaining process into a curve from the point with coordinates (0,1) to the halving line of the first quadrant in Cartesian coordinates, Bargaining Process Chart makes the current and historical bargaining processes become visible. Thus, the negotiators can obtain efficient support from the useful information in their price bargaining. The bargaining process chart had been applied to the e-procurement centre of a big enterprise group in China. The application results are satisfactory.

1. INTRODUCTION

For the competition in the world market, it is a new trend in China that a number of small and medium enterprises organize a big group of enterprises. It is referred in Chinese words as "building big ship for sailing abroad". Thus, the centralized procurement becomes an efficient way to reduce the purchasing cost of materials and parts for these enterprise groups (Virolainen 1998). Since the member enterprises and suppliers possibly distribute in a large region, the e-commerce is the best choice for the centralized procurements of enterprise groups (Davila et al 2003, Olson and Boyer 2003).

The Chinese business process of centralized procurement centres usually includes two procedures: annual contract process and daily operations.

The long term contract of procurement for large enterprise groups usually depends on many factors, such as user demand, budget constraint, source quality, supplier capacity and others (Levaggi 1999, Martel et al 1995, Serel et al 2001). its basic procedure done on internet usually consists of following steps:

Step 1: The member enterprises submit their annual material requirement report to the procurement centre of groups via internet.

Step 2: The procurement centre collect all material requirement and make the annual gross purchasing plan.

Step 3: The procurement centre search for the goods sources and candidate suppliers, and calls for bidding on internet.

Step 4: The centre asks all candidate suppliers bid their possible price, goods quality, supply potential, and other additional conditions.

Step 5: The centre invites the user agents and experts with different areas to evaluate all candidates and make decision on the selection of product marks and suppliers.

Step 6: The purchasing agents negotiate and bargain with selected suppliers and conclude the annual supply contracts for various goods.

The annual contract is just a blank contract. It only fixes the price, goods quality, gross quantity and additional supply conditions. The real purchasing amount and payment depend upon the daily operations. The daily operations consist of following steps:

Step 1: Users (member enterprises) submit their weekly or daily material requirement orders to the procurement centre.

Step 2: The centre submits the orders to the right suppliers.

Step 3: Suppliers deliver the materials to the users directly.

Step 4: Users confirm the reception to the centre.

Step 5: The centre informs the financial office to pay the bill to suppliers with the contracted prices.

Except the daily goods deliver, In e-procurement, demand collection, calling bidding and negotiation, all are done via internet. The procurement cost can be greatly serving. E-business makes the communication between the procurement centre, users and suppliers much easy than before (Chiu et al 2005). Because the centralized procurement mode can bring big business to supplier, it is a typical "win-win" mode to enterprise groups and suppliers (Davila et al 2003, Olson and Boyer 2003)..

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Procurement optimization can bring lower cost and big profit to enterprises (Martel et al 1995, Sundarraj and Talluri 2003). In Chinese current business environment, sellers usually ask a very higher price than their expectation, but the buyers bargain a very lower price. In Chinese words, it calls "Asking a price on sky but bargaining in ground." Thus, there remains a large price gap for bargaining. Since the purchasing contracts of centralized procurements usually are of very large size (Levaggi 1999). The price reduction of one cent can save a big money to the buyer (Dzeng and Lin 2004). Thus, the price bargaining becomes a very hard work to the negotiators (Sucky 2007, Tang et al 1999). The purpose of our research is how to support bargaining process via the mathematical models and people's experiences from the records of historical price negotiation.

Since Nash (1950) proposed the classical bargaining problem and model in fifty years ago, the bargain and negotiation models have been an active research area (Kennedy 1998, Muthoo 1999). Bilateral and Multilateral bargaining (Krishna, and Serrano 1996, Suh and Wen 2006), multi-criterion and multistage bargaining (Sobel and Takahashi 1983), cooperative bargaining (Minner 2007), due-date bargaining (Wang et al 1998, Wang et al 1999), negotiation with asymmetric information (DeFraja and Muthoo 2000, Sucky 2007), and computerized Bargaining Support Systems were addressed by many authors (Delaney et al 1997, Jelassi, and Foroughi 1989). With the fast growth of e-business, the study on negotiation with e-commerce has been an active area also (Chiu et al 2005, Davila et al 2003, Oprea 2002).

The presented researches on bargaining and negotiation are most based on game theory (Gale and Sabourian 2006, Sebenius 1992). The advantage of game theory models is that it can achieve the benefit balance of both sellers and buyers via the equilibrium strategy. As some authors pointed out, the basic assumption of game theory is that all players are rational and rationality is common knowledge (Samuelson 1997). In view of the fact that the people in bargaining and negotiation are not always rational, the equilibrium strategy is not applied into practice.

Our purpose is just support the buyers in centralized procurement. The basic idea of this research is to design a visible tool to support buyer bidding via the analysis on seller's response. Firstly, we propose the concept of Bargaining Process Chart. The process chart is a tool to make the bargaining process visible. It records the seller's character curves in historical bargaining. We can evaluate the possible deal price for current bargaining via the historical bargaining processes. Based on the bargaining process chart, the multi-point combination method and the linear extension method for evaluation of the deal price are suggested. The definition of bargaining revenue and computational method are developed also.

The obtained result is fit the negotiator's experience very well. The bargaining process chart and revenue computation approach both are embedded into the Negotiation Support System of a real e-purchasing company of a large enterprise group in China.

2. BARGAINING PROCESS CHART

Bargaining Process Chart is tool to make the bargaining processes visible by mapping the current and historical bargaining process into a standard zone of Cartesian coordinate.

Price bargaining is a multistage bilateral negotiation. Its process can be described in the Bargaining Process Chart as follows.

Let the initial biding prices from buyer and seller are B_0 and S_0, separately. The difference is defined by:

$$\Delta = S_0 - B_0 . \quad (1)$$

Let the bidding prices of buyer and seller in k-th turn of bargaining are $P_B(k)$ and $P_S(k)$, respectively. Their coordinates in the process chart are:

$$x_k = [P_B(k) - B_0]/\Delta , \; y_k = [P_S(k) - B_0]/\Delta . \quad (2)$$

It is evident that the starting point of bargaining process is the point A with coordinate of (0,1), as shown in Fig.1. For all points in the bargaining process, the bidding prices can be calculated from its coordinates by formulas:

$$P_B(k) = B_0 + x_k\Delta \;, \; P_S(k) = B_0 + y_k\Delta . \quad (3)$$

Once the buyer and seller get agreement on the price in n-th turn of bargaining, the deal price is Z, then, we have

$$Z=P_B(n)=P_S(n). \quad (4)$$

From equations (2), it is clear that the point B with coordinated $x_n=y_n$. It means that B is in the halving line of first quadrant in Cartesian coordinates, OZ, as shown in Fig.1.

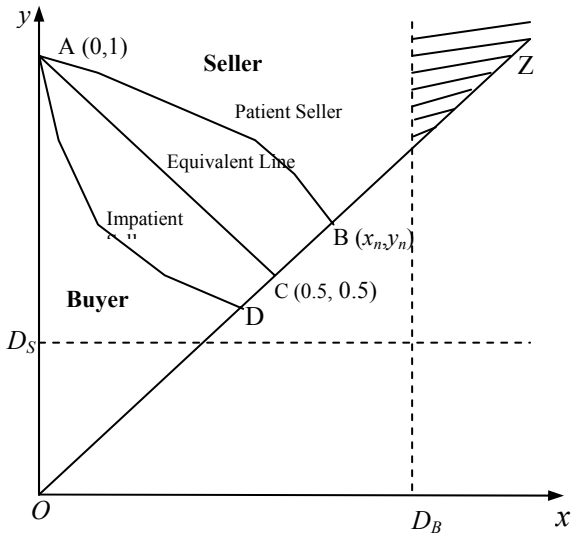

Fig. 1 The bargaining process chart

From the bargaining process chart shown in Fig. 1, we can see that any bargaining process will start at point A with (0,

1), go through a curve combined by line segments, and terminate at the halving line OZ, finally. Once the both sides of buyer and seller compromise in each turn of bidding equivalently, the bargaining process will go through the beeline AC to the terminate line OZ. AC is named as the equivalent bargaining line. For example, a seller asks \$200 for the goods, but the buyer is going to pay only \$100 for it. They begin to bargain. In each turn, the seller reduces \$10 and the buyer pluses \$10. After five turn of bargaining, they get deal at the price of \$150. The bargaining process composes just the equivalent line AC. It means that the both sides of buyer and seller share the bidding difference by 50% for each side. Once the process curves are upper the equivalent line AC, it means the seller's reduction is lower than the increment of buyer. We say that the bargaining situation is seller dominant. Contrarily, when the process curve is below AC, the situation is buyer dominant.

Usually, the buyer and seller both have their price baselines which depend on demand, market and operation cost but not on the bargaining. By using formula (2) we can easily translate the baseline prices into their coordinates, D_B and D_S. The dashed lines compose the baselines for buyer and seller in the bargaining process chart as shown in Fig.1. Since the chart is designed for buyer, e-procurement centre, we usually can know only the baseline of buyer but not that of seller. Therefore, the negotiator of buyer side has to control the process chart never into the slashed zone in Fig.1.

The process and result of bargaining depend on many factors, such as target prices, baselines, relationship and friendship, negotiation environment, and even weather. The psychological character of seller is a key factor, certainly [10]. As we know, an impatient seller possibly reduces the asked price very fast, but resists with anger when the price approaches his baseline. On other hand, a patient seller may keep his asking price with any noticeable reduction for long bargaining, but make deal kindly when his target price is achieved.

Define the response function of a seller to be:

$$y = f(x), \quad x \in (0,1), \tag{5}$$

where, *x, y* are the coordinates in the bargaining process chart.

If $f(x)$ is convex, as the curve AD in Fig.1, we refer the seller to be impatient ones. Contrarily, if $f(x)$ is concave as the curve AB, the seller is referred as patient one.

In a regular bargaining, the seller reduces the asking price monotonously; the buyer raises the biding price monotonously, too. And the seller's price is always higher than buyer's before they get deal. Consequently, we have following definition.

Definition: If a bargaining process meets following inequalities for any k-th turn of biding, k=1, 2, …, n,

$$x_k \geq x_{k-1}, \quad y_k \leq y_{k-1} \text{ and } x_k \leq y_k, \tag{6}$$

we refer it as a *Regular Bargaining*.

Of course, a bargainer may change his/her idea irregularly. As long as both buyer and seller are rational bargainers, the conditions for regular bargaining can be met.

The main function of the Bargaining Process Chart is to provide a visible tool for price negotiation. Since the chart maps all current and historical bargaining processes into a normalized region, negotiators can easily evaluate the bargaining situation and forecast the result. For example, a negotiator faces the current bargaining situation shown in Fig.2. He/she may compare the current process with historical processes and guess that the seller is patient one. Thus, he/she can forecast that the deal may be achieved at point D.

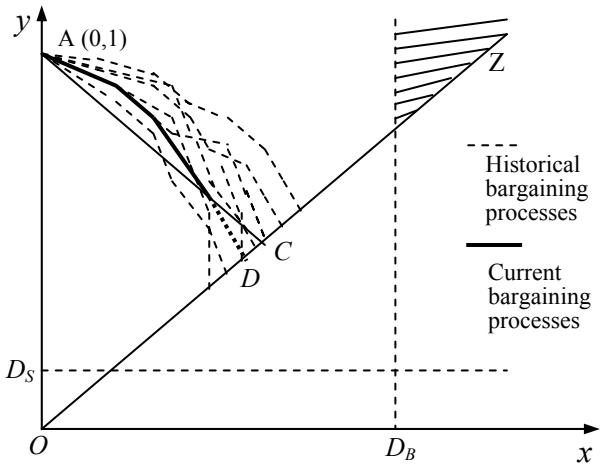

Fig.2 The comparison of current and historical bargaining

The bargaining support tool is especially suitable to the bargaining in internet. This is because that the bargainers do not face to face in internet environment. Thus, they can easily use the computer aided tools in bargaining process.

Additional to the visible function of bargaining process, the process chart can be used to evaluate the final deal price and optimize the bidding strategy. We will discuss the two functions in following sections.

3. EVALUATION OF DEAL PRICE AND BARGAINING REVENUE

3.1 Evaluation of Deal Price

The evaluation of deal price is helpful to bargainers know what can be achieved or lost in advance. Thus, they can adjust the bidding strategy on time. Based on the Bargaining Process Chart two evaluation methods, Multi-Point Combination and Final Line Extension, are developed.

1) Multi-Point Combination

Without the loss of generality, we assume after n turns of bargaining the process stops at point B with coordinate (x_n, y_n), as shown in Fig.3. The extension of the line from the

starting point A (0,1) to B crosses the bargaining terminate line OZ at point E with coordinate (z_n, z_n).

It is easily to be obtained z_n by following formula:

$$z_n = \frac{x_n}{1 + x_n - y_n}, \tag{7}$$

Then, z_n can be token as the evaluated deal price upon the n-th bargaining.

Considering the previous n turns of bargaining, the evaluated price can be calculated from their weighted summation. To set the later bargaining with larger weight, we define a forgetting factor α ($0<\alpha<1$). The weight of k-th turn bargaining is defined as:

$$\overline{w}_k = \alpha^{n-k}, \tag{8}$$

where, α^k stands for the k order power of the forgetting factor α.

To normalize the weight sum to 1, we modify the weight by:

$$w_k = \frac{\overline{w}_k}{\sum_{i=1}^{n} \overline{w}_i}. \tag{9}$$

Thus, the evaluation of final deal price can be calculated based on n turns of bargaining by the formula:

$$z = \sum_{i=1}^{n} w_i z_i, \tag{10}$$

where, z_i is the evaluation calculated by formula (7) in the i-th turn of bargaining.

It is easily to be translated from coordinate into the price by formula (2), i.e. $Z=B_0+z\Delta$.

In the case of the response function of a seller, $f(x)$, is neither convex nor concave, the process curve is rocking to right or left. The multi-point combination method would be very proper.

2) Extension of Final Line

The evaluation by multi-point combination has several disadvantages.

(i) Once $f(x)$ is either convex or concave, the slope of lines changes monotonously. Its evaluated value possibly has a larger deviation.
(ii) The evaluated value may not meet the condition of regular bargaining, i.e. the final price, z, may be larger than y_n or lesser than x_n. It cannot be accepted by users.

In this case, we recommend to adapt the method named as the extension of final line. By this method, the cross point of the extension of final line to the terminate line OZ is token as the final evaluation. As shown in Fig.3, the extension of DB crosses OZ at point F. The coordinate of F can be calculated by following formula:

$$z' = \frac{x_k y_{k-1} - x_{k-1} y_k}{x_k - x_{k-1} + y_{k-1} - y_k}, \tag{11}$$

where, z' is the coordinate of the evaluated value for the final deal price.

We can prove that the obtained evaluated price meets the conditions of regular bargaining as long as its previous bargaining is regular.

Theorem. The evaluated value of deal price by formula (11) meets the conditions of regular bargaining as long as its previous bargaining is regular.

Proof: Since the previous bargaining is regular, we have: $x_k \geq x_{k-1}$, $y_k \leq y_{k-1}$ and $x_k \leq y_k$. Then,

$$z' - x_k = \frac{x_k y_{k-1} - x_{k-1} y_k - x_k (x_k - x_{k-1} + y_{k-1} - y_k)}{x_k - x_{k-1} + y_{k-1} - y_k}$$
$$= \frac{(x_k - x_{k-1})(y_k - x_k)}{(x_k - x_{k-1}) + (y_k - x_k)} \geq 0,$$

due to the four terms in parentheses are positive, and similarly,

$$y_k - z' = \frac{y_k (x_k - x_{k-1} + y_{k-1} - y_k) - x_k y_{k-1} + x_{k-1} y_k}{x_k - x_{k-1} + y_{k-1} - y_k}$$
$$= \frac{(y_k - x_k)(y_{k-1} - y_k)}{(x_k - x_{k-1}) + (y_{k-1} - y_k)} \geq 0.$$

Therefore, $x_k \leq z' \leq y_k$ and z'=z'. It means that the inequalities of (6) can all be met. The bargaining with the evaluation of deal price is regular one.

3.2 Evaluation of Bargaining Revenue

The evaluation of bargaining revenue is important to the analysis and optimization of bargaining strategy. It is also a feasible criterion to quantify the working achievement of negotiators.

Assuming the final deal price after bargaining is z. The price baseline of buyer side is D If there is no serious bargaining, the e-procurement centre has to purchase in its baseline. Therefore, we can evaluate the bargaining revenue by formula:

$$E=(D - Z)\, Q, \tag{12}$$

where, Q is the purchasing quantity after this bargaining.

In the real life, sellers usually give different discounts with different purchasing quantities. Buyers often purchase a big amount once they get a good price. However, the larger purchasing amount may cause the higher inventory cost and

the larger risk of overstock. Hence, there is an optimal purchasing quantity, certainly.

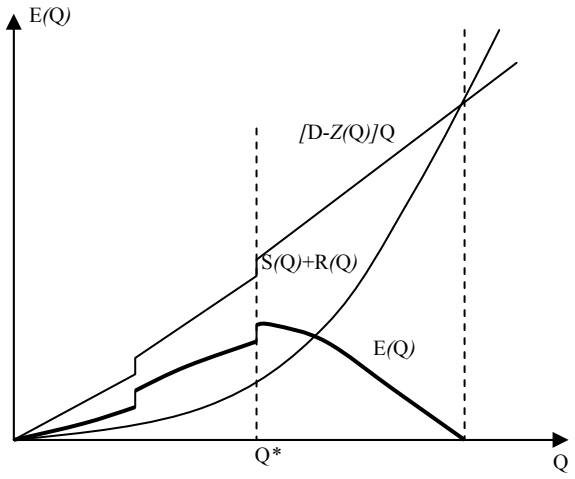

Fig.4. The bargaining revenue changes with purchasing quantity

Let the additional inventory cost be and the risk of overstock be $S(Q)$ and $R(Q)$. Then, the optimal purchasing quantity can be determined by following formula:

$$E(Q) = \max_Q [D - Z(Q)]Q - S(Q) - R(Q), \quad (13)$$

Thus, the optimal value $E(Q^*)$ from formula (13) is token as the bargaining revenue in the optimal purchasing. The changing curve of $E(Q)$ with Q is shown in Fig.4.

4. NUMERICAL EXAMPLE OF EVALUATION

To illustrate the process chart and the evaluation methods, we discuss the example in the literature (Tang et al 1999). According to the bidding and asking prices from buyer and seller in the seven turns of bargaining shown in the first two rows in Table 1, the coordinates of each side in each turn are listed in the medium two rows.

We set the forgetting factor $\alpha = 0.80$. The evaluated deal prices by the multi-point combination (marked as Z) and the extension of final line (marked as Z') in each turn are listed in the last two rows of Table 1. The corresponding process curve is shown in Fig.5.

From Table 1, we see that the evaluated deal prices of two methods are both satisfactory. Just after first bargaining, we can forecast the deal price as 20.625. It is very close to the real deal price 18.95. Although the evaluation of last turn by the multi-point combination deviates out of the regular region (18.3, 19.3) a little, it is acceptable to users in practice. The bargaining process chart makes the bargaining process be visible. Thus, the negotiator can know his/her situation with the bargaining to be going.

Table 1. The bidding prices and evaluations in each turn

Turn	0	1	2	3	4	5	6
$P_B(k)$	5	10	13.5	15.5	16.5	17.5	18.3
$P_S(k)$	30	27	24.7	23	21	20	19.3
x	0	0.20	0.34	0.42	0.46	0.50	0.532
y	1	0.88	0.788	0.72	0.64	0.60	0.572
Z	---	20.625	20.499	20.295	19.864	19.574	19.379
Z'	---	20.625	20.259	19.554	18.000	18.750	18.833

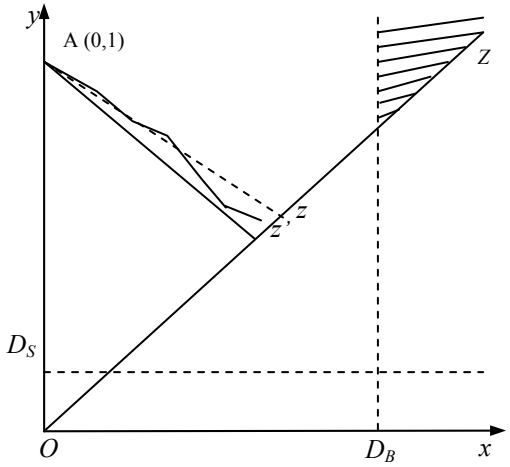

Fig.5. An example of bargaining and evaluation

5. CONCLUSIONS

Centralized procurement by internet can save purchasing cost greatly, and bring "Win-Win" to both buyers and suppliers. To support the bargaining process of e-procurement centres of large enterprise groups, we propose a visible tool named as Bargaining Process Chart. It maps various bargaining processes into a normalized space. Thus, the bargainers are able to evaluate their situation by comparing current situation with historical records. The two recommended evaluation methods for final deal price, multiply point combination and final line extension, are both efficient to buyers' analysis on bargaining situation. The bargaining revenue evaluation method provides a quantifying tool to calculate the bargainers' working achievement. It is to meet the requirement of the professional examination by Chinese enterprises to their employers.

The software embedded this approach can provide the suggestion on the best bidding strategies to the bargainers online. It will be a very helpful tool to the negotiators who are puzzled with the hard and painful bargaining of very high contract values. The bargaining support system embedded the tool is welcome by practical purchasers of large enterprise groups.

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