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Analytical Approach of Virtual Auction Scheme to Joint Purchase of Leisure Farms

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Abstract: Since Taiwan became a member of the World Trade Organization (WTO), farmers and distributors have been free to import their agricultural products into Taiwan. One of the feasible solutions to the intrusion of foreign produce has been to establish leisure farms in Taiwan. However, so many leisure farms are emerging that a new problem has been created: how to reduce the costs of producing agricultural products. In order to solve possible purchase problems that a virtual organization may face in the supply chains, we present through the application of auction mechanism a feasible purchase pattern for a virtual organization in purchasing raw materials when they face upstream suppliers. This study describes an application of the theoretical model of auction mechanism to the purchase mechanism of a virtual organization within the context of virtual organization in supply chains. Feasible purchase methods for introduction of auction mechanism under the situation of one virtual organization to single and several raw material suppliers. By means of analysis and the application of auction mechanism, this study establishment of an auction mechanism model under one-to-several situation and proposes several feasible and effective ways of helping leisure farms that use virtual organization to reduce their costs.

Key words: Virtual organization, supply chains, auction mechanism, leisure farm

INTRODUCTION

According to the definition of leisure farm in Regulations of Agricultural Development, leisure farm means a kind of agriculture that takes advantage of field landscape, natural ecology and environmental resources and combine with agricultural, forest, fishery and animal husbandry, rural culture and peasant family life to provide people with leisure activities that aim to enhance people's agricultural and rural experiences. So leisure farm has its legal basis in rural construction and development. Item 1 of Article 4 in Measures for Leisure Farm Guidance and Regulation drafted up by authorization of item 3 of article 63 of Regulations of Agricultural Development stipulates the qualifications of leisure farm area: (1) local agricultural characteristics, (2) agricultural landscape resources and (3) cultural assets of special ecology and preservation values (FAO, 2004; Geraldo *et al*., 2003).

The rural area in Taiwan now is facing declining agriculture and the flowing out of serious young population, outside keen competition and the significant impact of free import of WTO member countries after 2005 (according to the agreement, five years after joining WTO in 2000, agricultural products from WTO member countries are allowed to freely import into Taiwan), many farmers transform their agricultural activities into leisure and tourist agriculture because leisure tourism is the industry that could not be defeated by imported products. But most of current leisure farms operate independently and less integral and unified planning that need to enhance in their practices. It is necessary to solidify farmers' strength, flexibly exercise the principles of overall construction of community to combine the various resources of natural landscape, agricultural products and rural labor

forces that have rural characteristics. It will generate multiplicative effects and achieve purpose of reducing production cost to accelerate to create local job opportunities and revitalize rural economy (Rigby *et al*., 2001; Piorr, 2003).

Internet is structural development of information technology that fundamentally changed production and life style in human society. With the help of information technology and means, the patterns of exchange and acquisition of knowledge and technology changed qualitatively that is not only convenient and quick but also showing repeatedly new idea, model and methods that all traditional ideas, models and methods faced serious challenges (Kalakota and Whinston, 1998). The most outstanding challenge is the virtualization caused by information technology. Under the guidance of virtualized conception, a series of virtualized forms such as virtual community, virtual society, virtual school, virtual enterprises and virtual organization emerged. Among them, the most important are virtual enterprises and virtual organization because, for a society, enterprises are cells of economic system and economic system is the basis of existence and development of entire society (De, 1998).

Virtual Organization, or called virtual enterprises, virtual corporation, extended enterprise, virtual integration, networked enterprises, dynamic alliance, etc., some researches even include E-commerce into the scope of research on virtual organization. But no matter what the name is, they all mean temporary alliance of some independent commercial processes or business organizations under the condition of increasing enhancement of information standard (Mowshowitz, 1997; Hale and Whitlaw, 1997). The alliance might be a value chain in which the member business organizations contribute their core capabilities, realize the share of resources, information, knowledge, technology in the different rings of the value chain to adapt themselves to the rapid-changing demands from markets under the environment of information. Certainly, the alliance could be a enterprise clusters or other forms (Saabeel *et al*., 2002).

The existence of virtual organization is an objective fact and many corporations have successfully taken advantage of virtual organization to gain competitive edges. Among them, Nike is a typical example. From virtual organization, an enterprise may achieve the goals of operation and gain the incomparable speed of development and performance in other enterprises of same type in the same times. Many international well-known large companies like Dell emerged in recent one or two decades that they may go beyond many traditional giants in the same industry. One of the important reasons is the use of virtual organization. Without virtual organization, enterprises will continue to adopt the existed operation model whereas new enterprises will follow the path that the successful enterprises have walked. In this way, enterprises will be difficult, or even impossible to catch up to or go beyond those enterprises that have absolute competitive edges. If there is a possibility, it should be theoretical possibility that has little practical meaning (Lau *et al*., 2002; Cloutier *et al*., 2001).

Informationalization is a trend and common sense that is paid great attention. In turn, the theoretical research of virtual organization has become a focus point of management science. As a result, the researches of virtual enterprise and virtual organization have important realistic meaning and profound strategic meaning for a society, country or region (Wymbs, 2000). Therefore, the study is trying to apply the theoretical model of auction mechanism to the purchase mechanism of virtual organization under the background of virtual organization in supply chains. By means of effective method of auction mechanism, we hope to help leisure farms that had participated in virtual organization to achieve the goal of cost reduction.

TYPES OF AUCTION MECHANISM AND RELATED THEORIES

Following two sections will describe auction mechanism and its classification.

Auction Mechanism

Auction is an economic mechanism that is designed to determine the prices of products in a market. It means a patter of transaction in which when a mono-seller (or mono-buyer) and a group

buyers (or sellers) is trading in a market, because the mono-seller (or the mono-buyer) is not clear about demands from buyers (or sellers) for the products, the mono-seller (or the mono-buyer) calls buyers (sellers) together to bid to determine which is the most appropriate resource distribution or price. Generally speaking, when the value of a product cannot be determined by an immediate and objective standard, it is the best time to apply auction system (Turban *et al*., 2002; Prince, 1999).

McAfee and McMillan (1987) and Klein and O'Keefe (1999) argued that auction is a market system that determines resource distributions and prices on the basis of bids from participants in the market. Cramton (1998) stressed that basically auction is a mechanism of distribution and pricing of rare resources under an uncertain status.

Classification of Auction Mechanism

Market mechanism is generally divided into 1-side auction and 2-side auction in auction theories.

1-Side Auction

It means that under the condition of several buyers and one seller or several sellers and one buyer, several buyers bid for an article or several sellers ask for a purchase. The former is usually applied to auction of agricultural products, auction of sealed-up articles by court and auction of artistic articles. The latter is called procurement that is usually applied to the bidding in large engineering cases (Huhns and Vidal, 1999; Chen, 1999).

2-Side Auction

It means that there are several buyers and several sellers at the same time who could continue to observe markets and offer the prices they want to buy or sell. The final transaction price is the clearing price of market that the supply and demand is balanced. The most common example is stock, foreign currency and future transactions.

1-side auction is divided into single auction or multiple auction on the base of single or several articles for auction. Single auction can further to be divided into open auction or sealed bids auction on the base of openness whereas open auction can further to be divided into Dutch Auction and English Auction according to the directions of the rise and fall (Liang, 1999; Resnick *et al*., 2003). Sealed bids auction can be divided into the first price sealed bids auction and the second price sealed bids auction. The section will introduce the four main auctions of single auction: English auction, Dutch auction, first price sealed bids auction and second price sealed bids auction. The classifications are shown as Fig. 1 (Liang, 1996; Mogan and Brown, 2006).

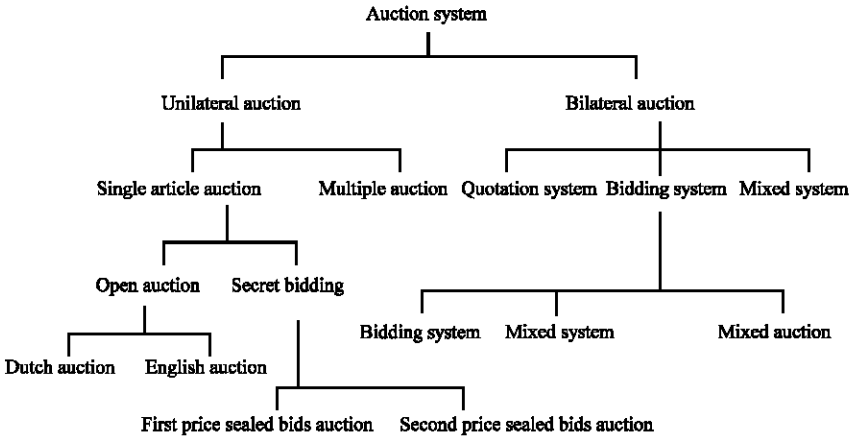

Fig. 1: The classifications of auction

THE APPLICATION OF AUCTION MECHANISM

In order to solve possible purchase problems that a virtual organization may face in the supply chains, we present through the application of auction mechanism a feasible purchase pattern for a virtual organization in purchasing raw materials when they face upstream suppliers (Byrne, 1993; Strader *et al*., 1998).

Firstly we have to clarify the types of possible relationship between virtual organization and upstream suppliers. According to the study of related literature, one-to-one and one-to-several may be the two types of the relationship (Goldman *et al*., 1995; Vickrey, 1961; Turban *et al*., 2000; Adler, 2003). The study will make different researches separately on the two types of relationship.

The Purchase Pattern of Negotiation Mechanism Between Virtual Organization and Single Raw Material Suppliers

In the relationship of supply chains, the consultation between partners is common, such as the price consultation between virtual organization and suppliers. We could describe the problem as follows: the two parties in the consultation are Virtual Organization A and Raw Material Supplier B; A wants to mandate a task to B at a specific indicator x, $x \in X$ is indicator set, X is bidding amount, x_i is the concrete indicator of the consultation between A and B, such as product price, completion date or processing quantity. A and B have consulted the realization of indicators for many times and both are trying to maximize their own interests. The problem is which strategies both parties should adopt.

In the study, we assume that Virtual Organization A needs to buy a kind of raw materials and Supplier B may supply the raw materials. Virtual Organization A and Raw Material Supplier B consult the price. Define F as the set of feasibility indicating all possible results of the consultation, C as the conflicting point indicating that if both parties cannot reach an agreement, there will be no result of agreement. Obviously, for Virtual Organization A, the conflicting point is the ceiling price they may afford while it is the bottom price Supplier B could accept. We assume:

Individual Rationality: That is, the rational individual never accepts benefits that is lower than the conflicting point. Suppose that (E_A, E_B) is the final result and c_A and c_B are conflicting points for both parties, then

$$E_A \leq c_A \tag{1}$$

$$E_B \geq c_B \tag{2}$$

The premise indicates that the purpose of consultation is to find higher effectiveness between buyer (hope to buy at the lowest price) and seller (hope to sell at the highest price).

Group Rationality: If a possible result S_1 could make both parties obtain higher benefit than the other result could. That is, if

$$E_A(S_1) > E_A(S_2) \tag{3}$$

$$E_B(S_1) > E_B(S_2) \tag{4}$$

$$(E_A(S_1), > E_B(S_1)) \in F \tag{5}$$

$$(E_A(S_2), > E_B(S_2)) \in F \tag{6}$$

then (z_A (S_2), z_B (S_2)) certainly is not the final result. Among them, z_A, z_B are effectiveness for Raw Material B and Virtual Organization A.

Both parties have full knowledge of their own interest, rules of consultation, the structure of indicator set and have partly or full knowledge of benefit requested by the counterpart.

Under such circumstance, the process of consultation is: with a hope to reach agreement, Raw Material B offers the price P_B, Virtual Organization A counter-offers P_A that is not accepted by B. B thus offers a new price for a new round consultation. The consultation will continue in this cycle until both parties reach an agreement. The process of consultation can be indicated as:

$$Z_1 (P_B) = E_A (P_B) - c_1 \tag{7}$$

In the Eq. 7, Z_1 (P_B) is the net profit Raw Material Supplier B gains from P_B and E_A (P_B) is the profit of Virtual Organization A, c_1 is the price that A could afford. In the same way, the net profit Raw Material Supplier B gains from P_A is

$$Z_1 (P_A) = E_A (P_A) - c_1 \tag{8}$$

Obviously,

$$Z_1(P_B) > Z_1(P_A) \tag{9}$$

If Raw Material Supplier insist on the offer P_B, then there are two possibilities:

- Virtual Organization A accepts P_B and both parties reach an agreement, or
- Virtual Organization A rejects P_B and the consultation suspends.

Raw Material B faces choices, so does Virtual Organization A. To solve the problem, we adopt related methods in economic theory under uncertain situation:

Assume the probability of Virtual Organization A rejecting Raw Material Supplier B's offer P_B is P, so1-P is the probability of Virtual Organization A accepting price P_B. At this point, Virtual Organization A will gain net profit Z_2 (P_B). According to risk policy-decision theory, the rational behaviors of Raw Material Supplier B is:

When $Z_1 (P_A) > (1-P) Z_1 (P_B)$, that is when $Z_1 (P_B) - Z_1 (P_A))/Z_1 (P_B) < P$, Raw Material Supplier B may accept Virtual Organization B's counter-offer.

When $Z_1 (P_B) - Z_1 (P_A))/Z_1 (P_B) > P$, Raw Material Supplier B will insist on their own offer.

So, formula $Z_1 (P_B) - Z_1 (P_A))/Z_1 (P_B)$, indicates Raw Material Supplier B's determination to insist on their offer.

In the same way, indicates Virtual A's determination to insist on their offer. Suppose here that if one party in the consultation finds that the counterpart's determination to insist on offer is greater than their own determination, they would make a concession. The extent of concession is to make their own determination to insist on new offer greater their counterpart's determination to insist on original offer. If the extent of determination of both parties is equal, then both parties make a little concession at the same time. After concession, both parties may continue to consult in the new situation and the final conclusion will go to a balance point.

Therefore, we could describe above-mentioned problems as follows: both parties give their offer because of their own selfish motives. Generally speaking, at the beginning of consultation, both parties will not accept their counterpart's offer. According to above analyses, one party (both parties) will

make concessions and give new offer(s). After concession, if they still could not reach agreement, then one party will make concession. The concessions will go on until the product of net profit of both parties is maximum.

Feasible Purchase Methods for Introduction of Auction Mechanism under the Situation of One Virtual Organization to Several Raw Material Supplier

The measure the paper expects to adopt for solving one to several cooperative relationship is the introduction of auction mechanism into the process of establishment of cooperative relationship in supply chains.

Auction mechanism could introduce competition on the tender side and is helpful to the showing of real values of task indicators to bidding side and could help who invites bidding to gain higher utility. Contract Net is a more matured measure that both parties cooperate through inviting tender to bid for a task, bidding and signing contract. The party who invites bidding breaks down the task before broadcasts sub-tasks to all, possible and potential cooperative partner enterprises through proper routes. Other related enterprises would decide whether to bid after receiving invitation and considering their capability and interest. The party who invites bidding will select successful bidders according to their highest offers (the lowest offers in the study) and reward sub-tasks. The successful bidders implements sub-tasks and bring back results. The party who invites bidding then combines the sub-tasks and submit upper lever party who invites bidding. Contract Net adopts simple "price" priority to determine successful bidder and in fact, it is only one of auction mechanisms.

Most common auction mechanisms that meet requirements of characteristics of establishment of cooperative relationship in supply chains:

English Auction

The bidding-inviter sets a starting price for auction, the tenders compete in offers and the bidder who offers the lowest price will be the successful bidder for a task. That is the most common form in auction.

Dutch Auction

The bidding-inviter set a very low indicator/price in advance and raise the indicator step by step. The first one who accepts the indicator will be the successful bidder and reward the task to the bidder at the indicator.

First Price Sealed Auction

The bidders secretly offer their indicators. The bidding-inviter selects the one who offers the lowest price as the successful bidder who should accept the task according to their offered indicator.

Second Price Sealed Auction or Vickrey Auction

The bidding and the selection of a successful bidder is same as First Price Sealed Auction except that the indicator is determined by the second lowest value in all offers.

Establishment of An Auction Mechanism Model under One-to-Several Situation

In the process of auction, the participants are bidding-inviter A-Virtual Organization, bidder B-Raw Material Supplier (B is a set, B_i is the ith raw material supplier, i = 1, 2, ...,n). The task of bidding is $x \in X$ and we take X as standard interval (0, 1). Following bindings should be met:

- The premise for designing bidding is:

$$Per(Tar^{aution} \mid T_r) = C_r(T_r) - C_r(T_r - T^{aution}) > 0 \quad (10)$$

- The premise for participating bidding is:

$$Per(T^{aution} \mid T_q) = C_q(T^{aution} \cup T_q) - C_q(T_q) > 0 \tag{11}$$

Per represents profit, C represents cost function, T is bidding task.

Bidding Strategy

For fixed bidding task T, has real value R_i to T and R_i is the private type space of B_i. Here the private type means private internal information, related situation or data that corresponding bidder B_i understands but others could not be sure.

Auction Strategy

According to the offer $\bar{b} = (b_1,...,b_n)$ by B, the bidding-inviter A selects B_i as the successful bidder with a certain probability P_i. The selection of P_i depends on the design of auction by bidding-inviter A.

The Results of Auction

B_i accepts task indicator x, bidding-inviter A obtains effectiveness E_A (x), E_A(x), is not negative value and strict increasing function of x; B_i obtains effectiveness E_j (r_i, t_i, x), E_j (r_i, t_i, x) is not negative value and strict monotone decreasing function. The effectiveness E_j ($j \neq i$) is 0. In fact, according to the auction theory, we could design some kinds of auction mechanisms. The above-mentioned auction models are only special examples in auction models. In selecting auction pattern, the bidding-inviters, in fact, is selecting or designing a game rule. The design of auction mechanism directly determines the size of profit for bidding-inviter. The design of auction mechanism falls within the field of research of game under incomplete information. It includes three stages:

- Bidding-inviter designs auction rule and signals to bidders with the rule
- Bidders decide whether to accept the rule and the premise is they have to meet the requirement of binding for participation
- Bidders determine their own behaviors in the auction according the rule

Because every participant is rational, B_i is inclined to offer low bidding price in the auction (in the plan, B_i is inclined to offer high bidding price). Meanwhile, because the bidder may adopt means of hiding and alliance, the profit of bidding-inviter may be affected. In fact, for the offers of bidders, $\bar{b} = (b_1,...,b_n)$, A hopes to obtain the real evaluation R_i by B_i. The meaning goes without saying that evaluations could reflect the real evaluations of bidding task T from bidders. According to Revelation Principle, we give the principle of design for auction mechanism. Under such principle, the offers from bidders should be the real evaluation of T.

Supposing B is the set of n bidders whose real evaluations of T are R_i (i = 1, 2,...,n) and satisfy the standard distribution of (0, 1), we design following auction mechanism: The bidder B_i indicates that their bidding price is b_i, but the concluded price is $pr_i = \frac{b_i}{\theta}$, the probability of successful bidding for the bidder B_i is

$$q_i = \frac{b_i}{\sum_{k=1}^{n} b_k} \qquad \sum_{i=1}^{n} q_i = 1 \tag{12}$$

Suppose the bidding price b_i of B_i linear homogeneous, that is $bi = k_i R_i$. The expected profit of bidder B_i for bidding price b_i is:

$$E = \frac{b_i}{\sum_{k=1}^{n} b_k} \times (R_i - \frac{b_i}{\theta}) = \frac{k_i R_i}{\sum_{k=1}^{n} b_k} \times (V_i - \frac{k_i R_i}{\theta}) \tag{13}$$

For rational bidders, their hope is that the expected profit could be maximum, that is

$$\max_{k_i} [\frac{R_i^2}{\sum_{k=1}^{n} b_k} \times (\frac{k_i \theta - k_i^2}{\theta})] \tag{14}$$

The one-order condition is the above formula to k_i, differentiate and obtain

$$k_i = \frac{\theta}{2} \tag{15}$$

So-called tell the truth by bidders is $k_i = 1$, $b_i = R_i$. Thus, we could learn that when, $\theta = 2$, all bidders will give their real evaluation of T, no matter how others bid. So we design a new auction pattern in which the bidders offer their prices for T, the probability of successful bidding is strict increasing function of their offer. The concluded price is 1/2 of offer. That could prove that rational bidders surely tell the truth under such auction mechanism.

Followings are brief analyses of above-mentioned auction mechanism:

- From the angle of realization, English auction and Dutch auction need a bidding occasion established by the bidding-inviter and solve the problem of simultaneous information in communicating with more than one bidders. But the realization of the first and the second price sealed bids are relatively simple that the only thing need to do is to guarantee the dependability of communication channels.
- From the angle of communication cost, English auction and Dutch auction have to adopt broadcasting communications each time to inform all bidders about bidding results, the amount of communications will linearly increase with the times of auction whereas the first and the second price sealed bid auctions need only one bid.
- From the angle of calculation of strategies representing the task demander and service provider, for bidding-inviter, it is easy to adopt scaling methods of English auction or Dutch auction. Two sealed bid auctions need a process of order-arrangement of indicators that will not be a problem. Therefore, we may focus our consideration on bidders' bidding policy.

Followings are best calculation methods of bidding strategies for bidders.

Under the situation in which above conditions are satisfied, the best bidding strategy for bidder B_i is:

- English Auction: Properly raise the price each time until the bidding price goes beyond R_i
- Dutch Auction: Same as the first price sealed bids auction
- First Price Sealed Auction: n is the number of bidders

$$b_i^* = \frac{n-1}{n} R_i \tag{16}$$

- Second price sealed bids auction:

$$b_i^* = R_i \tag{17}$$

From the view of effects of bidding, the offer of English auction is lower. The offers of bidders in Dutch auction and the first price sealed bids auction have linear corresponding relationship with real evaluation and they are closer to real evaluation with the increase of the number of participants.

Therefore, this study concludes that the second price sealed bids auction is the best fittest auction mechanism for virtual organization and raw materials to establish cooperative relationship in the supply chains. In general, according to auction mechanism, a bidding-inviter could select a right bidder. Certainly, there is possibility of failure of auction. At this point, the bidding-inviter could ease the restrictions of indicators and bid again or select possible cooperative enterprise from the results of previous bidding and establish cooperative relationship through further negotiations.

CONCLUSIONS

This study aims to apply the theoretical model of auction mechanism to the purchase mechanism of virtual organization under the background of virtual organization in supply chains. By means of the analyses and application of auction mechanism, the paper proposed feasible and effective ways to help leisure farms that had participated in virtual organization to achieve the goal of cost reduction. The study also adopted the second price sealed bids auction mechanism under the complex situation of one virtual organization to several suppliers to establish the mode of purchase pattern for virtual organizations.

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