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Vendor selection and management in environmental purchase

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ABSTRACT

Vendor selection and management is an important part of environmental purchase in green supply chains. This article explores how to determine suitable suppliers and manage them in supply chain. Although there are many approaches having been put forward by previous researches, considering the complexity these decisions, the paper conducts an analysis for the first time on how to select desired suppliers in bidding process and then discusses how to manage the chosen suppliers by Game Theory. After the selection of suppliers, in order to avoid the adverse selection of suppliers, there must have the appropriate incentives to the supplier.

KEYWORDS

Vendor selection; Vendor management; Environmental purchase; Green supply chain; Incentive mechanism.

INTRODUCTION

Purchase is a boundary-spanning function within the supply chain. The world has witnessed a dramatic increase in environmental consciousness in recent years. Vendor selection and management is an important part of environmental purchase (also known as green purchase) in green supply chains. Environmental purchase is defined as purchasers' involvement in supply chain management activities in order to facilitate recycling, reuse and source reduction (Carter, 1998)[1]. Some other researchers also called environmental purchase socially responsible buying (Drumright, 1994)[2]. The empirical work on this topic consists primarily of surveys of purchasing professionals. It does not examine the process through which the buying decision is made or the manner in which the noneconomic criterion is integrated with other considerations. Procurement personnel can play a key role in environmental purchase. Purchasing department is in an advantageous position to assess the firm's peripheral environment for product and process change. By being located at the beginning of the forward flow of materials within an organization, purchasing is placed in an advantageous position to implement resource reduction activities (Ho LWP et al., 2010)[3].

VENDOR SELECTION BY BIDDING

The selection of "optimal suppliers" for environmental purchase in supply chain should be conducted in order to realize the aim of environment and efficient supply. Hence, a systematic and goal-oriented process of supplier selection is needed. Sometimes, the existing procedures in the field of supplier evaluation do not take environmental factors into consideration.

Generally speaking, procurement by bidding fully reflects the equality, credibility, legitimacy of the modern competitive practices, which is an organized, public, regulatory competition, and is an advanced form of competition. Environmental performance in itself contains a number of standards. Suppliers' selection in environmental purchase can be a complex task for managers in charge of purchasing, in which they should take the specific needs of economic benefits and environmental performance into consideration, and then weigh among the different indicators. Thus, more and more procurement in green supply chain should be and have been conducted by bidding.

We use game theory to analyze green procurement in the market access for suppliers (signal) in the bidding game. It is assumed that all the players in the game are rational, who pursue their own maximizing utility. In the process of analyzing suppliers' capability, it is necessary for managers to consider whether the suppliers' performance could be in line with environmental purchasing target of buyers, and to consider whether suppliers have the will and potential of improvement according to environmental requirements. Select qualified suppliers and their products by bidding in green procurement. The following analysis is based on Bayesian game model. In the green procurement bidding, bids were open, in which there are a total of n (usually $n \geq 3$) bidders in bidding. Before the opening, bid price will be submitted to the purchaser by sealed documents. Bidder's price is their cost plus reasonable profit. Besides price of the procured products, environmental factors should also be included in the bid. After comprehensive consideration, the purchaser will select the winning bidder. Each bidder determine their own costs while the other bidders do not know the true costs of others and only know the probability distribution of bidding activities. The bidding is static game of incomplete information, so Bayesian equilibrium exists.

$$ui(bi,bj,ci) = \begin{cases} bi-ci, & \text{when } bi<bj \\ (bi-ci)/n, & \text{when } bi=bj \\ 0, & \text{when } bi>bj \end{cases}$$

In that, j=1,2,...i,i+1,...n

Suppose bidder i's price and cost of tender were bi (bi> 0) and ci (ci> 0), the other bidders do not know the exact value of ci, but know that ci is defined independently from [0, 1] uniform distribution function. Assume that the bidders are risk neutral and the utility function is linear. For simplicity, we ignore the cost to participate in bidding activities. Bidder i's payoff function is:

Since the game is symmetric, in the process of analysis we only consider the symmetric equilibrium offer b = b * (c).

Let the cost bidder i is c, quoted at b, then his expected return is: $Eu_i=(b-c)\prod_{j\neq i}p\ (b<b_j)$

Where (bc) is the successful bidder's net profit, $\prod p\ (b<b_j)$ is the probability of winning the bid, bj is the price of the bidder j, bj is a function on the cj. $P\ (b<b_j) = p\ (b\leq b_j)= p\ (b\leq b^*\ (c_j)$

When the price quoted is b, his cost is c (b), c is defined independently from [0,1] uniform distribution function. $Eu_i=(b-c)\prod_{j\neq i}p\ (b<b_j)= (b-c)\ (c\ (b))^{n-1}$

The goal of the bidders is to maximize their own utility, that is, to make the function take maximum value, which is available by Bayesian equilibrium: $b^*(c)=(n-1)c/n$

It can be seen from the above formula, with increasing n,, b * (c) decreases. When n tends to infinity, b * (c) equals to c. That is, the number of people to bid more, the closer the actual cost of each bid, the purchaser can get a lower price of goods suppliers and the higher the efficiency of green procurement. In practice, though there is not the possibility of an infinite number of suppliers, but the cost can be permitted in the case of the bidder and invite more bidders. In the case of the same quality, through the competition among bidders, the purchaser can get a lower purchase price.

SUPPLIER INCENTIVE MECHANISM IN GREEN SUPPLY CHAIN

In many cases, the purchaser can't get all information of the supplier. Information asymmetry exists, so there will be adverse selection. After the selection of suppliers, in order to avoid the adverse selection of suppliers, there must have the appropriate incentives to the supplier. By the reasonable design the incentive mechanism, the two sides increased propensity to cooperation.

Supplier incentive mechanism –an incomplete information game

Mechanism design is actually a three-stage game of incomplete information (Fudenberg, 2002)[4].

The first stage: the purchaser designs a mechanism, that is, the game rules. According to this rule, the supplier sends a signal. The second stage: suppliers choose to accept or reject the mechanism. If rejects, it means the suppliers reject to participate the game. The general assumption is that the suppliers can get some kind of "reservation utility". In our discussion, we assume supplier will accept the incentive mechanism. The third stage: supplier will game according to mechanism design.
In the discussion of the following game, we assume there is only one supplier involved in the game.

Let A be all selected combination of actions of the supplier. a $\in A$ represents a particular action of the supplier. Let θ(θ~(0, σ2) obeys a normal distribution, which is a exogenous random variable not affected by the supplier and the purchaser, representing uncertain factors affecting output. H is the range of θ and the distribution function and the density function are G (θ) and g(θ)respectively. A and θ determine an observable results of profit x (a,θ)and output π (a,θ). Assume π is a concave function of a and π is strictly increasing function ofθ, in that x=π. C (a) is the supplier's cost.

The purchaser needs to design an incentive contract s(π). According to the observedπ (a,θ), the purchaser will award or punish the supplier.

Assume the expected utility function of the purchaser and supplier are u(π-S(π)) and v(S(π)-c(a))respectively, in that $v' > 0, v'' \leq 0$, $u' \rangle 0$, $u'' \leq 0$, $c' > 0, c'' > 0$; $c' > 0$ means the purchaser needs more incentive to encourage the supplier.

The expected utility function of the purchaser is $\int u(\pi(a,\theta)-s(\pi(a,\theta)))g(\theta)d\theta$. The purchaser should select a and s(π) to maximize the expected utility function. However, when the purchaser is doing so, he will face two constraints. The first constraint is participation, which is utility the supplier gets from contracts is not less than the utility of not accepting the contract, i.e. $\int v(s(\pi(a,\theta)))g(\theta)d\theta - c(a) \geq \bar{v}$. The second constraint is compatibility of supplier. The purchaser cannot observe the supplier's action a and θ and in any incentive contract, the supplier always chooses a to maximize his expected utility. That is $\int v(s(\pi(a,\theta)))g(\theta)d\theta - c(a) \geq \int v(s(\pi(a',\theta)))g(\theta)d\theta - c(a')$ $a' \in A$.

Because of the information asymmetry, the purchaser cannot observe the supplier's effort, so when purchaser the formulate the incentive contract, the supplier will choose the proper level to get the maximum utility that is maxE(v(w))=max(w(s(π)-c(a)).

Analysis of the game

When the supplier is risk averse, $v'' < 0$ and the buyer is risk neutral, given $s(\pi) = \alpha + \beta\pi$ and Eu=Eπ, E(u(π))=$-\alpha + (1-\beta)g(a)$. The utility function of the supplier has risk averse characteristics v(w)=-e-$^{\rho w}$. In that $\rho > 0$, this means the coefficient of the absolute risk avoidance. The actual income of the supplier is W=$s(\pi) - c(a) = \alpha + \beta\pi - c(a)$. Because W= $s(\pi) - c(a)$ belongs to the normal distribution, so the income is EW-1/2 $\rho\ \beta^2\sigma^2 = \alpha + \beta g(a)$ - 1/2 $\rho\ \beta^2\sigma^{2}$-c(a). In that EW is the supplier's expected revenue, and 1/2 $\rho\ \beta^2\sigma^2$ is the supplier's risk cost.

Let $\bar{w}$ is the retaining income level for the supplier. When $\alpha + \beta g(a)$ - 1/2 $\rho\ \beta^2\sigma^2$-c(a) < $\bar{w}$, the supplier will not accept the contract and the incentive mechanism designed by purchaser fails. So the participation constraint to the supplier is $\alpha + \beta g(a)$ - 1/2 $\rho\ \beta^2\sigma^2$-c(a) ≥ $\bar{w}$.

So maxEu (π-s(π))

(α,β)

s.t.

$$\begin{cases} \alpha + \beta g(a) - 1/2\ \rho\ \beta^2\sigma^2 - c(a) \geq \bar{w} \quad (IR) \\ \max\ (\alpha + \beta g(a) - 1/2\ \rho\ \beta^2\sigma^2 - c(a) \quad (IC) \end{cases} \qquad (*)$$

In order to deepen the analysis the above issue, we assume g(a)=ln a, and a>0, thus ln a is a strictly increasing convex function of a, (ln a)'=1/a >0, (ln a)"=-1/a^2 <0. we also let c(a) =Aa^2 and A>0, and the total cost and marginal cost are increasing.

$$c'(a) = 2Aa > 0 \quad c''(a) = 2A > 0$$

We take the assumptions into (*) and get max[$-\alpha + (1-\beta)$ ln a],So the hypothesis condition (*) can be changed to max[a].

$$\begin{cases} \alpha + \beta g(a) - 1/2\ \rho\ \beta^2\sigma^2 - Aa^2 \geq \bar{w} \quad (IR) \\ \alpha + \beta\ \ln a - 1/2\rho\ \beta^2\sigma^2 - Aa2 \geq \alpha + \beta\ \ln a' - 1/2\rho\ \beta^2\sigma^{2} - A(a')^2\ (IC)(\text{in that } a' \in A) \end{cases}$$

The Lagrange function is constructed:

$L=-\alpha+(1-\beta)\ln a+\gamma(\alpha+\beta\ln a-1/2\rho\beta^2\sigma^2-Aa2-\overline{w}+u(\beta\ln a-$

$\beta\ln a'-Aa^2-A(a')^2)$

F.O.C. $L_\alpha=-1+\gamma=0$ so $\gamma=1$ **(1)**

$L_\beta=—\ln a+\gamma\ln a—\rho\sigma^2\beta+u\ln a—u\ln a'=0$

So $\beta=u\ln a—u\ln a'/\rho\sigma^2$ **(2)**

$L_\gamma=\alpha+\beta\ln a-1/2\rho\beta^2\sigma^2-Aa^2-\overline{w}$ **(3)**

$Lu=\beta\ln a-\beta\ln a'-Aa^2-A(a')^2=0$

So $\beta=(Aa^2-A(a')^2)/\ln a-\ln a'$ **(4)**

When the supplier is risk averse, $\gamma>0$且u >0, $\gamma=1$. And we need prove u>0.

If (IC) does not work, then u=0, in (2) β=0, then s(π)=α is a constant. For the supplier, max($\alpha+\beta$ ln-1/2 $\rho\beta^2\sigma$ **2**-Aa2) and $a=\sqrt{\beta/2A}$ or $\beta=2Aa^2$ (5)

From the formula (2) mentioned above, $\partial\beta/\partial\rho<0$ $\partial\beta/\partial\sigma^2<0$, the α and β which constitute the optimal mechanism have close relations with the cost coefficient and the risk coefficient, In order to solve the incentive problem, when the purchaser considers awards to the suppliers, it is suggested that the purchaser should let the supplier share part of the risks in supply chain, which is to establish supply chain partnership alliance. With the increase of β, suppliers will have the enthusiasm to adopt better green technology and produce more green products.

CONCLUSIONS

The number of people to bid more, the closer the actual cost of each bid, the purchaser can get a lower price of goods suppliers and the higher the efficiency of green procurement. In order to avoid the adverse selection of suppliers, there must have the appropriate incentives to the supplier. So supplier incentive mechanism is discussed with game theory. When the purchaser considers awards to the suppliers, it is suggested that the purchaser should let the supplier share part of the risks in supply chain, which is to establish supply chain partnership alliance.

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