

Reverse Logistics Outsourcing Mechanism Research Based on Principal-Agent Theory

Wang Haiyan, Tu Min

School of Transportation, Wuhan University of Technology, Wuhan, P.R.China, 430063

(E-mail: hywang777@163.com)

Abstract Operating reverse logistics in enterprise better or not is directly related to customers' satisfaction and loyalty. Therefore, many enterprises usually adopt a policy to outsource their reverse logistics in order to strengthen their competence in the market. How to design an incentive mechanism is a key problem in reverse logistics outsourcing management. Through the reputation effects model pursued by the agent and the ratchet effects model caused by the principal increasing the standard, the reverse logistics outsourcing mechanism is analyzed, and a relative performance contrast is put forward to weaken the ratchet effects to design the incentive mechanism which can get two-win between the principal and the agent.

Key words Reverse logistics outsourcing; Reputation effects; Ratchet effects; Relative performance contrast

1 Introduction

Reverse logistics is a process whereby companies can become more environmentally efficient through recycling, reusing, and reducing the amount of materials used, but reverse logistics has the un-prediction characteristics in return time, quantity, quality and site. Therefore, reverse logistics in many enterprises is outsourced while there are two advantages of outsourcing reverse logistics to third-party service providers(3PSPs), one is focusing their capital and resources on core competence to get maximum return; the other is to enhance labor productivity, reduce cost, and increase agility, as well as gain the specific services.

But there exists some problems in outsourcing the reverse logistics in enterprises owing to their information asymmetry. In this paper, introduce the importance and problems of outsourcing reverse logistics in part one, and then review the literature domestic and abroad in part two, analyzing the reputation model of the third party in part three, through the ratchet effects analysis, study how the ratchet effects weaken the incentive mechanism in outsourcing, and conclude in last part.

2 Literature Review

Many literature studied logistics outsourcing in abroad and domestic. Wang Keling et al (2008) present a framework of logistics outsourcing partnership governance in the whole process of a closed-loop supply chain. Li Yaohui et al (2009) establish a profit equilibrium model in the Center of recycling product for Third-Party Logistics Service (3PLS) in order to solve a profit equilibrium problem of recycling product.

Serrato, Marco (2006) present analytical model to address the outsourcing decision-making problem by considering two factors: the length of the product life cycle and the variability in the rate of returns between consecutive periods. A Markov Decision Model (MDM) is proposed to help a firm to decide whether or not to follow an outsourcing strategy for its RL activities.

And some literatures adopt quantitative analysis, such as AHP, ANP, DEA, risk matrix and fuzzy comprehensive evaluation. Guo Tengda et al (2008) adopt ANP to study outsourcing or self-operation decision making in reverse logistics; Xu Xianhao et al (2006) get a risk assessment of logistics outsourcing based on risk matrix; Wu Rong et al (2008), Sheng Feng (2008) used AHP and DEA to study selection of the third party reverse logistics provider.

But how to design the incentive mechanism to get the enterprise's objective is the most important before making an outsourcing decision. Therefore, outsourcing mechanism should be analyzed first, and then design fair and available incentive mechanism can get two-win between the enterprise and the third-party service providers (3PSPs). The enterprise is as a principal and the 3PSP is as an agent, a principal-agent theory is adopted to study the enterprise reverse logistics outsourcing mechanism.

3 3PSPs Will be in Positive Effects of Choosing Efforts—Reputation Effects

Suppose the enterprise outsources its reverse logistics to a 3PSP, and not in a time. There are two stages, $t = 1, 2$, the product function in each stage of 3PSP is

$$\pi_t = a_t + \theta + \mu_t, \quad t = 1, 2$$

π_t ——the product in t stage of 3PSP;

a_t ——the working level of 3PSP;

θ ——the operation ability and efforts level of 3PSP(nothing with time);

μ_t ——exterior random variable(such as uncertainty of market);

Suppose a_t is private information of 3PSP, π_t is public information, θ and μ_t are normal distribution, mean value is 0 ($E\theta = E\mu_t = 0$), the variance is σ_θ^2 and σ_μ^2 . Suppose random variable μ_1 and μ_2 is isolate, namely $\text{cov}(\mu_1, \mu_2) = 0$.

Suppose 3PSP is risk-neutral, given the discount rate is 0, then its utility is:

$$U = w_1 - c(a_1) + w_2 - c(a_2)$$

w_t ——the profit of 3PSP in stage t ;

$c(a_t)$ ——the cost of 3PSP in stage t , namely negative utility of efforts. Suppose $c(a_t)$ is a convex function, and $c'(a_t) = 0$.

If the principal-agent is in one stage, obviously, the 3PSP as an agent has no incentive to work hard, while the principal-agent is in T stages, the profit of 3PSP as an agent in T stage depends on the anticipation of operation ability θ in $T - 1$ stage. And a_{T-1} will influence this anticipation by acting on π_{T-1} . First two stages model is discussed, and then spread to multi-stage.

Suppose the market is perfect competition, the profit of 3PSP equals to its anticipated profit, then

$$w_1 = E(\pi_1) = E(a_1 + \theta + \mu_1) = E(a_1) + E(\theta) + E(\mu_1)$$

$$\text{And } E(\theta) = E(\mu_1) = 0$$

$$\text{Therefore } w_1 = E(a_1) = \bar{a}_1$$

$$w_2 = E(\pi_2 | \pi_1)$$

\bar{a}_1 ——the market anticipation to the efforts of 3PSP in stage1;

$E(\pi_2 | \pi_1)$ ——the market product anticipation in stage2 at the condition of the actual product in given stage1;

$$\text{Then } E(\pi_2 | \pi_1) = E(a_2 | \pi_1) + E(\theta | \pi_1) + E(\mu_2 | \pi_1) = E(\theta | \pi_1)$$

$$\text{For } E(a_2 | \pi_1) = E(\mu_2 | \pi_1) = 0$$

Suppose the market anticipation is rational, \bar{a}_1 is actual choice of 3PSP under the equilibrium. When π_1 is observed, the market $\theta + \mu_1 = \pi_1 - \bar{a}_1$. The market can not separate θ from μ_1 , since the market can not analyze the observed π_1 whether is the result of θ or μ_1 except the efforts of 3PSP.

$$\tau = \frac{\text{Var}(\theta)}{\text{Var}(\theta) + \text{Var}(\mu_1)} = \frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\mu^2}$$

$$\text{According to rational formula: } E(\theta | \pi_1) = (1 - \tau)E(\theta) + \tau(\pi_1 - \bar{a}_1) = \tau(\pi_1 - \bar{a}_1)$$

$$\text{For } E(\theta) = 0, \quad \tau \in [0, 1]$$

$$\tau > 0, \quad w_2 = E(\theta | \pi_1) = \tau(\pi_1 - \bar{a}_1)$$

Namely the higher product in stage1, the more profit in stage2, the utility of 3PSP is:

$$U = \bar{a}_1 - c(a_1) + \tau(a_1 + \theta + \mu_1 - \bar{a}_1) - c(a_2)$$

Calculate a derivative of a_1 and a_2 , get first-order dominance condition:

$$c'(a_1) = \tau > 0 \quad c'(a_2) = 0$$

Therefore

(1) Under the condition of information asymmetry with principal, 3PSP efforts level in stage1 strictly greater than 0, the bigger τ is, the better the incentive action, the better the reputation utility is.

(2) If the outsource is two-stage, the optimum efforts level of 3PSP as an agent in stage2 is 0.

(3) If the outsource is multi-stage, the optimum efforts level of 3PSP as an agent in stage T is 0, but the efforts in stage T-1 is greater than 0, namely the profit of 3PSP increases with the increasing of π_{T-1} in last stage, and reputation is improved with the improving reputation in last stage.

4 3PSPs Will be in Negative Effects of Choosing Efforts—Ratchet Effects

In the former part, the reputation effects model of 3PSP as an agent is analyzed, but in practice, the harder the agent works, the better performance it is, and the principal will work our a higher standard. When the agent can predict the principal will increase the standard, the incentive to work hard will be decreased. That is ratchet effects in principal-agent modes.

Take a two-stage game theory model for an example to analyze how the ratchet effects weaken the incentive mechanism.

The product function: $\pi_t = a_t + \theta + \mu_t, t = 1, 2$

π_t ——the product of 3PSP in stage t;

a_t ——the efforts level of 3PSP;

θ ——the intrinsic productivity of enterprise;

μ_t ——the exogenous random variable;

Suppose θ normal distribution, mean value $E(\theta) = \bar{\theta} > 0$, the variance is σ_θ^2 . The principal can only observe product π_t when each stage is finished, not observe θ and μ_t . Therefore, the principal can adjust its judgment according to the observed product. Suppose the anticipation of market is rational:

$$E(\theta|\pi_1) = (1 - \tau)\bar{\theta} + \tau(\pi_1 - \bar{a}_1)$$

Suppose the 3PSP is risk-neutral, its utility function is:

$$U = w_1 - c(a_1) + w_2 - c(a_2)$$

Suppose the explicit contract is available, but the principal can not promise the long-term contract. According to the characteristics of explicit contract, the principal get a fixed profit α_t at each stage. And the profit of 3PSP in stage t is: $w_t = \pi_t - \alpha_t$

The profit α_t of principal at each stage should equal to expected intrinsic productivity at the same stage under the condition of perfect competition in capital market:

$$\alpha_1 = E(\theta) = \bar{\theta}$$

$$\alpha_2 = E(\theta|\pi_2) = (1 - \tau)\bar{\theta} + \tau(\pi_1 - \bar{a}_1)$$

Put α_1 、 α_2 into 3PSP utility function:

$$\begin{aligned} U &= \pi_1 - \alpha_1 - c(a_1) + \pi_2 - \alpha_2 - c(a_2) \\ &= a_1 + \theta + \mu_1 - \bar{\theta} - c(a_1) + a_2 + \theta + \mu_2 - \bar{\theta} + \tau\bar{\theta} - \tau(a_1 + \theta + \mu_1) + \tau\bar{a}_1 \\ &= [(1 - \tau)a_1 + (1 - \tau)\theta + (1 - \tau)\mu_1 - c(a_1)] + (a_2 + \theta + \mu_2 - c(a_2)) - (2 - \tau)\bar{\theta} + \tau\bar{a}_1 \end{aligned}$$

Calculate a derivative of a_1 and a_2 , get first-order dominance condition:

$$c'(a_1) = 1 - \tau < 1 \quad c'(a_2) = 1$$

Therefore: $c'(a_2) > c'(a_1)$

From the above analysis, the main reason of ratchet effects is that the principal can not get a long-term contract with the 3PSP. For the long-term contract can not conform to the agent's participated constraints, namely the profit to accept contract should be greater than that to refuse contract. When the 3PSP get a good performance in stage1 by working hard, the principal would retreat contract to heighten standard and increase its fixed profit; adversely, if the 3PSP can not get the principal standard, the 3PSP should request to retreat contract to lower the fixed profit of principal. Therefore, the long-term contract can not meet the dynamic consistency.

5 Conclusions

Owing to the information asymmetry, the principal can not observe the overall operation process of the agent, and 3PSP as an agent should prevent ratchet effects of the principal while in pursuit of reputation effects. And how to weaken ratchet effects as a principal or agent? "Relative performance contrast" is put forward to weaken it. The "relative performance contrast" is that to adopt another relative 3PSP performance as a reference. When the relevance between intrinsic productivity in outsourcing enterprises is greater than that between the exogenous random variables, the "relative performance contrast" is introduced will decrease the weight of anticipated intrinsic productivity which depends on the performance in stage1, and then weaken the ratchet effects.

References

- [1] Wang Keling, Dong Jianxin. A Framework of Logistics Outsourcing Partnership Governance in a Closed-Loop Supply Chain[C]. International Symposium on Distributed Computing and Applications for Business Engineering and Science; 20080727-31; Dalian (In Chinese)
- [2] Li Yaohui, Li Renwang, et al. Profit Equilibrium Model in 3PLS Reverse Logistics[J]. Computer Engineering, 2009, 35(18): 280-284 (In Chinese)
- [3] Guo Tengda, Li Xiangyang. Outsourcing or Self-operation Decision Making in Reverse Logistics Based on Analytic Network Process[J]. System Engineering and Electronic, 2008, 30(6): 1181-1187 (In Chinese)
- [4] Marco A. Serrato; Sarah M. Ryan et al. A Markov Decision Model to Evaluate Outsourcing in Reverse Logistics[J]. International Journal of Production Research, 2007, 45 (18-19)
- [5] Xu Xianhao, Tang Zelin. Risk Assessment of Logistics Outsourcing Based on Risk Matrix[J]. Logistics Technology, 2006, (5): 67-70 (In Chinese)
- [6] Wu Rong, Yu Yanggang. Selection of the Third Party Reverse Logistics Provider Based on AHP and DEA[J]. Journal of Anhui Agriculture Science, 2008, 36(33): 14767-14769 (In Chinese)
- [7] Sheng Feng. The Choice of the Third Party Reverse Logistics Provider Based on AHP[J]. Logistics Science -technology, 2008, (8): 77-82 (In Chinese)
- [8] Zhang Weiyong. Game Theory and Information Economics[M]. Shanghai Shanghai People Publishing House, 1996 (In Chinese)