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 enterprises 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

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

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

- \( \pi_t \) — the product in \( t \) stage of 3PSP;
- \( a_t \) — the working level of 3PSP;
- \( \theta \) — the operation ability and efforts level of 3PSP (nothing with time);
- \( \mu_t \) — exterior random variable (such as uncertainty of market);

Suppose \( a_t \) is private information of 3PSP, \( \pi_t \) is public information, \( \theta \) and \( \mu_t \) are normal distribution, mean value is 0 (\( E\theta = E\mu_t = 0 \)), the variance is \( \sigma^2_\theta \) and \( \sigma^2_\mu \). Suppose random variable \( \mu_1 \) and \( \mu_2 \) 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:

\[
w_i = w_1 - c(a_1) + w_2 - c(a_2)
\]

- \( w_i \) — the profit of 3PSP in stage \( t \);
- \( c(a_i) \) — the cost of 3PSP in stage \( t \), namely negative utility of efforts. Suppose \( c(a_i) \) is a convex function, and \( c'(a_i) = 0 \).

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 \( \theta \) in \( T - 1 \) stage. And \( a_{T-1} \) will influence this anticipation by acting on \( \pi_{T-1} \). 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

\[
w_i = E(\pi_i) = E(a_i + \theta + \mu_i) = E(a_i) + E(\theta) + E(\mu_i)
\]

And \( E(\theta) = E(\mu_t) = 0 \)

Therefore \( w_i = E(a_i) = \overline{a_i} \)

\[
w_2 = E(\pi_2 | \pi_1)
\]

\( \overline{a_i} \) — 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;

Then \( E(\pi_2 | \pi_1) = E(a_2 | \pi_1) + E(\theta | \pi_1) + E(\mu_2 | \pi_1) = E(\theta | \pi_1) \)

For \( E(a_2 | \pi_1) = E(\mu_2 | \pi_1) = 0 \)

Suppose the market anticipation is rational, \( \overline{a_i} \) is actual choice of 3PSP under the equilibrium. When \( \pi_1 \) is observed, the market \( \theta + \mu_i = \pi_1 - \overline{a_i} \). The market can not separate \( \theta \) from \( \mu_i \), since the market can not analyze the observed \( \pi_1 \) whether is the result of \( \theta \) or \( \mu_i \) except the efforts of 3PSP.

\[
\tau = \frac{\text{Var}(\theta)}{\text{Var}(\theta) + \text{Var}(\mu_1)} = \frac{\sigma^2_\theta}{\sigma^2_\theta + \sigma^2_\mu}
\]

According to rational formula: \( E(\theta | \pi_1) = (1 - \tau)E(\theta) + \tau(\pi_1 - \overline{a_i}) = \tau(\pi_1 - \overline{a_i}) \)

For \( E(\theta) = 0 \), \( \tau \in [0,1] \)

\( \tau > 0, \; w_2 = E(\theta | \pi_1) = \tau(\pi_1 - \overline{a_i}) \)

Namely the higher product in stage1, the more profit in stage2, the utility of 3PSP is:
\[ U = \bar{a}_i - c(a_i) + \tau(a_i + \theta + \mu_i - \bar{a}_i) - c(a_2) \]

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 stage 1 strictly greater than 0, the bigger \( \tau \) is, the better the incentive action, the better the reputation utility is.

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

(3) If the outsourc 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 \( \pi_{T-1} \) 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 out 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:

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

\( \pi_t \) —— the product of 3PSP in stage \( t \);

\( a_t \) —— the efforts level of 3PSP;

\( \theta \) —— the intrinsic productivity of enterprise;

\( \mu_t \) —— the exogenous random variable;

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

\[ E(\theta|\pi_t) = (1-\tau)\bar{\theta} + \tau(\pi_t - \bar{a}_t) \]

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 \( \alpha_t \) at each stage. And the profit of 3PSP in stage \( t \) is: \( w_t = \pi_t - \alpha_t \)

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

\[ \alpha_t = E(\theta) = \bar{\theta} \]

\[ \alpha_2 = E(\theta|\pi_2) = (1-\tau)\bar{\theta} + \tau(\pi_2 - \bar{a}_2) \]

Put \( \alpha_1 \)、\( \alpha_2 \) into 3PSP utility function:

\[ U = \pi_1 - \alpha_1 - c(a_1) + \pi_2 - \alpha_2 - c(a_2) \]

\[ = a_1 + \theta + \mu_i - \bar{\theta} - c(a_1) + a_2 + \theta + \mu_i - \bar{\theta} - \tau(a_i + \theta + \mu_i) + \tau\bar{a}_i \]

\[ = [(1-\tau)a_1 + (1-\tau)\theta + (1-\tau)\mu_i - c(a_1)] + (a_2 + \theta + \mu_i - c(a_2)) - (2-\tau)\bar{\theta} + \tau\bar{a}_i \]

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


