A Study on Incentive Mechanism of logistics Outsourcing among Multi-Task Principal-Agent

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Abstract: Logistics Outsourcing of the Enterprises is to develop third-party specialty logistics. It is a basic content about how to realize logistics industrial organization optimization. Outsourcing leads to incentive problem about external logistics enterprises agencing the enterprises’ logistics service which is different from logistics management in enterprise. Third-party specialty logistics enterprises often accept several logistics service demanders’ logistics service principal. In this paper we use multi-task principal-agent theory to discuss the process of logistics outsourcing and optimal incentive mechanism with multi-task in the case of dependent endeavor cost and independent endeavor cost.

Keyword: principal-agent, logistics outsourcing, incentive mechanism

1 Introduction

Logistics Outsourcing of the Enterprises is to develop third-party specialty logistics. It is a basic content about how to realize logistics industrial organization optimization. Outsourcing leads to incentive problem about external logistics enterprises agencing the enterprises’ logistics service which is different from logistics management in enterprise. At present, the study about logistics outsourcing contract is a hot issue of logistics field. Because logistics outsourcing party and third-party logistics enterprise belong to different interest subjects, have independent legal personality, so both sides’ right and benefit is decided by contract. In the third-party logistics’ contract, because various information transmission and display obstacle exist in both sides of logistics outsourcing, so asymmetric information problem produce. In the logistics outsourcing, logistics entrusting party (logistics outsourcing party) hopes logistics agent (third-party logistics service provider or third-party logistics enterprises trying their best to advance the quality of logistics service. In the process of achieve this goal, message asymmetry exists between logistics outsourcing party and logistics agent. Logistics agent has more private message. Before logistics outsourcing, logistics service capability is the private message of logistics agent. After logistics outsourcing, logistics agent’s action is the private message of logistics agent. The former is ex ante information asymmetry whose model is adverse selection model. The latter is ex post information asymmetry whose model is moral risk model. Principal-agent problem is aroused by message asymmetry between logistics outsourcing party and logistics agent. Principal-agent problem is that adverse selection and moral risk exist at the same time.

Shuyun wang (2004) interpretes the mechanism and economic significance of logistics outsourcing, constructs logistics outsourcing model about economies of transaction cost and core competence, but it is lack of quantitative analysis [1]. Third-party specialty logistics enterprises often accept several logistics service demanders’ logistics service principal. Hohnstrom and Milgorn (1991) prove that the conclusion is obtained by simple principal-agent theory when agent engages in multitasks is inapplicable. Especially in some situations, the contract which total price is fixed is better than incentive contract [2]. Dixit & A (1997) combines the models of multi-task analysis method and multi-agent, discusses economic organization’s incentive weakening problem, emphasizes the importance of multi-task analysis method [3]. Bernard Sinclair Desgagne shows that stronger incentives can be restored through a scheme of selective audits, in which the appraisal of less tangible activities is contingent on observing high performance levels in the more visible tasks [4]. A. Karmann consider two types of linear-quadratic principal-agent models: one in which a single agent has to perform several tasks and one in which several agents have to perform a certain task. For both models, we derive optimal contractual
principal-agent relations. It turns out that under certain conditions the multiple-agent problem reduces to a multiple-task one-agent problem[5].Z Justin Ren and Yong-Pin Zhou study the contracting issues in an outsourcing supply chain consisting of a user company. They model the call center as a G/G/s queue with customer abandonment. The call center makes two strategic decisions: how many agents to have and how much effort to exert to achieve service quality[6]. Gérard P. Cachon • Patrick T presents a model of competition between two firms that face scale economies with price- and time-sensitive demand and competition between two retailers with fixed-ordering costs and price-sensitive consumers (an Economic Order Quantity game). He shows that the firms strictly prefer to outsource and scale economies provide a strong motivation for outsourcing[6].

The paper begins with a brief description of the principal-agent problem in the logistics outsourcing. Section 3 sets up the basic model among multi-task principal-agent. The paper ends with a discussion of the incentive mechanism of third-party logistics enterprises when costs are independent.

2 the basic model among multi-task principal-agent

\( a = (a_1, a_2, a_3) \) denotes third-party logistics enterprises’ endeavor vector, thereinto, \( a_1 \) is agent’s endeavor which is in order to raise logistics efficiency, \( a_2 \) is agent’s endeavor which is in order to improve the quality of logistics service, \( a_3 \) is agent’s endeavor which is in order to reduce logistics cost. \( B(a_1, a_2, a_3) \) denotes the expected revenue of agent’s endeavor (the direct object is principal), \( B' > 0, B'' > 0 \). \( C(a_1, a_2, a_3) \) denotes endeavor cost (the direct object is agent), \( C' > 0, C'' > 0 \). The selection of third-party logistics enterprises’ endeavor decides partly the following information vector which can be observed.

\[ x_1 = a_1 + \epsilon_1, x_2 = a_2 + \epsilon_2, x_3 = a_3 + \epsilon_3 \]

where, \( \epsilon_1 \), \( \epsilon_2 \) and \( \epsilon_3 \) figure the influence of external disturbance, deciding the degree which can be observed. \( \epsilon_i \sim N(0, \delta_i^2) \).

It is assumed that the contract which both sides sign is a linear incentive contract

\[ s(x_1, x_2, x_3) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \]

logistics outsourcing party is risk-neutral, third-party logistics enterprise is risk aversion and its utility function is fixedness and absolute risk aversion, namely \( u(s) = -e^{-\rho \omega} \). \( \rho \) is absolute risk aversion measurement. \( \omega \) is actual monetary income, endeavor cost \( C(a_1, a_2, a_3) \) is monetary equivalent. Well then, the actual income of third-party logistics enterprise is

\[ CE = \omega - \frac{1}{2} \rho \left( \beta_1^2 \delta_1^2 + \beta_2^2 \delta_2^2 + \beta_3^2 \delta_3^2 \right) \]

\[ = \alpha + a_1 \beta_1 + a_2 \beta_2 + a_3 \beta_3 - \frac{1}{2} \rho \left( \beta_1^2 \delta_1^2 + \beta_2^2 \delta_2^2 + \beta_3^2 \delta_3^2 \right) - C(a_1, a_2, a_3) \]

certainty equivalent income is

\[ CE = \omega - \frac{1}{2} \rho \left( \beta_1^2 \delta_1^2 + \beta_2^2 \delta_2^2 + \beta_3^2 \delta_3^2 \right) \]

Where, \( \frac{1}{2} \rho \left( \beta_1^2 \delta_1^2 + \beta_2^2 \delta_2^2 + \beta_3^2 \delta_3^2 \right) \) is risk cost. The expected revenue of logistics outsourcing party is

\[ V = B(a_1, a_2, a_3) - E\left( s(x_1, x_2, x_3) \right) = B(a_1, a_2, a_3) - \alpha - a_1 \beta_1 - a_2 \beta_2 - a_3 \beta_3 \]

The problem of logistics outsourcing party is to choose \( \beta^T = (\beta_1, \beta_2, \beta_3) \) in order to maximize its profit and meet the IR and IC constraint.

\[ \max V = B(a_1, a_2, a_3) - \alpha - a_1 \beta_1 - a_2 \beta_2 - a_3 \beta_3 \]
\[(I)\alpha + a_i\beta_i + a_2\beta_2 + a_3\beta_3 - \frac{1}{2}\rho(\beta_i^2\delta_i^2 + \beta_2^2\delta_2^2 + \beta_3^2\delta_3^2) - C(a_i, a_2, a_3) \geq \varpi\]

\[(IC) (a_i, a_2, a_3) \in agr \max \left(a_i\beta_i + a_2\beta_2 + a_3\beta_3 - C(a_i, a_2, a_3)\right)\]

\(\varpi\) is agent’s retained income. If certainty equivalent income is less than \(\varpi\), agent will not accept the contract. Because giving more to agent is not necessary for client, so the constraint equation is tenable in the optimal condition. Because of

\[\max V = B (a_i, a_2, a_3) - \frac{1}{2}\rho(\beta_i^2\delta_i^2 + \beta_2^2\delta_2^2 + \beta_3^2\delta_3^2) - C(a_i, a_2, a_3) - \varpi\quad (2)\]

Let \(\frac{\partial V}{\partial \beta} = \frac{\partial B}{\partial a} \frac{\partial a}{\partial \beta} - \rho \sum \frac{\partial C}{\partial a} \frac{\partial a}{\partial \beta} = 0\)

\[\beta = (I + \rho \left[C_y\right] \sum)^{-1} B\quad (3)\]

Where, \(\Sigma\) is covariance matrix. \(\left[C_y\right] = \frac{\partial \beta}{\partial a} = \begin{bmatrix}
\frac{\partial \beta_1}{\partial a_1} & \frac{\partial \beta_1}{\partial a_2} & \frac{\partial \beta_1}{\partial a_3} \\
\frac{\partial \beta_2}{\partial a_1} & \frac{\partial \beta_2}{\partial a_2} & \frac{\partial \beta_2}{\partial a_3} \\
\frac{\partial \beta_3}{\partial a_1} & \frac{\partial \beta_3}{\partial a_2} & \frac{\partial \beta_3}{\partial a_3}
\end{bmatrix}\]

3 The effects of logistics task’s Relevance on Invigorative Function

3.1 Third-party logistics enterprise’s incentive mechanism with multi-task and independent endeavor cost

If the marginal cost of several logistics services which third-party logistics enterprises undertake is independent, it expresses that every task’s effort degree has no effect to other task’s effort degree, namely \(C_{ij} = 0, i \neq j\). \(C_{ij} = 0\) is substituted into the expression(3) results in

\[
\begin{bmatrix}
\beta_1 \\
\beta_2 \\
\beta_3
\end{bmatrix} = 
\begin{bmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1
\end{bmatrix}
+ \rho
\begin{bmatrix}
C_{11} & 0 & 0 \\
0 & C_{22} & 0 \\
0 & 0 & C_{33}
\end{bmatrix}
\begin{bmatrix}
\sigma_i^2 & 0 & 0 \\
0 & \sigma_2^2 & 0 \\
0 & 0 & \sigma_3^2
\end{bmatrix}
\begin{bmatrix}
B_1 \\
B_2 \\
B_3
\end{bmatrix}
= 
\begin{bmatrix}
\frac{B_i}{\rho C_i \sigma_i^2 + 1} \\
\frac{B_i}{\rho C_i \sigma_i^2 + 1} \\
\frac{B_i}{\rho C_i \sigma_i^2 + 1}
\end{bmatrix}
\quad (4)
\]

Formula(4) can be simplified as \(\beta_i = \frac{B_i}{\rho C_i \sigma_i^2 + 1}\). According to formula(4), if the third-party logistics enterprise’s multi-task is independent and the marginal costs of multi-task endeavor are mutually independent, every task’s optimal performance reward \(\beta_i\) is inter-independent under the condition of incentive compatible constraint. \(\beta_i\) is a decreasing function in absolute risk aversion \(\rho\), change rate of marginal cost \(C_i\) and observable variables’ variance \(\sigma_i^2\).
3.2 Third-party logistics enterprise’s incentive mechanism with multi-task and dependent endeavor cost

If the marginal cost of several logistics services which third-party logistics enterprises undertake is dependent, it expresses that every task’s effort degree has effect to other task’s effort degree, namely \( C_{ij} \neq 0, i \neq j \). If \( C_{ij} < 0, i \neq j, i, j = 1, 2, 3 \), relevance exists among three-task. The accomplish of one task can improve the accomplish of other tasks, that is to say, the three tasks are complementary. If \( C_{ij} > 0, i \neq j, i, j = 1, 2, 3 \), the advance of a task’s endeavor degree makes the increase of the other tasks’ marginal opportunity cost, that is to say, the three tasks are substitute. Logistics outsourcing party has two means to inspirit third-party logistics enterprise to increase endeavor in any given movement. One is to encourage this action directly. The other one is to reduce this action’s opportunity cost (weakening incentive to other task). It is assumed that only third-party logistics enterprise’s endeavor degree to improve logistics efficiency \( (a_1) \) can be observed. Third-party logistics enterprise’s endeavor degrees to improve the quality of logistics service \( (a_2) \) and reduce logistics cost \( (a_3) \) can not be observed. So the only information is \( x = x_i = a_i + \varepsilon_i \) \( (\delta_2^2, \delta_3^2 = \infty, \delta_1 = 0 (i \neq j)) \).

It is assumed that third-party logistics enterprise’s endeavor degree to improve logistics efficiency and improve the quality of logistics service is dependent, but they and endeavor degree to reduce logistics cost are independent. According to formula (3), we can get

\[
\begin{bmatrix}
\beta_1 \\
\beta_2 \\
\beta_3
\end{bmatrix} =
\begin{bmatrix}
1 & 0 \\
0 & 0 & + \rho \\
0 & 1
\end{bmatrix}
\begin{bmatrix}
C_{11} & C_{12} & 0 \\
0 & C_{21} & C_{22} \\
0 & 0 & C_{33}
\end{bmatrix}
\begin{bmatrix}
\sigma_i^2 & 0 & 0 \\
0 & \sigma_j^2 & 0 \\
0 & 0 & \sigma_k^2
\end{bmatrix}^{-1}
\begin{bmatrix}
B_1 \\
B_2 \\
B_3
\end{bmatrix}
\]

Namely

\[
\beta_1 = \frac{B_1 (\rho C_{22} \delta_1^2 + 1) - \rho C_{12} \delta_2^2 B_2}{1 + \rho^2 C_{11} \delta_1^2 \delta_2^2 + \rho C_{11} \delta_1^2 + \rho C_{12} \delta_2^2 - \rho^2 C_{12} \delta_1^2 \delta_2^2}
\]

\[
\beta_2 = \frac{B_2 (\rho C_{11} \delta_2^2 + 1) - \rho C_{12} \delta_1^2 B_1}{1 + \rho^2 C_{11} \delta_1^2 \delta_2^2 + \rho C_{11} \delta_1^2 + \rho C_{22} \delta_2^2 - \rho^2 C_{12} \delta_1^2 \delta_2^2}
\]

\[
\beta_3 = \frac{B_3}{1 + \rho C_{13} \delta_1^2}
\]

Because of \( \delta_2^2, \delta_3^2 = \infty, \delta_1 = 0 (i \neq j) \), so \( \beta_1 = \frac{B_1 \rho C_{22} - \rho C_{12} B_2}{1 + \rho^2 C_{11} \delta_1^2 \delta_2^2 + \rho C_{11} \delta_1^2 + \rho C_{22} \delta_2^2 - \rho^2 C_{12} \delta_1^2 \delta_2^2} \), \( \beta_2, \beta_3 = 0 \)

4 Conclusions and Future Research

In this paper, we have focused on incentive mechanism design of logistics outsourcing among Multi-Task Principal-Agent. The problem of principal-agent exists because of information asymmetry between logistics entrusting party and logistics agent. This paper uses multi-task principal-agent model to discuss some basic problems about optimal mechanism of logistics outsourcing and detailed analysis the incentive mechanism among multi-task in the case of dependent endeavor cost and independent endeavor cost. The results show that if the marginal cost of several logistics services which third-party logistics enterprises undertake is independent, every task’s optimal performance reward \( \beta_i \) is inter-independent under the condition of incentive compatible constraint. If the marginal cost of several logistics services which third-party logistics enterprises undertake is dependent, every task’s optimal performance reward \( \beta_i \) is inter-dependent under the condition of incentive compatible constraint.

Because the third-party logistics provides the whole proceeding, integrative bardian service to clients, logistics outsourcing activity has the speciality of multi-task and there is benefit deviation among multi-tasks, so we design outsourcing contracts by multi-task contract. Because there is incentive
weakening phenomenon among multi-tasks, we should transformed substitute relation into complementary relation when designing contract, which is a way to solve incentive weakening phenomenon. Logistics outsourcing party and the third-party logistics enterprise should establish long-term cooperative partnership to avoid short-term opportunism behavior.

References


