Logistics Service Supply Chain service quality inspection results contract coordination under information asymmetry

Tao Dai

Institute of Logistics Science & Engineering, Shanghai Maritime University, Shanghai 201306, China.

ABSTRACT

Aiming at the two-level service supply chain, which is dominated by logistics service provider (LS) and logistics service Platform operator (LP), it is faced with the problem of uncertain market demand and asymmetric information of logistics capacity service failure rate. Under the income distribution mode of LS and LP income sharing, this thesis uses the Stackelberg game principle to propose a cost-sharing compensation contract based on the result of capacity service quality test to coordinate the supply chain. The results show that the compensation contract of cost allocation can effectively solve the problem of information asymmetry and realize the growth of supply chain income. However, the overall supply chain income has not been maximized due to the inability to achieve the simultaneous coordination of LP’s effort level and capacity supply decision.

Keywords: Information asymmetry; Quality testing; Capacity service failure rate; Compensation contract; Level of effort

*eCorrespondence to Author:
Tao Dai
Institute of Logistics Science & Engineering, Shanghai Maritime University, Shanghai 201306, China.

How to cite this article:
1. Introduction
With the rapid development of China's logistics industry, logistics service supply chain has attracted wide attention, this new service supply chain can make up for the low level of informatization, lack of talent and insufficient funds in China's small and medium-sized logistics enterprises at this stage. At present, China's logistics service supply chain is still in the initial stage of development, in order to promote its better development and application, improve the logistics service supply chain operation in the process of logistics service quality appears to be crucial. Therefore, taking logistics service quality testing as the starting point, in the information asymmetry environment, this thesis studies how to apply the contract to the coordination of all parties under the test of capacity service quality. This has important practical significance for expanding market demand and increasing supply chain income.

From the literature of the existing Research service supply chain coordination, the research on supply chain contract coordination, SHIBAJI PANDA[1] studies the supply chain contract coordination problem of income sharing and cost sharing significantly reduces the channel conflict; LONG GAO[2] uses subsidy contract to optimize the double marginal effect of supply chain; The Wuzeyan[3] uses the master and slave game and Nash game to coordinate the contract, and studies the coordination of the supply chain based on the logistics platform according to the different supply capabilities of the suppliers. In the aspect of service quality contract coordination, LEE CH et AL.[4] use quality compensation contract to study the coordination of supply chain contract under the uncertainty of quality; Zhang Zhiyong et al.[5] studies the effectiveness of the reward and punishment contract to optimize the quality level of the service supply chain; Zhen Jie et AL.[6] use the principal-agent theory to construct the guarantee contract based on internal quality inspection and external fault detection to realize supply chain coordination; Mou Xiaoli[7] establishes the functional relationship between quality loss and quality level in the two-level supply chain model, and uses loss allocation strategy to optimize the supply chain. In the aspect of information asymmetry, WANG XH et AL.[8] use screening contract and order quantity contract to study the contract mechanism design of supply chain composed of risk neutral suppliers and retailers under the asymmetry of cost information; HU BY et AL.[9] using revenue sharing contracts to coordinate supply chains in an environment of uncertain supply and demand; Zhao Yangyang[10] proposes three kinds of contract models to coordinate the supply chain and analyze and discuss its coordination effect in the case of information asymmetry and asymmetry; Shi Wenqiang et AL.[11] uses the display mechanism to study the optimization of emergency quantity elastic contract under the asymmetry of price stochastic and sales cost information. To study the level of service supply chain effort, the research methods in the traditional service supply chain are mainly applied to the logistics service supply chain. Guo Yanli et AL.[12] establishes the compensation contract model which is different from the product supply chain and is suitable for SaaS service supply chain; Liang Changyong et AL.[13] put forward the different influence mechanism of effort level on demand and price, and study the sharing mechanism based on technical effort cost and compensation cost to realize the coordination problem of cloud service supply chain. However, the existing research has not paid much attention to the failure rate of capacity service and the influence of platform operator's effort level on market demand and overall supply chain profit, and has not taken into account the important influence of capacity service failure rate and effort level on supply chain channel coordination under the background of intelligent cloud service and low cost. Therefore, aiming at the direction and insufficiency of the existing literature neglect, this thesis constructs a two-level logistics service supply chain, analyzes the influence of capacity service failure rate and effort level on supply chain coordination, in order to provide theoretical reference for realizing the coordinated development of logistics servic-
Taking the two-level logistics service supply chain composed of logistics service platform operators and logistics service providers as the research object, this thesis analyzes the influence of capacity service quality inspection behavior on the overall supply chain income, and discusses the coordination effect of using the cost-sharing compensation contracts\[^{12-13}\] under the quality inspection results. Compared with the existing literature, it has the following characteristics: (1) based on the results of capacity service quality testing, this thesis establishes a cost-sharing compensation contract to coordinate supply chain; (2) The existing literature mainly discusses the income through the form of wholesale price and sales prices, and the thesis studies supply chain coordination under the distribution mode of income sharing among the two members of the supply chain.

2. Problem description and model hypothesis

A two-tier logistics service supply chain consisting of a logistics service provider (LS) and a logistics service platform operator (LP), in the course of its operation, LS and LP share the overall revenue of the supply chain, LP's income distribution ratio $\lambda$ is determined by LS. The specific revenue model is shown in Figure 1.

When the market demand is uncertain fluctuation, because LP exists unit capacity information cost $c_{in}$, so in the capacity supply decision, will only take the maximization of their own income as the goal, often prone to the supply of capacity is less than the market demand, resulting in LS facing the risk of loss of opportunity income; LS, as the leading party in the logistics service supply chain, has the advantage of the failure rate information of capacity service, in order to reduce the risk of loss of opportunity income and increase its own income, LS may conceal the real capacity service failure rate, the external announcement is less than the real value of the capacity service failure rate $\theta f(0<\theta \leq 1)$, Misleading logistics service platform operators of the level of effort and capacity supply decision, and ultimately lead to the emergence of information asymmetry problems.

In response to the above questions, the thesis makes the following assumptions and instructions:

1. Assume that LS and LP are risk-neutral.
2. Assume that LP effort costs are expressed in the form of $\frac{1}{2}du^2$.
3. Assuming that the market demand for logistics transport services $X$ is expressed in the form of $x = a + \rho u + \xi$, Assuming that $\xi \in [-b, b]$ obeys its probability density function $f(\xi)$, the distribution function is the distribution of $F(\xi)$, $F(\xi)$ is a continuous, micro, monotone increment function, and $F^{-1}(\xi)$ is the inverse function of the distribution function.
4. Assuming that there is only an asymmetry between LP and LS for the failure rate in information of capacity service, there is no other information asymmetry. From the above hypothesis, when $q = a + \rho u + \xi$, that is $\xi_0 = q - a - \rho u$, market demand is equal to the capacity provided, supply and demand to achieve a balance; When $\xi \in [-b, \xi_0)$, market demand is less than the order volume, there is an oversupply situation, when $\xi \in (\xi_0, b)$, market demand is greater than capacity, there is a shortage of supply.
3. Basic decision model of logistics service supply chain

3.1 Basic decision model under centralized decision
The goal of supply chain under centralized decision is to maximize the profit of the whole supply chain, and the expression of expected income of supply chain is:

\[
\pi_p = p(1-f)\min \{x,q\} - p\max \{x-q,0\} - \frac{1}{2}du^2 - c_oq - rfq
\]

(1)

Solution (1) for the first and second order biases of \(u\) and \(q\), the determinant of Hessian Matrix can be obtained:

\[
\frac{\partial^2 E(\pi_p)}{\partial u^2} \cdot \frac{\partial^2 E(\pi_p)}{\partial q^2} - \frac{\partial^2 E(\pi_p)}{\partial u \partial q} = p(2-f)d > 0
\]

(2)

Therefore, when the maximum value of \(E(\pi_p)\) exists under the centralized decision, the optimal order quantity \(q^*_j\) satisfies \(\frac{\partial E(\pi_p)}{\partial q} = 0\). It can draw the \(q^*_j = a + pu + b \frac{2b(c_oq + rfq)}{p(2-f)}\); Under the centralized decision, the supply chain has the optimal effort level \(u^*_j\), and satisfies the

\[
\frac{\partial E(\pi_p)}{\partial u} = 0 \; ; \text{From this, we can find the}
\]

\[
u^*_j = \rho \left( p(1-f) - c_o - rf \right)
\]

From the above, the size of the order quantity of logistics service supply chain increases with the increase of LP effort level, and the effort level is affected by the failure rate of capacity service, which decreases with the increase of the failure rate of capacity service, which is in line with the actual situation.

3.2 Basic decision model of information symmetry under dispersed decision
When information is symmetrical, the expected return expression of LP is:

\[
\pi_p = \lambda p(1-f)\min \{x,q\} - \lambda p\max \{x-q,0\} - \frac{1}{2}du^2 - c_oq
\]

(3)

LS’s expected return expression is:

\[
\pi_s = (1-\lambda) p(1-f)\min \{x,q\} - (1-\lambda) p\max \{x-q,0\} - rfq
\]

(4)

Solving the expected income expression (3) of LP about the first-order bias of \(q\), that is

\[
\frac{\partial E(\pi_p)}{\partial q} = 0 \; ; \text{From this, we can draw the}
\]
\[ q_j^* = a + \rho u + b - \frac{2bc_{os}}{\lambda p(2-f)}; \]

To bring the obtained \( q_j^* \) into the \( \frac{\partial \mathbb{E}(q)}{\partial u} \); By the same token, we can obtain \( u_j^* \) as \( u_j^* = \frac{\rho \left( \lambda p(1-f) - c_a \right)}{d} \). By adding \( q_j^* \) and \( u_j^* \) to the expected income expression of LS and solving the first derivative of \( \lambda \), the income distribution ratio \( \lambda^* \) decision of LS can be determined.

**Proposition 1** Logistics service provider LS concealing capacity service failure rate will lead to logistics service platform operator LP to improve the level of effort and capacity supply decision.

Prove: Solving the first derivative of \( f \) on the optimal decision \( q_j^* \) and \( u_j^* \) under Information symmetry, we can draw the

\[ \pi_{op} = \lambda_p p \left( 1 - \theta f \right) \min \{ x_o, q_o \} - \lambda_p p \max \{ x_o - q_o, 0 \} - \frac{1}{2} du^2 - c_a q_o \]  

The real income expectation expression of LP is:

\[ \pi_{sp} = \lambda_p p \left( 1 - f \right) \min \{ x_o, q_o \} - \lambda_p p \max \{ x_o - q_o, 0 \} - \frac{1}{2} du^2 - c_a q_o \]  

In order for LS not to be aware of its behavior of concealing the service failure rate, the LS expresses the expected return expression as:

\[ \pi_{op} = (1 - \lambda_p) p \left( 1 - \theta f \right) \min \{ x_o, q_o \} - (1 - \lambda_p) p \max \{ x_o - q_o, 0 \} - r\theta f q_o \]  

The true expected return expression for LS is:

\[ \pi_{sp} = (1 - \lambda_p) p \left( 1 - f \right) \min \{ x_o, q_o \} - (1 - \lambda_p) p \max \{ x_o - q_o, 0 \} - rf q_o \]  

Solving expressions (5) about the first derivative of \( q \), we can conclude that when information asymmetry, LP’s decision on the supply of capacity is \( q_{of} = a + \rho u_{of} + b - \frac{2bc_{os}}{\lambda p(2-f)}; \)

By adding \( q_{of}^* \) to the formula (5), we can determine that LP’s decision on the level of effort is

\[ u_{of}^* = \frac{\rho \left( \lambda p(1-f) - c_a \right)}{d} \]; By adding \( q_{of}^* \) and \( u_{of}^* \) to the expression (7), we can determine the decision of LS on the ratio \( \lambda_{of}^* \) of income distribution when the information is asymmetric.

**Proposition 2** Logistics service provider LS concealing the failure rate of capacity service will improve its own income, and lead to the reduction of LP income of logistics service platform operators.

Prove: According to the expression of capacity supply, the capacity supply \( q \) is about the increase function of the effort level \( u \), Solving expressions (4) about the first derivative of \( u \),

We can draw the \( \frac{\partial \pi}{\partial u} = \rho(1-\lambda) p(1-f) - rf > 0 \),

Obviously raising the level of effort will boost the increase in LS earnings; Similarly, solving the expression (4) about the first derivative of \( q \), we can draw the \( \frac{\partial \pi}{\partial q} > 0 \), According to the derivation of Proposition 1, LS concealing the failure rate of capacity service will mislead LP’s decision to improve the level of effort and supply of capacity, that is, it can be proved that LS concealing capacity service failure rate helps to improve their own earnings.

When the real capacity failure rate is \( f \), for LP, the optimal capacity supply and effort level is \( q_j^* \) and \( u_j^* \), Because LP is misled by the error information of LS, the decision result of LP is...
and \( u^*_f \) when the information is asymmetric, and both are greater than \( q^*_f \) and \( u^*_f \). Therefore, under the wrong decision \( q^*_f \) and \( u^*_f \), LP can not realize the maximization of its own income, that is, the expected return of LP is less than the value under the optimal decision \( q^*_f \) and \( u^*_f \).

4. Contract coordination based on quality inspection results

Because the cause of capacity service failure is not only the problem of LS itself, the wrong decision of customers will often lead to the occurrence of capacity service failure rate, so the quality of capacity service is detected to avoid that the logistics service providers need to carry out two services due to the customer's own problems. This can save the service costs while avoiding the loss of revenue. In order to expand their own revenues, logistics service providers choose to conceal the service failure rate of logistics service platform operators. Obviously, in order to prevent their own information hiding behavior from being discovered by logistics service platform operators, they will not actively encourage logistics service platform operators to participate in capacity quality of service testing. Therefore, under the information asymmetry, logistics service providers are more suitable for capacity service quality inspection. However, as the cooperation time between the two parties grows, the logistics service platform operators will eventually be aware of the information concealment behavior, and the supply chain will become extremely unstable. Therefore, in order to promote the stability of the logistics service supply chain under information asymmetry, it is necessary to establish corresponding contracts between the two parties for coordination.

According to the previous analysis, the logistics provider conceals the failure rate of the transportation service, which will mislead the logistics service platform to improve the effort level and capacity supply. The logistics service platform needs to bear the effort cost. At the same time of pay cost, the service failure rate is greater than the false information, resulting in the logistics service platform operators did not get reciprocal returns, that is, the cost paid is greater than the revenue, resulting in a decline in profits. Therefore, in view of the high cost of logistics service platform operators, the thesis proposes that the LS can mobilize the enthusiasm of the LP by using the cost sharing method based on the result of the service quality inspection.

The logistics service provider detects the result based on the quality of the service, that is, when the test result is the failure of the capacity service, that is, the cost paid is greater than the false information, resulting in the logistics service platform operators did not get reciprocal returns, and the platform operator according to the price \( v \) to share the part cost of the platform operator., thus promoting coordination and stability of the supply chain.

LP and LS cooperate under the coordination of cost-sharing compensation contracts. The decision function of LP is:

\[
\pi^*_w = \lambda_p (1 - \theta \varphi f) \min \{ x_o, q_o \} - \lambda_p \max \{ x_o - q_o, 0 \} - \frac{1}{2} du_o^2 - c_{oa} q_o + v \theta \varphi f q_o
\]  

(9)

The real profit function of LP is:

\[
\pi^*_w = \lambda_p (1 - \varphi f) \min \{ x_o, q_o \} - \lambda_p \max \{ x_o - q_o, 0 \} - \frac{1}{2} du_o^2 - c_{oa} q_o + v \theta \varphi f q_o
\]  

(10)

After LS carries on the capacity service quality inspection and participates in the cost-sharing compensation contract, its external profit expression is:

\[
\pi^*_w = (1 - \lambda_p) (1 - \theta \varphi f) \min \{ x_o, q_o \} - (1 - \lambda_p) \max \{ x_o - q_o, 0 \} - r \theta \varphi f q_o - h(\varphi f q_o - v \theta \varphi f q_o)
\]  

(11)

LS's real profit expression is:

\[
\pi^*_w = (1 - \lambda_p) (1 - \varphi f) \min \{ x_o, q_o \} - (1 - \lambda_p) \max \{ x_o - q_o, 0 \} - \varphi f q_o - h(\varphi f q_o - v \theta \varphi f q_o)
\]  

(12)

To solve the first derivative of \( q_o \) on an expression (9), the optimal capacity supply decision of the logistics Service platform operator LP under the compensation contract of cost allocation is

\[
q^*_o = b + a + \rho u_o \frac{2b - \lambda \rho}{\lambda} \frac{(c_{oa} - v \theta \varphi f)}{\lambda(2 - \varphi \theta f)} ; \quad \text{Similarly, by adding } q^*_o \text{ to the expression (9), the optimal effort level decision can be obtained as}
\]

\[
u^*_o = \frac{\lambda p (1 - \varphi f)}{\rho (c_{oa} - v \theta \varphi f)} \frac{2b - \lambda \rho}{\lambda} \frac{(c_{oa} - v \theta \varphi f)}{\lambda(2 - \varphi \theta f)} ; \quad \text{By adding } q^*_o \]
and $u_o^{**}$ to the expression (9), we can get the decision of LS on the ratio $\lambda_o^{**}$ of income distribution when the information is asymmetric. From the expression of the optimal decision, it can be seen that the compensation contract of cost sharing is beneficial to promote the logistics service platform operators to improve the supply of capacity and the level of effort, which is in line with the original intention of logistics service providers to participate in contract coordination.

**Proposition 3** after the compensation contract coordination of the cost allocation, the logistics service provider conceals the influence of the failure rate of the capacity service on the logistics platform operator's decision and the size of the compensation price, when the compensation price is greater than the Unit Capacity service income $\lambda p$ equal to the logistics platform operator, Cost-sharing compensation contract can solve the problem of information asymmetry caused by concealing the failure rate of capacity service.

Prove: Solving the first derivative of $u_o^{**}$ and $q_o^{**}$ about $\theta$ under the optimal decision of contract coordination, we can draw

$$\frac{\partial u_o^{**}}{\partial \theta} = \frac{d}{d}(v - \lambda p)\varphi f, \quad \text{and}$$

$$\frac{\partial q_o^{**}}{\partial \theta} = \frac{d^2}{d}(v - \lambda p)\varphi f + \frac{2\varphi f(2v - c_u)}{\lambda p(2 - \varphi f)\varphi f} \cdot$$

Obviously, when $v \geq \lambda p$, $u_o^{**}$ and $q_o^{**}$ increase with the increase of $\theta$. Therefore, $\theta=1$, that is, under information symmetry, the optimal decision $u_o^{**}$ and $q_o^{**}$ of logistics service platform operators reach the maximum. The problem of information asymmetry is solved.

The coordination of supply chain can be realized when the optimal decision of logistics service platform operators approaches the optimal decision under the centralized decision under the coordination of contract. According to $u_o^{**} = u_j$ and $q_o^{**} = q_j$, $v = p(1 - f) - \lambda p(1 - \varphi f) - rf - rf = v_i$ can be obtained.

Obviously, the cost-sharing compensation contract can not make $u_o^{**}$ and $q_o^{**}$ equal to the optimal decision at the same time under the centralized decision.

In order to ensure that logistics service providers and logistics service platform operators are willing to provide and accept contracts, it is necessary to ensure that the respective earnings of both parties after the contract coordination have increased, that is, to meet the

$$\left\{ \begin{array}{ll}
\pi_o^{**} = n_p > \pi_{o_p}^{**}, \\
\pi_i^{**} = n_i > \pi_{i_i}^{**},
\end{array} \right.$$ 

where $n_p$ and $n_i$ is constant, $n_p + n_i$ equals the contract coordination of the overall supply chain income, at this time the supply chain members can adjust the size of $n_p$ and $n_i$ to realize the elastic distribution of the expected earnings of LP and LS. At the same time, parameter $(\lambda, v)$ has a feasible area, when the corresponding threshold is exceeded, the contract loses its coordination function, and the corresponding analysis will be given by a concrete example.

5. **Analysis of numerical examples**

In order to discuss the coordination effect of the analysis model more intuitively, this thesis makes a concrete example analysis of the derivation results of the model, and discusses the influence of the change of the concealment coefficient $\theta$ on the supply chain decision and the expected income under the decentralized uncoordinated decision; Comparing the optimal decision and expected income under decentralized uncoordinated, compensation contract coordination and centralized decision, and analysis the coordination effect of compensation contract under the test of service quality; Drawing the growth chart of the expected income of LP and LS under the coordination of compensation contract, this thesis discusses the feasible domain of parameter $(\lambda, v)$ change, and discusses the practical significance of adjusting parameter $(\lambda, v)$ in feasible domain to realize the elastic distribution of income between LP and LS. Refer to the relevant literature\[14\], the failure rate is usually around 0.05, the maximum possible value is 0.1, the minimum pos-
sible value is 0.01, the basic parameters are set as follows table 2:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>5</td>
</tr>
<tr>
<td>f</td>
<td>0.05</td>
</tr>
<tr>
<td>a(103)</td>
<td>300</td>
</tr>
<tr>
<td>b(103)</td>
<td>20</td>
</tr>
<tr>
<td>c(102)</td>
<td>0.2</td>
</tr>
<tr>
<td>h(102)</td>
<td>0.1</td>
</tr>
<tr>
<td>r(102)</td>
<td>0.5</td>
</tr>
<tr>
<td>d</td>
<td>1</td>
</tr>
<tr>
<td>$\rho$</td>
<td>1</td>
</tr>
<tr>
<td>$\varphi$</td>
<td>0.5</td>
</tr>
</tbody>
</table>

(1) Sensitivity analysis of concealment coefficient $\theta$

In order to discuss the impact of logistics service providers on the overall supply chain decision and revenue by concealing the failure rate of capacity service, the results of the overall supply chain decision and revenue under different concealment coefficient $\theta$ are obtained according to the parameters and model derived from table 2, as shown in table 3:

<table>
<thead>
<tr>
<th>$\theta$</th>
<th>$u^d_{\theta_f}$</th>
<th>$q^d_{\theta_f}$</th>
<th>$\lambda^d_{\theta_f}$</th>
<th>$E(\pi_{\eta_1})$</th>
<th>$E(\pi_{\eta_2})$</th>
<th>$E(\pi_{\eta_3})$</th>
<th>$E(\pi_{\eta_4})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.0372</td>
<td>303.217</td>
<td>0.04768</td>
<td>5.66429</td>
<td>1316.807</td>
<td>1322.471</td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td>0.0364</td>
<td>303.202</td>
<td>0.04776</td>
<td>5.775612</td>
<td>1316.637</td>
<td>1322.413</td>
<td></td>
</tr>
<tr>
<td>0.3</td>
<td>0.0356</td>
<td>303.187</td>
<td>0.04784</td>
<td>5.886921</td>
<td>1316.467</td>
<td>1322.354</td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>0.0348</td>
<td>303.172</td>
<td>0.04792</td>
<td>5.998217</td>
<td>1316.297</td>
<td>1322.295</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>0.0340</td>
<td>303.156</td>
<td>0.04800</td>
<td>6.109503</td>
<td>1316.123</td>
<td>1322.233</td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>0.0332</td>
<td>303.141</td>
<td>0.04808</td>
<td>6.220772</td>
<td>1315.953</td>
<td>1322.174</td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td>0.0324</td>
<td>303.125</td>
<td>0.04816</td>
<td>6.332031</td>
<td>1315.779</td>
<td>1322.111</td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>0.0316</td>
<td>303.109</td>
<td>0.04824</td>
<td>6.443275</td>
<td>1315.605</td>
<td>1322.048</td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>0.0307</td>
<td>303.093</td>
<td>0.04832</td>
<td>6.554505</td>
<td>1315.431</td>
<td>1321.985</td>
<td></td>
</tr>
</tbody>
</table>

As can be seen from table 3, the optimal level of effort and capacity supply of logistics service platform operators increases with the increase of concealment degree, and the cost of decision increases is greater than the actual return, so the revenue of logistics service platform operators is decreasing, and gradually transferred to logistics service providers; This phenomenon is consistent with the purpose of the logistics service provider concealing the capacity failure rate. At the same time, because the logistics service provider’s concealment of the capacity failure rate behavior misled the logistics service platform operator to improve the level of effort and promote the growth of market demand, so the overall income of the supply chain gradually increased. However, due to the decline of logistics service platform operators, so from the LP to maximize the benefits of the point of view, at this time the logistics service supply chain is unstable.

(2) Analysis of coordination results of cost-sharing compensation contract

In order to solve the problem of information asymmetry and promote the stability of logistics service supply chain, this paper uses cost-sharing compensation contract to coordinate the supply chain. Combined with the results obtained in table 3, the coordination effect and practical significance of the compensation contract are analyzed by comparing the decision results under decentralized uncoordinated, compensatory contract coordination and centralized decision making, as shown in table 4:

<table>
<thead>
<tr>
<th>Decision type</th>
<th>$\theta=0.1$</th>
<th>Cost-sharing compensation contract coordination</th>
<th>Centralized decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispersed decision without coordination</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4 Comparison table of decision and income before and after compensation contract coordination supply chain
As can be seen from Table 4, under the optimal income distribution ratio \( \lambda \) decision of logistics service providers, the cost-sharing compensation contract helps to promote the improvement of the level of effort and the supply of capacity, increase the income of supply chain members and the overall supply chain, and solve the problem of information asymmetry, but because it is unable to promote the level of effort and capacity, the overall revenue of the supply chain only gets the suboptimal solution, and the maximization of the income is not realized.

Using MATLAB to draw the relationship between the change of parameter \((\lambda, \nu)\) and the increase of LP and LS earnings under contract coordination, as shown in Figure 2 and 3:

![LS's optimal expected income growth graph](image1)

![LP's optimal expected income growth graph](image2)

Fig. 2 LS's optimal expected income growth graph

As can be seen from Figures 2 and 3, the expected return of LP and LS can be increased simultaneously by adjusting the size of the parameter \((\lambda, \nu)\) within the feasible domain range. When the proportion of income distribution is less than 0.05, the coordination result of compensation contract is more favorable to LS, on the contrary, it is more favorable to the expected income growth of LP. LS's expected income growth chart is saddle-like, that is, the compensation price has a peak at different income distribution ratio, And with the increase of the proportion of income distribution, the peak point of compensation price decreases gradually; As the party receiving compensation, the growth chart of LP's expected income increases with the increase of parameter \((\lambda, \nu)\).

In the actual operation, LS can take advantage of the change relationship between parameter \((\lambda, \nu)\), flexibly adjust the distribution of supply chain income, realize its own expected income growth and ensure the stable development of logistics service supply chain.

In order to show more intuitively the effect of the change of parameter \((\lambda, \nu)\) on the expected return of LP and LS, We draw a diagram of the impact of the respective changes of \(\lambda\) and \(\nu\) on supply chain earnings, as shown in Figures 4, 5, 6, 7:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LP's earnings</th>
<th>LS's earnings</th>
<th>(\theta)</th>
<th>0.1</th>
<th>1</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>(u)</td>
<td>0.0372</td>
<td>0.0441</td>
<td>4.525</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(q)</td>
<td>303.217</td>
<td>315.516</td>
<td>323.602</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\lambda)</td>
<td>0.04768</td>
<td>0.01174</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\nu)</td>
<td>-</td>
<td>7.475</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Total revenue of the supply chain | 1322.471 | 1391.55804 | 1363.340 |
As can be seen from figures 4 and 5, with the increase of the proportion of income distribution $\lambda$, the expected income of LS decreases gradually, and the degree of reduction increases gradually, and the expected income of LP grows steadily. From the relationship shown in Figure 6 and 7, for LS, the relationship between the change of compensation price and the expected income is no longer monotonous increment or decreasing, but the existence of the optimal compensation price makes LS income to achieve the best. It is worth noting that when the compensation price is greater than the optimal value, LS's expected income shows a sharp decline trend, and the relationship between LP's expected income and compensation price is still steady growth. Therefore, when LS adjusts parameters, the increase of $\lambda$ and $\nu$ should be very cautious, the size of $\lambda$ and $\nu$ should be adjusted to a small extent, and the optimal equilibrium point should be found by observing the changes in the market. The above analysis is for LP and LS each expected earnings growth, but the feasible domains that satisfy the expected revenue growth of LP and LS are different. Obviously, it is only in the common feasible domain of LP and LS that the parameter $x$ can be adjusted in order to realize the co-win of the members of both sides of the supply chain. Therefore, on the basis of figures 2 and 3, the respective parameters of LP and LS are plotted, as shown in Figures 8 and 9:
As can be seen intuitively from figures 8 and 9, the feasible area to realize LP expected earnings growth is much larger than the feasible area to achieve LS expected earnings growth, and when the two diagrams are superimposed, the coincident area is the feasible domain to realize the simultaneous growth of LP and LS expected income, in this area, by adjusting the parameter \((\lambda, \nu)\), it can effectively meet the different requirements of LP and LS for expected income and realize the elastic distribution of supply chain income.

6. Conclusion
In a two-level service supply chain consisting of logistics service provider LS and logistics service platform operator LP, the thesis discusses the impact on the overall supply chain when logistics service providers conceal the service failure rate and mislead the decision of the logistics service platform operator. Through the analysis of the income and cost components of the supply chain members, using cost-sharing compensation contract to coordinate the supply chain, combined with the analysis of examples, the following conclusions are drawn:

(1) The improvement of the level of effort is conducive to the growth of supply chain revenue, but the improvement of effort level will lead to the increase of cost, so there is a zero point where the supply chain income reaches the optimal level. When LP makes decisions, it can determine the optimal effort level according to changes in market demand and related influencing factors to maximize revenue. The increase in the service failure rate will lead to a decline in the overall revenue of the supply chain, so LS can increase its own revenue by reducing the service failure rate.

(2) The cost-sharing compensation contract can effectively solve the information asymmetry problem caused by the logistics service provider concealing the service failure rate, realize the expected revenue growth of the logistics service provider and the logistics service platform operator, and improve the stability of logistics service supply chain operation, and promote the healthy development of the supply chain.

(3) The cost-sharing compensation contract cannot achieve the coordination of the effort level and the capacity supply chain at the same time. Therefore, the coordination result only obtains a sub-optimal solution, and the overall supply chain revenue is not maximized.

References


10. Y.Y Zhao. The Coordination method and system implementation of level two supply chain under the condition of information symmetry/asymmetry [D]. Harbin Institute of Technology, 2016. (In Chinese)


