Pricing strategy of NVOCC considering paying freight in advance

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Abstract—In recent years, with the increasingly fierce competition, non-vessel operating common carriers (NVOCCs) often pay freight for some small and medium-sized shippers in advance to win more customers. Therefore, NVOCC, whose main source of profit is freight difference, will adjust the freight rate to balance the risk-benefit relationship in the business process. Based on the above business process, this paper establishes the two-sided market pricing model, analyzing the pricing strategy of NVOCC. We find that there is a positive relationship between the capacity utilization and the optimal freight rate and profit of NVOCC; there is a threshold point for the incentive degree of the paid freight in advance by NVOCC to the small and medium-sized shippers: when the incentive degree is higher than the threshold point, the NVOCC obtains the maximum profit by paying freight for some small and medium-sized shippers in advance.

1. INTRODUCTION
In recent years, the LCL (less than container load) demand of small and medium-sized shippers, considerable freight difference and supportive policies have promoted the development of non-vessel operating common carriers (NVOCCs). However, the competition in the industry becomes much more fierce. In order to seek new market space and win more customers, NVOCCs often choose to pay freight for some small and medium-sized shippers in advance (Zhang and Zhao, 2010), which makes NVOCCs not only bear the liability risk, but also face the risk of uncollectible receivables after freight is paid in advance. As a capacity wholesaler (Song et al., 2017), NVOCC takes freight difference as its main source of profit (Lee and Song, 2017). When paying freight for some small and medium-sized shippers in advance, they usually balance the risk-benefit relationship by adjusting freight rate (Wang et al., 2017). Based on the theory of two-sided market pricing, this paper establishes a two-sided market freight rate decision-making model when NVOCC pays freight for the small and medium-sized shippers, analyzing pricing strategy of NVOCC.

2. LITERATURE REVIEW
NVOCC has obvious characteristics of two-sided market. It meets the needs of users whose needs are complementary. The more actual shippers will attract more actual carriers. The more actual carriers will also bring more choices to the actual shippers. Besides, abundant cargo volume and capacity are also conducive to improving the bargaining power of NVOCC.

Many scholars research the pricing model under the theory of two-sided market. Some scholars mainly explore the influencing factors of the pricing strategy. Rochet and Tirole (2003) find that if one side has lower price elasticity of demand, the price structure will incline in the way beneficial to the
other side. Armstrong (2006) finds that there are three determinants of platform equilibrium price: the scale of cross group externality, charge for one or every transaction, and whether users join one or more platforms. Hagiu (2006) researches how the sequence in which the buyer and the seller joined the platform and their loyalty to the platform affected the pricing. He finds that in the case of monopoly, if the seller joined the platform first and kept a good expectation of the platform, the optimal pricing strategy of the platform was to negotiate with the buyer following the public seller price. Roberto (2006) summarizes the literatures on the theory of two-sided market: the price elasticity, the intensity of network externality, the single and multiple attribution of the market and the product differentiation of the bilateral market affect the pricing strategy of the two-sided market.

Some scholars research how different types of platforms conduct two-sided pricing. Xu and Chen (2009) analyze bank pricing strategies under the duopoly situation. Li (2016) analyzes the two-sided pricing strategy of the retail platform based on different charging standards of the retail industry. Tan and Zhou (2017) build a two-stage game model of platforms providing differentiated services in the bilateral market. Li and Zhao (2017) analyze the optimal pricing strategy combination of container assembly platform respectively considering membership fee mode, transaction fee mode and two-part fee mode. Xing et al (2018) analyze the pricing strategy of logistics information monopoly platform for vehicle and cargo matching. Li and Han (2019) explore the optimal pricing decision of the non-warehouse operating common carriers.

In this paper, paying freight in advance means permissible delay in payments of freight. Regarding the pricing strategy in the case of permissible delay in payments, Teng et al. (2005) analyze the retailers’ optimal pricing and ordering strategies. Lili et al. (2012) use the infinite repeated game theory to research the optimal replenishment and sales strategies from the perspective of manufacturers and retailers respectively. Some scholars also considered the characteristics of commodities. Tripathi et al. (2012) analyze the pricing strategy for non-deteriorating items whose inventory was only relevant to demand, and Mishra et al. (2018) analyze the pricing strategy for deteriorating items with controllable deterioration rate.

The theory of two-sided market is becoming much more mature. In addition, in the aspect of permissible delay in payments, scholars mostly discuss the pricing strategy in the case of physical sales. There are a few researches involved the pricing decision about service industry. According to the business characteristics of NVOCC, combined with the special situation of delay payment, this paper analyzes the two-sided market pricing strategy when NVOCC agrees to delay the payment of freight.

3. MODEL CONSTRUCTION

3.1. Assumptions

After the NVOCC purchases the capacity from the actual carriers at certain price, the small and medium-sized shippers make a price inquiry to the NVOCC, then the small and medium-sized shipper and the NVOCC negotiate the freight rate, and the NVOCC determines whether to pay the freight for the small and medium-sized shippers in advance. If the NVOCC agrees to pay the freight in advance, there will be certain opportunity cost.

According to the above business process, in order to establish the freight rate decision model of the NVOCC, we make the following assumptions:

I) The NVOCC is a monopoly platform in certain areas and regions;
II) The agreed freight rate between the NVOCC and actual carrier is constant throughout the process;
III) The value of service provided by the NVOCC to users on both sides is the same;
IV) The definition of freight paid by the NVOCC for the small and medium-sized shipper in advance is that the NVOCC agree the small and medium-sized shipper to delay the payment of all freight without any interest;
V) If the small and medium-sized shipper fails to pay all the freight on time, it is deemed as default. The NVOCC bears all the loss on its own, and the loss value is calculated according to the total freight;
VI) The costs of the NVOCC are constant.

3.2. Notation
The main parameters used in the model and their meanings are introduced as follows:
- $u_a$: the utility of each actual carrier
- $u_b$: the utility of each small and medium-sized owner
- $v$: the value of services provided by the NVOCC to both sides of the platform
- $\theta_a$: the service value conversion coefficient of each actual carrier after accessing the NVOCC platform, $\theta_a \in [0, 1]$
- $\theta_b$: the service value conversion coefficient of each small and medium-sized shippers after accessing the NVOCC platform, $\theta_b \in [0, 1]$
- $\alpha_a$: the interactive benefits that each actual carrier enjoys from interacting with each small and medium-sized shippers, $\alpha_a > 0$
- $\alpha_b$: the interactive benefits that each small and medium-sized shipper enjoys from interacting with each the actual carriers, $\alpha_b > 0$
- $n_a$: the number of actual carriers accessing the NVOCC platform, $n_a \in [0, 1]$
- $n_b$: the number of small and medium-sized shippers accessing the NVOCC platform, $n_b \in [0, 1]$
- $p_a$: the agreed freight rate between the actual carrier and NVOCC
- $p_b$: the agreed freight rate between small and medium shippers and the NVOCC
- $c_a$: the total service cost incurred by the actual carrier after joining the NVOCC platform
- $f$: the capacity utilization which directly affects the actual carriers’ willingness to trade
- $i$: the rate of increase in transaction after the NVOCC agrees to pay freight for small and medium-sized shippers
- $c$: the total operating cost of the NVOCC
- $\gamma$: the risk-free interest rate, which affects the cost of capital turnover of NVOCC in a period
- $P_r$: the probability of default of small and medium-sized shippers, $P_r \in [0, 1]$
- $\pi_1$: the profit of the NVOCC when it refuses to advance freight
- $\pi_2$: the profit of the NVOCC when it agrees to advance freight

3.3. Practicing Model
The utility obtained by each actual carrier after joining the NVOCC platform is
\[ u_a = \theta_a v + \alpha_a n_b + p_a - c_a \]  \hspace{1cm} (1)
The utility obtained by each small and medium-sized shipper joining the NVOCC platform is
\[ u_b = \theta_b v + \alpha_b n_a - p_b \]  \hspace{1cm} (2)
To encourage both small and medium-sized shippers and actual carriers to join the platform, there are
\[ u_a \geq 0; u_b \geq 0 \]  \hspace{1cm} (3)
By combining (1), (2) and (3), we can get the threshold point between the actual carrier and the small and medium-sized shipper accessing the NVOCC platform and respectively is
\[ \theta_a^* = \frac{\alpha_a n_b + p_a - c_a}{v}; \theta_b^* = \frac{\alpha_b n_a - p_b}{v} \]  \hspace{1cm} (4)
So the number of actual carriers and small and medium-sized shippers accessing the NVOCC platform is respectively is
\[ n_a = \frac{p_a + p_b - c_a}{v}; n_b = \frac{p_a + p_b - c_a - \alpha_a n_b}{v - \alpha_a n_b} \]  \hspace{1cm} (5)
If the NVOCC refuses to pay the freight for the small and medium-sized shippers, the profit of the NVOCC is as follows:

\[ \pi_1 = n_b p_b - f n_s p_s - c \]  
(7)

If the NVOCC agrees to pay the freight in advance for the small and medium-sized shipper, the profit of the NVOCC is as follows:

\[ \pi_2 = \left[ (1 + \delta) n_b p_b - f n_s p_s - (1 + \delta) n_b p_b \eta - c \right] (1 - P_r) - (f n_s p_s + c) P_r \]  
(8)

4. OPTIMAL SOLUTION

4.1. Determination of the optimal price

Proposition 1. If the NVOCC refuses to pay the freight for the small and medium-sized shipper in advance, \( p_{b1}^* \) maximizes the profit of the NVOCC; if the NVOCC agrees to pay the freight for the small and medium-sized shippers in advance, \( p_{b2}^* \), maximizes the profit of NVOCC. \( p_{b1}^*, p_{b2}^* \) are as follows:

\[
\begin{align*}
  p_{b1}^* &= \frac{\nu^2 + \nu \alpha_2 + \alpha_b p_b - \alpha_3 c_2 + f \alpha_2 p_s}{2 \nu} \\
  p_{b2}^* &= \frac{\nu^2 + \nu \alpha_3 + \alpha_b p_b - \alpha_5 c_2 + f \alpha_2 p_s}{2 \nu (1 + \delta)} (1 - \eta) (1 - P_r) 
\end{align*}
\]

Corollary 1. According to proposition 1, both \( p_{b1}^* \) and \( p_{b2}^* \) increase with \( f \) increasing.

When the price agreed between the NVOCC and actual carrier is certain and constant, capacity utilization only affects the volume of transactions between the NVOCC and actual carriers. The higher the capacity utilization is, the higher the cost paid by the NVOCC to purchase the capacity is. The NVOCC needs to increase the agreed freight rate agreed with the small and medium-sized shippers in order to obtain the maximum profit.

Corollary 2. According to proposition 1, \( p_{b2}^* \) increases with \( P_r \) increasing.

When the NVOCC pays the freight for the small and medium-sized shippers in advance, it will consider the default probability of the small and medium-sized shippers. The higher the default probability is, the higher the risk of bad debts faced by the NVOCC is. Aiming at risk management, the NVOCC will correspondingly increase the freight rate agreed with the small and medium-sized shippers.

Corollary 3. According to proposition 1, \( p_{b2}^* \) decreases with \( \delta \) increasing.

The higher incentive degree is, the greater the willingness of the small and medium-sized shippers to make a deal is. When the small and medium-sized shippers are more excited to be paid the freight in advance, there are the higher transaction volume and lower the agreed freight rate between the NVOCC and the small and medium-sized shippers.

4.2. Decision of Permissible Delay in Payments

Proposition 2. When \((1 + \delta)(1 - \eta)(1 - P_r) \geq 1\) and freight rate is \( p_{b2}^* \), the NVOCC can pay the freight for the small and medium-sized shippers and obtain the maximum profit.

Proof Only when \( \pi_2 \geq \pi_1 \), will the NVOCC pay the freight for the small and medium-sized shippers. Combining (5), (6), (7) and (8), we have:

\[ (1 + \delta)(1 - \eta)(1 - P_r) - 1 \geq 0 \]  
(9)

Then we can get

\[(1 + \delta)(1 - \eta)(1 - P_r) \geq 1 \]  
(10)

According to (10), we find that the risk-free interest rate is relatively stable and low, and the degree of incentive and probability of default are relatively high. In other words, the degree of incentive and probability of default play an important role in optimal price in case of advancing freight. For small and
medium-sized shippers with better credit and higher incentive degree, the NVOCC will get the higher profits after paying the freight for them.

5. NUMERICAL EXAMPLE

Based on the research of Xing et al (2018), we take $v = 2$, $c_2 = 10$, $a_2 = a_b = 0.05$, $p_2 = 0.15$, $\gamma = 0.05$, $c = 0.2$ as basic data and analyze how $f$, $P_r$, and $i$ affect $p^*_o$.

As shown in Figure 1, we suppose $P_r = 0.1$, $i = 0.3$. Given that other variables remain constant, the freight rate and profits increase with capacity utilization increasing. It means that if the NVOCC wants to achieve higher profit, it needs to improve its ability as much as possible—coordinating its capacity resources, so as to achieve a win-win situation among the three parties.
As shown in Figure 2, we suppose \( f = 0.9 \), \( \mathbb{I} = 0.3 \). Given that other variables remain constant, the freight rate increases and the profit decreases with probability of default increasing. Besides, when the probability of default is higher than a threshold point, \( \pi_1^* > \pi_2^* \). It means that raising freight rate can balance part of credit risk, but for small and medium-sized shippers with high probability of default, the NVOCC can’t get the maximum profit if paying the freight in advance for them.

As shown in Figure 3, we suppose \( f = 0.9 \), \( R_e = 0.1 \). Given that other variables remain unchanged, the freight rate decreases and the profit increases with the degree of incentive increasing. Besides, when the degree of incentive is higher than a threshold point, \( \pi_2^* > \pi_1^* \). It means that freight paid in advance needs to provide enough incentive to small and medium-sized shippers to make a deal, so that the NVOCC can get the maximum profit.

6. CONCLUSIONS
This paper draws the following conclusions:

1) There is a positive relationship between the capacity utilization and the optimal freight rate and profit of NVOCC, which means that NVOCC has the power to plan the capacity reasonably. The matching of supply and demand of capacity brings win-win situation of actual carrier, NVOCC and small and medium-sized shippers.

2) For small and medium-sized shippers with high probability of default, NVOCC can choose to increase the agreed freight rate or even refuse to pay the freight for them.

3) There is a threshold point for the incentive degree of the paid freight in advance by NVOCC to small and medium-sized shippers. Only when the incentive degree is higher than this threshold point, can NVOCC obtain the maximum profit by paying freight for small and medium-sized shippers in advance.

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