Pricing Strategy of Logistics Service Supply Chain Considering Different Reciprocal Preference

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Abstract. This paper studies the influence of reciprocity preference on decision-making behaviour and supply chain benefits under different reciprocity preferences—chain members have independent preference and the integrator has linear preference. The Stackelberg game is used to analyze the influence of preference coefficient on supply chain decision and the outcome. It is found that there is a reasonable area of preference. When members have different independent preference, the supplier's service asking price decreases with her own preference, but increases with the integrator’s preference, and the quality of service increases with integrator’s preference at the reasonable area. The integrator’s profits increases with preference of itself, utility increases with provider’s preference. And the provider’s utility increases with preference of integrator and provider. Besides, the influence of preference coefficient on supply chain decisions and results depends on the value of the reciprocal dependency coefficient.

Introduction
There are numbers of researches on the logistics service supply chain logistics services providing. Tian Yu [1] put forward the general model of the logistics service supply chain, namely the integrated logistics service provider - an integrated logistics service provider - manufacturing, retail enterprise model, and the logistics service provider refers to the traditional functional logistics enterprises, such as transport enterprises, warehousing enterprises. After that, the Xiuxia et al [2], Cai Yunfei et al [3], Guo Mei et al [4], Zhang Dehai et al [5], Choy et al [6] studied this model in different ways. The theoretical system is being gradually improved, but quantitative research is relatively less. The researches above on logistics service supply chain are mostly based on the assumption of rational decision-makers, not taking into account the characteristics of decision-makers behavior. However, many scholars have found that decision makers are not only self-interested, but also have social preferences. Cui T H et al. [7], Loch C H et al. [8] studied the specific form of fair preference utility function. And in real life, the behavior of reciprocal preference is also more common, such as GM, pay great attention to its parts suppliers’ profitability, and even help them improve technological transformation to enhance R&D capabilities. So it is meaningful to add the effect of reciprocal preference in the theoretical study of the service supply chain.

The supply chain members' reciprocity preferences are incorporated into the supply chain to discuss the impact on optimal decision-making and the results.

Model Setting
We consider a two-tier service supply chain consisting of a functional logistics service provider and a logistics service integrator. The supplier acts as a leader, determining the quality of service $Q$ and $w$, makes Stackelberg game with integrator, setting $p$. $D = a - bp + \varphi Q$ is assumed to be the demands coming from the market, where $p$, $Q$ represent market price of logistics service and quality of service offered by the functional logistics service provider. Besides, $a > 0, b > 0, \varphi > 0$. And $c = LQ^2/2$ is supposed to be unit cost of the provider. And we assume the profits are: $\pi_l(p) = (p - w)D; \pi_e(w, Q) = wD - LQ^2/2$. 

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Decentralized Model with Independent Reciprocal Preference Coefficient (D1)

The utility function of the integrator and the supplier, both with independent reciprocity preferences can be expressed as:

$$
U_{\text{int}}(w) = wD - LQ^{1/2} + \alpha(wD - LQ^{1/2})/2
$$

$$
U_{\text{sup}}(w) = wD - LQ^{1/2} + \beta(wD - LQ^{1/2})/2
$$

The optimal solution:

$$
\alpha = 2L^2a(1-\alpha^2) - 2Lb(1-\alpha)(\alpha^2 + \beta^2 - 2\alpha^2 + 2\alpha \beta + 2\alpha \beta - 3\alpha^2 + 3\beta^2 - 2\alpha \beta - 3\alpha^2 / 2)
$$

Proposition 1. The service quality of the supplier, the ‘wholesale’ price are both increasing function of the reciprocal preference of the integrator; ‘wholesale’ price is decreased with its own reciprocal preference.

Proposition 2. The profit of the integrator increases with $\alpha$; the provider’s utility increases with $\alpha$; the profit and utility of the integrator increases with $\beta$; the profit of the provider deduced with its own reciprocal preference.

Decentralized Model with Linear Reciprocity Preference Coefficient of the Integrator(D2)

When the integrator has a linear reciprocal preference coefficient, the utilities are:

$$
U_{\text{int}}(w) = wD - LQ^{1/2} + \alpha(wD - LQ^{1/2})/2 + \beta(wD - LQ^{1/2})/2
$$

The optimal solution:

$$
\alpha = 2L^2a(1-\alpha^2) - 2Lb(1-\alpha)(\alpha^2 + \beta^2 - 2\alpha^2 + 2\alpha \beta + 2\alpha \beta - 3\alpha^2 + 3\beta^2 - 2\alpha \beta - 3\alpha^2 / 2)
$$

Proposition 3. When $(k^2 + \alpha \beta - 1) > 0$, the service quality of the supplier is the decreasing function of the reciprocal preference of the integrator, and the price the supplier asking to the integrator is the decreasing function of the reciprocal preference of the integrator; the provider’s utility increases with integrator’s reciprocal preference. And vise versa.

Centralized Model(C1)

When the integrator and the provider make centralized decision, the situation is:

$$
\pi_s(p, Q) = pD - LQ^{1/2}, \pi_f(w, Q) = wD - LQ^{1/2} + \beta(p - w)D
$$

The optimal solution:

$$
\alpha = 2L^2a(1-\alpha^2) - 2Lb(1-\alpha)(\alpha^2 + \beta^2 - 2\alpha^2 + 2\alpha \beta + 2\alpha \beta - 3\alpha^2 + 3\beta^2 - 2\alpha \beta - 3\alpha^2 / 2)
$$

Proposition 4. When $\beta(k^2 + 2\alpha \beta - 2) > 0$, the ‘wholesale’ price and the service quality in D1 is higher than that of D2, and vise versa. The profits of the whole channel in D1 and D2 are both less than that in C1.

$$
\pi_{\text{C1}} = \frac{La}{2L^2a^2} - \frac{ag}{2Lb - a}\pi_{\text{C1}}
$$
Numerical Analysis

In the part, we will discuss the conclusions of the theoretical study above by numerical analysis. We assume: \( \alpha = 5000, b = 3, \varphi = 2.8, L = 1000 \). In order to compare different situation, we take the intersection of different situation: \( \alpha \in [-1, -0.03], \beta \in [-0.7, 1] \).

From Figure 1, \( w \) increases with \( \alpha \), and decreases with \( \beta \). From Figure 2, the decentralized situation of \( Q \) is always lower than \( C1 \). In decentralized situations, \( Q \) increases with \( \alpha \) and \( \beta \). From Figure 3, \( p \) is the lowest in \( C1 \). In the decentralized cases, \( p \) decreases with \( \alpha \) and \( \beta \). when the integrator is more concerned with the benefits of suppliers, she is willing to accept suppliers’ raising prices with improving service quality, and it can reduce \( p \) to increases demands and if the supplier is more concerned about the benefits of integrators, it will reduce \( w \) and improve \( Q \) at the same time.

From Figure 4, the profit of the integrator increase with \( \alpha \) when \( \beta \) is close to -1 and decreases with \( \alpha \) when \( \beta \) is far from -1, but a decreasing function off \( \beta \). From Figure 5, the profit of the supplier is positively correlated with \( \alpha \), and decreases first and then increases with \( \beta \). Figure 6 shows the profit of the chain under the centralized situation is greatest, followed by the \( D1 \), \( D2 \) is the smallest. In the decentralized cases, the overall profit of the chain is positively correlated with \( \alpha \) when \( \beta \). For the entire supply chain, the supplier’s reducing \( w \) and improving \( Q \), will be retreated friendly by the integrator: reducing \( p \) to increase market demand, which will improve the profit of the chain and promote the long relation between chain members.

From Figure 7, the utility of the integrator is increases with the reciprocity preference of the integrator and the supplier. Figure 8 shows that the utility of the supplier is also increased with \( \alpha \) and \( \beta \). From Figure 9, the overall utility of the supply chain is an increasing function of \( \alpha \) and \( \beta \).
When the supplier and integrator are more concerned about each other's earnings, their utility will increase with the other side's increase in revenue, the overall utility of the supply chain will rise.

Conclusions
This paper discusses the pricing strategies and benefits of integrators and suppliers with different reciprocal preference in the logistics service supply chain. The discussion found that, regardless of different reciprocal preference situation, there is a reasonable preference area, which varies with the reciprocity dependency coefficient; when members have different independent preference, the supplier's service asking price decreases with her own preference, but increases with the integrator’s preference, and the quality of service increases with integrator’s preference in this reasonable area. The integrator’s profits increases with preference of itself, utility increases with provider’s preference. And the provider’s utility increases with preference of integrator and provider. The influence of preference coefficient on supply chain decisions and results depends on the value of the reciprocal dependency coefficient.

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