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Research Article

Investigation of Dynamic Incentive of Supply Chain under Information Asymmetry for Screening

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More and more high-end brand companies are exploring new markets by extending low-end product lines. When selecting agents in new markets, a principal often faces the problem of identifying the promotional ability of agents. This paper aims to study the dynamic incentive of supply chain under information asymmetry for the information screening in long-term supply chain cooperation. Also, it pioneers the rhythm of information disclosure in the extant literature. By establishing three two-stage supply chain models, this paper analyzes the impact of agents' information disclosure speed on the brand. We find that it is better to separate agents earlier out of the brand perspective; the semiseparated contract is beneficial for the brand to control information disclosure speed more flexibly and get more profits from the retailer. But, from the perspective of the supply chain, it is also possible to prefer the mixed contract. Under certain conditions, the pooling contract could also increase the profits of supply chain and improve the allocation efficiency of supply chain.

1. Introduction

Since long-term relationship is so significant to achieve supply chain efficiency and effectiveness [1], companies need to develop and maintain close relationship with their suppliers and customers. However, how to coordinate and perfect supply chain partnership is rather complex and difficult [2], especially when facing different options in practice. For instance, when a brand franchiser enters a new market and chooses new sales partners, such as franchisee, the franchisee understands its own business model and type very well. The franchiser, however, knows little about the franchisee's promotion ability (called the dealer's type hereafter); the franchiser can only learn it during their cooperating process. As the franchisee tries to hide this information in order to win the contract, the franchiser needs to understand how the franchisee's private information may alter key variables of its decision process, such as the contractual design, set up over periods. Therefore, the brand franchiser needs to design a mechanism to induce the franchisee to reveal its true type. Consequently, the adverse selection arises.

On the other hand, the brand franchiser and franchisee need to develop long-term collaboration relationship during which, the franchiser is able to separate the franchisee by paying for information rent. As the franchisee may conceal real-type information for maximizing its total utility across the period, forecasting the behavior of the franchisee, the brand franchiser needs to design appropriate incentives to control the rhythm of information disclosure. Therefore, this paper will consider how a brand franchiser designs the best cross-cycle incentive mechanism in the context of multicycle cooperation. We model the separating timing decision by assuming that the brand has the options of separate, semiseparate, or pooling contracts, thereby achieving optimal allocation of resources and finally achieving mutual understanding and long-term cooperation. In particular, we focus on two periods of dynamic screening problem in this paper.

To address this question, we establish a two-stage supply chain model with a brand franchiser and a franchisee in the presence of asymmetric information, where the brand is less informed by the franchisee's promotion ability. Therefore, the two partners may interact with each other over two stages. By anticipating the franchisee's motivation to hide its real type, the brand franchiser has the option to separate, semiseparate or pool in the first period, and fully separate (if necessary) in the second period. Specifically, this paper answers the following questions.

Question 1. What is the difference of the dynamic screening contract with the one-shot static contract?

Question 2. What is the impact of separating timing on the brand's marketing strategies in the presence of adverse selection?

Question 3. Compared with the one-shot case, do the firms prefer separating earlier or later?

The paper is organized as follows. Section 2 reviews the related literature. Section 3 outlines the model. Sections 4 and 5 compare the results in three cases, i.e., separated contract, semiseparated contract, and pooling contract. Conclusions are presented in the last section of the paper.

2. Literature Review

There are valuable research papers focusing on information screening and information franchising. The studies of information screening mainly focus on the optimal contract of one period and two periods under renegotiation-proof with commitment. In previous studies, Ha [3] has compared selections of optimal contracts and changes in the benefit of supply chain parties under symmetric and asymmetric information. Su et al. [4] found that the information rent depends on the value of the information and the status of resources available. Kim and Netessine [5] studied the influence on incentives of supply chain parties under asymmetry cost information. These three papers involved one-period information screening models with single asymmetric information. Li et al. [6] investigated the model with two heterogeneous suppliers and one dealer. Kong et al. [7] discussed the effect of revenue sharing in promoting information sharing in supply chain. Li et al. [8] proposed a model with dual information asymmetry. The above literature mainly aims at the information screening of single period and single factor under information asymmetry. Li and Debo [9] examined the impact of cooperation time on the benefits of supply chain parties. Ma et al. [10] have studied a two-period two-stage supply chain coordination model with a manufacturer and a dealer. These papers involved two-period dynamic information screening models, including separated contract and the pooling contracts but not the semiseparated contracts. Xu et al. [11] proposed a punishment scheme to suppress the attack motivation, which revealed how the punishment scheme impacts the adversary between the blockchain. These literatures involve multiperiod dynamic information screening, but mainly discuss one-step separation. In this paper, we supplement and improve this problem and discuss the possibility of separation rhythm in dynamic game.

The studies about franchising mainly focus on explanation of the mode, analysis of advantages and disadvantages, and modes of cooperation. Sen [12] used the principal-agent theory to explain the structure of franchising fees. Li et al. [13] compared the two franchising modes under different dominance rights. Xie et al. [14] compared the effects of three qualities (types) of franchising contracts on the profits of supply chain parties. Lal [15] has discussed the role of franchising factors in improving the cooperation among supply chain members. Lafontaine [16] made substantial assessment on various principal-agent theories based on franchising. Xie et al. [17] studied how franchising fees increase revenue for dealers. García-Herrera and Llorca-Vivero [18] built a model to predict the best cooperation time of franchising. The influence of supply chain coordination strategy has also been studied [19–21].

In addition, Wrenlewis [22] applied a contract-based procurement model discussing the qualifications used in incentive contracts. Pavan et al. [23] and Chaudey [24] studied the theory of incentives in dynamic contracts. Athey and Segal [25] constructed a Bayesian incentive compatibility mechanism, which proved that this mechanism is effective and balanced when the type change of the agent conforms to the Markov chain. Krähmer and Strausz [26] found that the classical model does not recognize binding incentive compatibility constraints in the presence of participation constraints.

In summary, most of the literatures focus on one-period principal-agent model in information disclosure, and little of them are about revelation principle in supply chain long-term cooperation. Therefore, we build a two-stage supply chain model to analyze the impact of agents' information disclosure rate on the brand and the supply chain through three models. The differences with existing literatures are as follows. Firstly, we introduce time of information disclosure in two-period cooperation. Secondly, we study the impact of intertemporal discount factor and the allocations under different contracts. Finally, we analyze the reason for contract selection from the perspective of the brand and the supply chain.

3. Model

We consider a two-stage supply chain with a brand (he) and a dealer (she), where the dealer's promotion ability is unknown to the brand. The brand has a well-established brand name in a market and sells his product through the dealer. To capture the feature that the dealer is closer to the market and may also have better expertise in his promotion ability than the brand, we assume that the quality (type) of the agent takes two values and is private information of the dealer. The brand can only know the quality (type) through market research. Due to asymmetric information between supply chain members, the brand has a motivation to incentive the dealer to reveal her quality (type) truthfully. In information asymmetry trading process, the agent (dealer) is in the position of information superiority, which may damage the interests of the brand in order to maximize its own interests. Therefore, the brand must design an appropriate incentive mechanism to identify the agent's private information.

Similar to the classical literatures, we suppose that the market revenue in each period is denoted by $S(q,\theta) = \theta q$ [27], where q is the quality (type) of the product, the brand incurs per-unit production costs of $c(q) = (1/2)q^2$, and θ represents the quality (type) of the dealer. We assume the dealer's quality (type) is constant over two periods. In our asymmetric information setting, the dealer knows her quality (type) exactly, while the brand only has an initial prior of the quality (type) of the dealer, which can be either a high value $\overline{\theta}$ with probability ρ, or a low value $\underline{\theta}$ with probability $1-\rho$, where $\Delta\theta = \overline{\theta} - \underline{\theta} > 0$. The intertemporal discount factor is δ.

It can be seen that both the dealers' type and the product quality determine the final revenue of the supply chain, and each of them is proportional to the final revenue [28–30]. The allocation of surplus among the brand and the dealer depends on the brand's incentive mechanisms, that is, a less well-informed brand may try to provide incentives for the more informed dealer to reveal her private quality (type) with a menu of contracts. The contracts are different in quality (type) q and transfer payment T for different qualities (types) of the dealer. The contract $(\overline{q}, \overline{T})$ is for $\overline{\theta}$ dealers, and the contract $(\underline{q}, \underline{T})$ is for $\underline{\theta}$ dealers. Therefore, the brand's utility is $\Gamma = T - c(q)$, and the dealer's utility is $U = \theta q - T$. The utility of supply chain is $\Pi(q) = \theta q - c(q)$. For simplicity, we assume that the reservation utility of the dealer is normalized to 0.

In addition, an important quality (type) of information asymmetry in supply chain is the mode of dynamic cooperation, where the two parties may play games in multiple periods. Therefore, when choosing the incentive mechanism, the brand should not only consider the payoffs in the current period, but also consider its impact on future payoffs. This problem can be multiperiod information screening. For simplicity, we consider a dynamic information screening model with two periods. During the game, the two parties make decisions according to the given market conditions and behaviors of the other member. In this paper, the brand can control the rhythm to distinguish the dealer through three different contracts. The first one is the separated contract, which the dealer is screened in period one. The second one is the pooling contract, which is the opposite of the separated contract. The third one is semiseparated contract, which the dealer is screened in two periods.

Generally, the sequence of the game is shown in Figure 1.

(1) At the beginning, the dealer knows her quality (type), and asymmetric information occurs

(2) According to research, the brand chooses appropriate incentive mechanism and offers a menu of two-period contracts, which are $\{(\overline{q}_1, \overline{T}_1), (\overline{q}_2, \overline{T}_2)\}$ and $\{(\underline{q}_1, \underline{T}_1), (\underline{q}_2, \underline{T}_2)\}$

(3) The dealer decides whether to accept it and if so, which contract to sign

(4) The signed contract is executed, and the two-period outputs are realized

According to the sequence of the game in Figure 1, we use backward induction to solve the problem. Let superscript

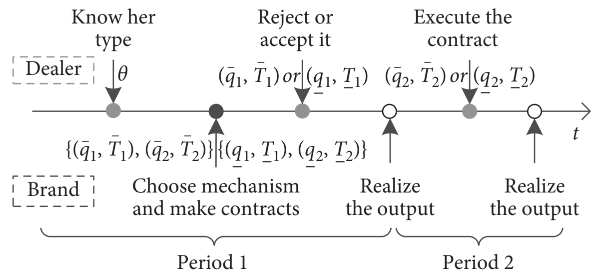

Figure 1: The sequence of the game.

S be the separated contract, P the mixed contract, and SS the semiseparated contract. And let subscript $\{1, 2\}$ be the time of game.

4. Three Incentive Models

First of all, we take the two-period information screening model under symmetric information as a benchmark. In this case, both the brand and the dealer know the dealer's quality (type). According to previous studies, the contract offers the dealer at least reservation utility, while the brand can obtain the overall surplus of the supply chain and realize the optimal allocation $\{\overline{q}^* = \overline{\theta}, \underline{q}^* = \underline{\theta}\}$, which is the repetition of single period information screening models under symmetric information [27]. With asymmetric information, in the long-term cooperation of the supply chain, the brand may inhibit the dealer from disclosing her quality (type) to reduce information rent, which may also lead to system allocative inefficiencies. So, the brand needs to trade-off between information rent and efficient allocation.

4.1. The Separated Contract. In this section, we discuss the separated contract with commitment under asymmetric information, that is, under symmetric information, the brand does not inhibit the dealer from disclosing her quality (type) and promises to pay rent compensation in order to ensure the dealer's utility from loss. In this case, the allocation in period 2 is optimal, i.e., $\overline{q}_2^* = \overline{q}^*, \underline{q}_2^* = \underline{q}^*$, and $\overline{\theta}$ dealer's rent compensation is $\overline{U}_2^S = \Delta\theta \underline{q}^*$. Using backward induction, we can obtain the product quality (type) q in period 1 and then derive the transfer payment T. In this article, we do not repeat it again. Lemma 1 characterizes the optimal quality (type) of the separated contract under the renegotiation proof.

Lemma 1. *The allocation of the separated contract under the renegotiation proof is satisfied:*

$$\begin{aligned} \overline{q}_1^S &= \overline{q}_2^S = \overline{q}^*, \\ \underline{q}_1^S &= \underline{q}^{Sb} = \underline{\theta} - \frac{\rho}{1-\rho}\Delta\theta, \\ \underline{q}_2^S &= \underline{q}^*. \end{aligned} \tag{1}$$

Lemma 1 is consistent with the conclusion of classical single period information screening models [27]. Lemma 1 indicates that, in period 1, due to asymmetric information, the brand has to distort the $\underline{\theta}$ dealer's quality (type) as inferior to reduce the rent for $\overline{\theta}$ dealer. This also leads to allocative inefficiencies. Therefore, there is a trade-off between efficient system allocation and information rents.

4.2. The Pooling Contract. In this section, we discuss the pooling contract with commitments under asymmetric information, that is, the brand only offers one pair of contracts in period 1 (the brand inhibits the dealer from disclosing her quality (type) completely). So, the allocation of the two qualities (types) with respect to the dealers is the same, and the brand's belief about dealer's quality (type) has not been updated at the end of period 1, which is still ρ: $1-\rho$. In period 2, the allocation is the same as the optimal allocation in static information screening model, i.e., $\overline{q}_2^{\mathrm{P}} = \overline{q}^*, \underline{q}_2^{\mathrm{P}} = \underline{q}^{\mathrm{sb}}$, and the information rent is $\overline{U}_2^{\mathrm{P}} = \Delta\theta \underline{q}^{\mathrm{sb}}$. In period 1, the product quality (type) is the same q_1^{P}.

In order to ensure that the dealer participates in the game and truly disclose information, constraints are as follows (participation constraint and incentive constraint, respectively):

$$\underline{U}_t^{\mathrm{P}} \geq 0, \tag{2}$$

$$\overline{U}_1^{\mathrm{P}} + \delta \overline{U}_2^{\mathrm{P}} \geq \underline{U}_1^{\mathrm{P}} + \Delta\theta q_1^{\mathrm{P}} + \delta\left(\underline{U}_2^{\mathrm{P}} + \Delta\theta \underline{q}_2^{\mathrm{P}}\right). \tag{3}$$

Because the brand only satisfies reservation utility for $\underline{\theta}$ dealer, $\underline{U}_1^{\mathrm{P}} = \underline{U}_2^{\mathrm{P}} = 0$. The allocation in period 2 is $\overline{q}_2^{\mathrm{P}} = \overline{q}^*, \underline{q}_2^{\mathrm{P}} = \underline{q}^{\mathrm{sb}}$. Applying this solution, (3) can be written as $\overline{U}_1^{\mathrm{P}} + \delta \overline{U}_2^{\mathrm{P}} \geq \Delta\theta q_1^{\mathrm{P}} + \delta \Delta\theta \underline{q}^{\mathrm{sb}}$. The problem of the optimal allocation under the pooling contract is the following:

$$\begin{aligned}
\left(P_1^{\mathrm{P}}\right)\Pi_1^{\mathrm{P}} = \max_{q_1^{\mathrm{P}}} & \rho\left(\overline{\theta} q_1^{\mathrm{P}} - c\left(q_1^{\mathrm{P}}\right) - \overline{U}_1^{\mathrm{P}}\right) \\
& + (1-\rho)\left(\underline{\theta}\, q_1^{\mathrm{P}} - c\left(q_1^{\mathrm{P}}\right)\right) \\
& + \delta\left[\rho\left(\overline{\theta}\,\overline{q}_2^{\mathrm{P}} - c\left(\overline{q}_2^{\mathrm{P}}\right) - \overline{U}_2^{\mathrm{P}}\right)\right. \\
& \left. + (1-\rho)\left(\underline{\theta}\, \underline{q}_2^{\mathrm{P}} - c\left(\underline{q}_2^{\mathrm{P}}\right)\right)\right], \\
& \text{subject to (2) and (3).}
\end{aligned} \tag{4}$$

When the utility function can be divided and added, we have the following.

Theorem 1. *The allocation of the pooling contract under the renegotiation proof is satisfied:*

$$\begin{aligned}
q_1^{\mathrm{P}} &= \underline{q}^*, \\
\overline{q}_2^{\mathrm{P}} &= \overline{q}^*, \\
\underline{q}_2^{\mathrm{P}} &= \underline{q}^{\mathrm{Sb}} = \underline{\theta} - \frac{\rho}{1-\rho}\Delta\theta.
\end{aligned} \tag{5}$$

Because the brand does not separate any dealer under the pooling contract in period 1, the allocation of $\overline{\theta}$ dealer is distorted to $\underline{q}^*$. And the allocation in period 2 is the optimal solution of the single period information screening model. Therefore, the allocative distortion occurs in two periods under the pooling contract. In period 1, the brand completely inhibits the dealer disclosing quality (type) information, resulting in the allocation of $\overline{\theta}$ dealer distorted downward to $\underline{q}^*$. In period 2, it is still a trade-off between rent and efficient allocation. Comparing the separated contract and the pooling contract, the separation of the former occurs in period 1, and the latter occurs in period 2. The change of separation time results in the allocative distortion (the pooling contract in period 1) and rent compensation (the separated contract in period 2). Which mechanism to choose depends on the combination of the two factors. We discuss this in detail in the next section.

4.3. The Semiseparated Contract. In this section, we study the semiseparated contract based on Bayesian updating, that is, the brand does not completely reveal or mix the dealer in period 1, but partly separates the dealer. In other words, $\overline{\theta}$ dealers are identified as $\underline{\theta}$ dealer with the probability α. Therefore, the semiseparated contract is between the separated contract and the pooling contract, and the separation of the dealer is completed in two periods. Figure 2 shows the probabilities of the dealer in two periods.

Because the dealer's reservation utility is 0, the participation constraints are shown as follows:

$$\begin{cases} \overline{\theta}\overline{q}_t^{\mathrm{SS}} - \overline{T}_t^{\mathrm{SS}} \geq 0, \\ \underline{\theta}\, \underline{q}_t^{\mathrm{SS}} - \underline{T}_t^{\mathrm{SS}} \geq 0. \end{cases} \tag{6}$$

In addition, in order to separate dealers partly, the contract also needs to satisfy the incentive constraint, as shown in the following equation:

$$\begin{cases} \left(\overline{\theta}\,\overline{q}_1^{\mathrm{SS}} - \overline{T}_1^{\mathrm{SS}}\right) + \delta\left(\overline{\theta}\,\overline{q}_2^{\mathrm{SS}} - \overline{T}_2^{\mathrm{SS}}\right) \geq \left(\overline{\theta}\underline{q}_1^{\mathrm{SS}} - \underline{T}_1^{\mathrm{SS}}\right) + \delta\left(\overline{\theta}\underline{q}_2^{\mathrm{SS}} - \underline{T}_2^{\mathrm{SS}}\right), \\ \left(\underline{\theta}\, \underline{q}_1^{\mathrm{SS}} - \underline{T}_1^{\mathrm{SS}}\right) + \delta\left(\underline{\theta}\, \underline{q}_2^{\mathrm{SS}} - \underline{T}_2^{\mathrm{SS}}\right) \geq \left(\underline{\theta}\,\overline{q}_1^{\mathrm{SS}} - \overline{T}_1^{\mathrm{SS}}\right) + \delta\left(\underline{\theta}\,\overline{q}_2^{\mathrm{SS}} - \overline{T}_2^{\mathrm{SS}}\right). \end{cases} \tag{7}$$

According to the above, the brand's objective function is

$$\begin{aligned}
\left(P^{\mathrm{SS}'}\right)\Pi^{\mathrm{SS}'} = \max_{\left\{\overline{q}_1^{\mathrm{SS}}, \overline{q}_2^{\mathrm{SS}}, \underline{q}_1^{\mathrm{SS}}, \underline{q}_2^{\mathrm{SS}}\right\}} & \rho(1-\alpha)\left(\overline{\theta}\,\overline{q}_1^{\mathrm{SS}} - c\left(\overline{q}_1^{\mathrm{SS}}\right) - \overline{U}_1^{\mathrm{SS}}\right) \\
& + (1-\rho+\alpha\rho)\left(\underline{\theta}\, \underline{q}_1^{\mathrm{SS}} - c\left(\underline{q}_1^{\mathrm{SS}}\right) - \underline{U}_1^{\mathrm{SS}}\right) \\
& + \delta\left[\rho\left(\overline{\theta}\,\overline{q}_2^{\mathrm{SS}} - c\left(\overline{q}_2^{\mathrm{SS}}\right)\right) - \alpha\rho \overline{U}_2^{\mathrm{SS}}\right. \\
& \left. + (1-\rho)\left(\underline{\theta}\, \underline{q}_2^{\mathrm{SS}} - c\left(\underline{q}_2^{\mathrm{SS}}\right) - \underline{U}_2^{\mathrm{SS}}\right)\right].
\end{aligned} \tag{8}$$

Formulae (6) and (7) are further simplified to

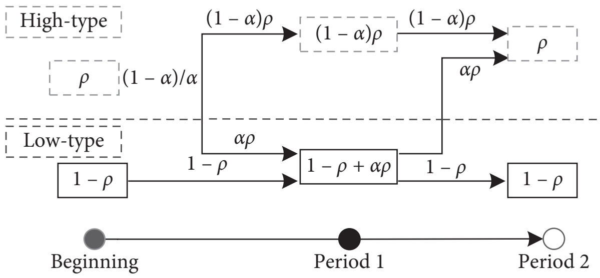

Figure 2: The probabilities of dealers.

$$\begin{cases} \overline{U}_t^{SS} \ge 0, \\ \underline{U}_t^{SS} \ge 0, \end{cases}$$
$$\begin{cases} \overline{U}_1^{SS} + \delta \overline{U}_2^{SS} \ge \underline{U}_1^{SS} + \Delta\theta \underline{q}_1^{SS} + \delta\left(\underline{U}_2^{SS} + \Delta\theta \underline{q}_2^{SS}\right), \\ \underline{U}_1^{SS} + \delta \underline{U}_2^{SS} \ge \overline{U}_1^{SS} - \Delta\theta \overline{q}_1^{SS} + \delta\left(\overline{U}_2^{SS} - \Delta\theta \overline{q}_2^{SS}\right), \end{cases} \tag{9}$$

where $\underline{U}_1^{SS} = \underline{U}_2^{SS} = 0$. First, in period 2, the proportion of the remaining dealer is $1 - (1-\alpha)\rho$, where the probability of $\overline{\theta}$ dealer is $\alpha\rho$ and probability of $\underline{\theta}$ dealer is $1-\rho$. In order to fully separate the remaining dealer, the brand has to pay $\overline{\theta}$ dealer the information rent $\Delta\theta\underline{q}_2^{SS}$. Moreover, under renegotiation, the brand also needs to pay $\overline{\theta}$ dealer who is wrongly separated in period 1. We have

$$\begin{aligned} \left(P_2^{SS'}\right)\Pi_2^{SS'} = \max_{\left\{\overline{q}_2^{SS}, \underline{q}_2^{SS}\right\}} & \rho(1-\alpha)\left(\overline{\theta}\overline{q}_2^{SS} - c\left(\overline{q}_2^{SS}\right)\right) \\ & + \alpha\rho\left(\overline{\theta}\overline{q}_2^{SS} - c\left(\overline{q}_2^{SS}\right) - \overline{U}_2^{SS}\right) \\ & + (1-\rho)\left(\underline{\theta}\,\underline{q}_2^{SS} - c\left(\underline{q}_2^{SS}\right) - \underline{U}_2^{SS}\right) \\ \text{s.t.} & \begin{cases} \overline{U}_2^{SS} \ge \underline{U}_2^{SS} + \Delta\theta\underline{q}_2^{SS} \\ \underline{U}_2^{SS} \ge 0 \end{cases}. \end{aligned} \tag{10}$$

The allocation in period 2 is $\overline{q}_2^{SS} = \overline{q}^*$, $\underline{q}_2^{SS} = \underline{\theta} - (\alpha\rho/(1-\rho))\Delta\theta$. Applying this solution, we have

$$\begin{cases} \overline{U}_1^{SS} + \delta\overline{U}_2^{SS} \ge \Delta\theta\underline{q}_1^{SS} + \delta\Delta\theta\underline{q}_2^{SS}, \\ \overline{U}_1^{SS} + \delta\overline{U}_2^{SS} \le \Delta\theta\overline{q}_1^{SS} + \delta\Delta\theta\overline{q}^*. \end{cases} \tag{11}$$

Next, the allocation in period 1 can be obtained by solving

$$\begin{aligned} \left(P_1^{SS}\right)\Pi_1^{SS} = \max_{\left\{\overline{q}_1^{SS}, \underline{q}_1^{SS}\right\}} & \rho(1-\alpha)\left(\overline{\theta}\,\overline{q}_1^{SS} - c\left(\overline{q}_1^{SS}\right) - \overline{U}_1^{SS}\right) \\ & + (1-\rho+\alpha\rho)\left(\underline{\theta}\,\underline{q}_1^{SS} - c\left(\underline{q}_1^{SS}\right) - \underline{U}_1^{SS}\right) \\ & + \delta\left[\rho\left(\overline{\theta}\overline{q}^* - c\left(\overline{q}^*\right) - \Delta\theta\underline{q}_2^{SS}\right)\right. \\ & \left. + (1-\rho)\left(\underline{\theta}\,\underline{q}_2^{SS} - c\left(\underline{q}_2^{SS}\right)\right)\right]. \end{aligned} \tag{12}$$

From the above, we have the following.

Theorem 2 (the full proof can be found in the Appendix). *The allocation of the semiseparated contract under the renegotiation is satisfied:*

$$\begin{aligned} \overline{q}_1^{SS} &= \overline{q}_2^{SS} = \overline{q}^*, \\ \underline{q}_1^{SS} &= \underline{\theta} - \frac{\rho - \alpha\rho}{1-\rho+\alpha\rho}\Delta\theta, \\ \underline{q}_2^{SS} &= \underline{\theta} - \frac{\alpha\rho}{1-\rho}\Delta\theta, \end{aligned} \tag{13}$$

where $\underline{q}_1^{SS}, \underline{q}_2^{SS} > \underline{q}^{sb}$.

From Theorem 2, it is found the brand can control the rhythm of separation more flexible.

The allocation of $\underline{\theta}$ dealer is distorted in two periods, but the distortion is smaller than under the other two types of contracts, i.e., $\underline{q}_1^{SS}, \underline{q}_2^{SS} > \underline{q}^{sb}$. Compared with the separated contract, which pays rent compensation to all $\overline{\theta}$ dealers, the semiseparated contract only pays it partly. In the same way, compared with the pooling contract, which does not pay any rent compensation at the cost of distorting the allocation of $\overline{\theta}$ dealer in period 1, the semiseparated contract is more efficient. Therefore, the semiseparated contract is the universal form of these two contracts: especially, the semiseparated contract is equivalent to the separated contract when $\alpha = 0$ and to the pooling contract when $\alpha = 1$.

4.4. Contract Selection. Section 3 has introduced three contracts under asymmetric information in detail. The first one is the separated contract, which completely separates the dealer in period 1. The second one is the pooling contract, which mixes the dealer in period 1 and separates her in period 2. The third one is the semiseparated contract, which separates the dealer in two periods. Based on this discussion, we know the mechanism of how contract affects the payoff of both the supply chain and the brand. Therefore, we analyze the choice of contract from the perspective of the supply chain and the brand, respectively, in this chapter. First of all, three contracts are summarized as shown in Table 1.

5. Effect on Members' Profit

In this section, we investigate the effect of supply chain and members' profit under three types of contract. Supply chain management focuses on the profit of the system. The intertemporal profit of the system under three contracts is shown in (14)–(16), respectively.

$$\begin{aligned} V^S &= V\left(\overline{q}^*, \underline{q}^{Sb}\right) + \delta V\left(\overline{q}^*, \underline{q}^*\right) \\ &= \rho\overline{\Pi}\left(\overline{q}^*\right) + (1-\rho)\,\underline{\Pi}\left(\underline{q}^{Sb}\right) \\ &\quad + \delta\left[\rho\overline{\Pi}\left(\overline{q}^*\right) + (1-\rho)\,\underline{\Pi}\left(\underline{q}^*\right)\right], \end{aligned} \tag{14}$$

where $V(\overline{q}, \underline{q}) = \rho\overline{\Pi}(\overline{q}) + (1-\rho)\,\underline{\Pi}(\underline{q})$ represents the system revenue of single period when the allocation is $\overline{q}, \underline{q}$.

Table 1: The allocation of three contracts.

Contracts	Period 1	Period 2
The separated contract	$(\overline{q}^*, \overline{\theta}\,\overline{q}^* - \Delta\theta \underline{q}^{\mathrm{sb}})$ $(\underline{q}^{\mathrm{sb}}, \underline{\theta}\,\underline{q}^{\mathrm{sb}})$	$(\overline{q}^*, \overline{\theta}\,\overline{q}^* - \Delta\theta \underline{q}^{*})$ $(\underline{q}^{*}, \underline{\theta}\,\underline{q}^{*})$
The pooling contract	$(\underline{q}^{*}, \underline{\theta}\,\underline{q}^{*})$	$(\overline{q}^*, \overline{\theta}\,\overline{q}^* - \Delta\theta \underline{q}^{\mathrm{sb}})$ $(\underline{q}^{\mathrm{sb}}, \underline{\theta}\,\underline{q}^{\mathrm{sb}})$
The semiseparated contract	$(\overline{q}^*, \overline{\theta}\overline{q}^* - \Delta\theta \underline{q}_1^{\mathrm{SS}})$ $(\underline{q}_1^{\mathrm{SS}}, \underline{\theta}\,\underline{q}_1^{\mathrm{SS}})$	$(\overline{q}^*, \overline{\theta}\,\overline{q}^* - \Delta\theta \underline{q}_2^{\mathrm{SS}})$ $(\underline{q}_2^{\mathrm{SS}}, \underline{\theta}\,\underline{q}_2^{\mathrm{SS}})$

$\overline{\Pi}(\overline{q}) = \overline{\theta}\,\overline{q} - (1/2)(\overline{q})^2$ represents the system revenue of $\overline{\theta}$ dealers when the allocation is $\overline{q}$. Similarly, $\underline{\Pi}(\underline{q})$ represents the system revenue of $\underline{\theta}$ dealer. As seen in (14), the intertemporal system revenue of the separated contract is divided into four parts, which are generated by $\overline{\theta}$ dealers and $\underline{\theta}$ dealers, respectively. In the same way, we have

$$V^{\mathrm{P}} = V\left(\underline{q}^*, \underline{q}^*\right) + \delta V\left(\overline{q}^*, \underline{q}^{\mathrm{Sb}}\right) = \rho\overline{\Pi}\left(\underline{q}^*\right) + (1-\rho)\,\underline{\Pi}\left(\underline{q}^*\right) + \delta\left[\rho\overline{\Pi}\left(\overline{q}^*\right) + (1-\rho)\,\underline{\Pi}\left(\underline{q}^{\mathrm{Sb}}\right)\right], \tag{15}$$

$$\begin{aligned} V^{\mathrm{SS}} &= \widetilde{V}\left(\overline{q}^*, \underline{q}_1^{\mathrm{SS}}\right) + \delta V\left(\overline{q}^*, \underline{q}_2^{\mathrm{SS}}\right) \\ &= \rho(1-\alpha)\overline{\Pi}\left(\overline{q}^*\right) + \alpha\rho\overline{\Pi}\left(\underline{q}_1^{\mathrm{SS}}\right) + (1-\rho)\,\underline{\Pi}\left(\underline{q}_1^{\mathrm{SS}}\right) \\ &\quad + \delta\left[\rho\overline{\Pi}\left(\overline{q}^*\right) + (1-\rho)\,\underline{\Pi}\left(\underline{q}_2^{\mathrm{SS}}\right)\right]. \end{aligned} \tag{16}$$

Under the pooling contract, the intertemporal system revenue is also divided into four parts. This is contrasted with the semiseparated contract under which system revenue is divided into five parts because of $\overline{\theta}$ dealer divided into two parts with the probability of $1-\alpha : \alpha$. Comparing three contracts, we have the following.

Proposition 1 (the full proof can be found in the Appendix). From the perspective of the supply chain, there are the following relations:

(1) When $0 < \rho < (1/2)$, the separated contract is optimal
(2) When $(1/2) < \rho < 1, \delta_1 > \delta_3 > \delta_2$,
   (a) The pooling contract is optimal if $0 < \delta \le \delta_2$
   (b) The semiseparated contract is optimal if $\delta_2 < \delta \le \min\{\delta_1, (1/\rho)\}$
   (c) The separated contract is optimal if $\delta_1 < \delta \le (1/\rho)$ (when $\rho < (1/(2-\alpha))$, $\delta_1 < (1/\rho)$) where $\delta_1 = 2\rho - 1/(\alpha\rho(1-\rho+\alpha\rho))$, $\delta_2 = ((2\rho-1)(1-\rho))/(\rho(1+\alpha)(1-\rho+\alpha\rho))$, and $\delta_3 = 2 - (1/\rho)$

From Proposition 1, it can be seen that from the perspective of the supply chain, the choice of contract is not only determined by the discount factor δ but also by the probability of $\overline{\theta}$ dealer ρ. In different cases, the supply chain shows different preferences for three contracts, including the pooling contract.

Figure 3 shows the difference of the supply chain revenue changing with the discount factor δ. Area I represents the

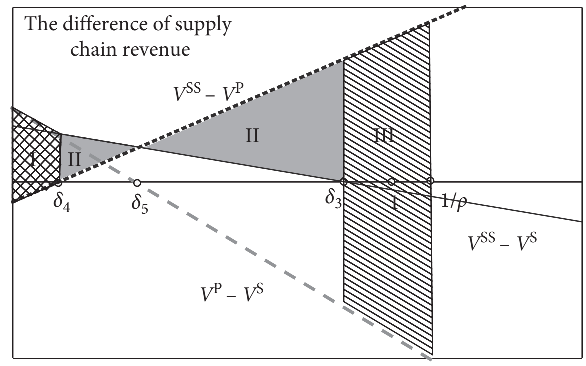

Figure 3: When $\rho > 1/2$, the difference of supply chain revenue changes with δ $(\alpha = 0.53, \rho = 0.6, \underline{\theta} = 0.33, \overline{\theta} = 0.5)$.

dominant area of the pooling contract. In this area, the gray dotted line is above the horizontal axis (i.e., $V^{\mathrm{P}} - V^{\mathrm{S}} > 0$), and the black dotted line is below the horizontal axis (i.e., $V^{\mathrm{SS}} - V^{\mathrm{P}} < 0$). The above means the pooling contract is better than the separated contract and the semiseparated contract. Similarly, area II and area III represent the dominant area of the semiseparated contract and the separated contract, respectively.

Furthermore, comparing the separated contract and the pooling contract, it is found that the allocation of $\overline{\theta}$ dealer in period 1 under the pooling contract is distorted from $\overline{q}^*$ to $\underline{q}^*$, resulting in the supply chain revenue decreasing by $\rho(\overline{\Pi}(\overline{q}^*) - \overline{\Pi}(\underline{q}^*))$, while $\underline{\theta}$ dealer results in increasing by $(1-\rho)(1-\delta)(\underline{\Pi}(\underline{q}^*) - \underline{\Pi}(\underline{q}^{\mathrm{sb}}))$.

In the same way, we compare the separated contract with the semiseparated contract. In the semiseparated contract, the allocation of $\overline{\theta}$ dealer, whose information disclosure is inhibited partly, is distorted from $\overline{q}^*$ to $\underline{q}_1^{\mathrm{SS}}$, resulting in the supply chain revenue decreasing by $\alpha\rho(\overline{\Pi}(\overline{q}^*) - \overline{\Pi}(\underline{q}_1^{\mathrm{SS}}))$, while $\underline{\theta}$ dealer results in an increase by $(1-\rho)(\underline{\Pi}(\underline{q}_1^{\mathrm{SS}}) - \underline{\Pi}(\underline{q}^{\mathrm{sb}})) - \delta(1-\rho)(\underline{\Pi}(\underline{q}^*) - \underline{\Pi}(\underline{q}_2^{\mathrm{SS}}))$.

From the separated contract to the semiseparated contract and then to the pooling contract, the combination of these factors determines the rhythm of separation. Therefore, in order to maximize the supply chain revenue, there is a trade-off on the rhythm of separation.

Firstly, when the probability of $\overline{\theta}$ dealer is small (i.e., $\rho < 1/2$), it is always optimal for systems to select the separated contract. Secondly, along with ρ increasing gradually, the brand has to distort downward the allocation of $\underline{\theta}$ dealer in order to decrease the information rent, which results in supply chain revenue under the separated contract or the semiseparated contract being smaller than that under the pooling contract in period 1, but that is reversed in period 2. Therefore, when the discount factor $\delta \le \delta_2$, the brand prefers to inhibit information disclosure completely (i.e., the pooling contract). With the increase of δ, the advantage of separated $\overline{\theta}$ dealers in allocation is more and more obvious in period 2. The semiseparated contract becomes more and more optimal. When δ is large enough, the disadvantage of the separated contract in period 1 is sufficiently weak that full separation leads to allocative efficiency, when finally, the separated contract is optimal.

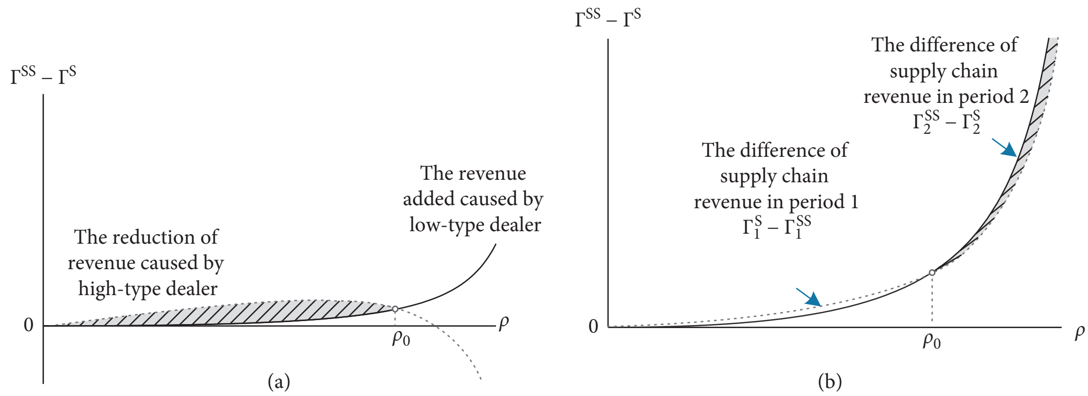

FIGURE 4: The comparison between the semiseparated contract and the separated contract. (a) According to the type. (b) According to the period $(0 < \rho < (1/(2 - \alpha)), \alpha = 0.7, \delta = 1.49, \overline{\theta} = 0.5)$.

Next, we focus on the brand's revenue under different contracts. From the perspective of the brand, the brand pays the rent and extracts all the surplus of supply chain on the premise that it can satisfy the dealer's reservation utility. The intertemporal revenue of the brand under the separated contract is shown in the following equation:

$$\Gamma^{S} = V^{S} - \overline{U}^{S} = V^{S} - \left(\rho\Delta\theta\underline{q}^{Sb} + \delta\rho\Delta\theta\underline{q}^{*}\right). \tag{17}$$

The right side of (17) is the difference between the system revenue and the information rent under the separated contract. In period 2, the brand needs to pay rent compensation $\Delta\theta\underline{q}^{*}$ to satisfy the renegotiation proof.

$$\Gamma^{P} = V^{P} - \overline{U}^{P} = V^{P} - \left(\rho\Delta\theta\underline{q}^{*} + \delta\rho\Delta\theta\underline{q}^{Sb}\right), \tag{18}$$

$$\Gamma^{SS} = V^{SS} - \overline{U}^{SS} = V^{SS} - \left(\rho\Delta\theta\underline{q}_1^{SS} + \delta\rho\Delta\theta\underline{q}_2^{SS}\right). \tag{19}$$

In the same way, the brand's revenue under other two contracts is shown in (18) and (19). The rent compensation under the semiseparated contract is $\Delta\theta\underline{q}_2^{SS}$, so the intertemporal rent is $\rho\Delta\theta\underline{q}_1^{SS} + \delta\rho\Delta\theta\underline{q}_2^{SS}$, while the intertemporal rent under the pooling contract is $\rho\Delta\theta\underline{q}^{*} + \delta\rho\Delta\theta\underline{q}^{sb}$. Comparing the brand's revenue under these three contracts, we have the following.

Proposition 2 (the full proof can be found in the Appendix). From the perspective of the brand,

(1) When $0 < \rho < (1/(2 - \alpha))$, if $\delta \leq \delta_4$, then the separated contract is optimal; otherwise, the semiseparated contract is optimal $(\delta_4 < \delta \leq \delta_0)$

(2) When $(1/(2 - \alpha)) < \rho < 0$, the separated contract is optimal

Where $\delta_4 = 1/(\rho(2 - \alpha)(1 - \rho + \alpha\rho))$, $\delta_5 = (1 - \rho)/(\rho(1 - \alpha)(1 - \rho + \alpha\rho))$, and $\delta_0 = 1/\rho$

From Proposition 2, it is found that the brand's selection is also affected by the probability of $\overline{\theta}$ dealers and the discount factor. In order to make the discussion more targeted, we focus on the case when $\delta \leq \delta_0$, which is consistent with the classical literature [27]. When we relax this constraint, the nature of the conclusion does not change. From Proposition 2, it is found the brand does not prefer the pooling contract when δ is bounded. When ρ is large enough, the separated contract is optimal for the brand.

Figure 4 shows the difference of the brand's revenue between the separated contract and the semiseparated contract along with ρ. In Figure 4(a), the shadowed area is the dominated area of $\overline{\theta}$ dealer. In this area, the dotted gray line is above the solid black line, which means the decrease in revenue caused by $\overline{\theta}$ dealer is greater than the increase revenue caused by $\underline{\theta}$ dealers, and the separated contract is optimal. Similarly, in Figure 4(b), the shadowed area is the dominated area of period 2, where ρ_0 is the solution of δ_4.

In order to analyze the trade-off on the rhythm of separation, we discuss it in two ways. Firstly, as shown in Figure 4(a), from the separated contract to the semiseparated contract, the reduction of the brand's revenue caused by $\overline{\theta}$ dealers is $(\overline{\Pi}(\overline{q}^{*}) - \overline{\Pi}(q_1^{SS})) + \rho\Delta\theta(\underline{q}_1^{SS} - \underline{q}^{sb}) - \delta\rho\Delta\theta(\underline{q}^{*} - \underline{q}_2^{SS})$, i.e., the gray dotted line. The increment of the brand's revenue caused by $\underline{\theta}$ dealer is $(1 - \rho)(\underline{\Pi}(\underline{q}_1^{SS}) - \underline{\Pi}(\underline{q}^{sb})) - \delta(1 - \rho)(\underline{\Pi}(\underline{q}^{*}) - \underline{\Pi}(\underline{q}_2^{SS}))$, i.e., the black solid line. The combined effect means that when $\rho < \rho_0$, the added revenue caused by $\underline{\theta}$ dealer is smaller than the reduction caused by $\overline{\theta}$ dealer, meaning the separated contract is optimal. Similarly, as shown in Figure 4(b), the difference between the semiseparated contract and the separated contract in period 1 is $\Gamma_1^{S} - \Gamma_1^{SS}$, i.e., $\alpha\rho(\overline{\Pi}(\overline{q}^{*}) - \overline{\Pi}(q_1^{SS})) - (1 - \rho)(\underline{\Pi}(\underline{q}_1^{SS}) - \underline{\Pi}(\underline{q}^{sb})) + \rho\Delta\theta(\underline{q}_1^{SS} - \underline{q}^{sb})$, which is the gray dotted line. The difference in period 2 is $\Gamma_2^{SS} - \Gamma_2^{S}$, i.e., $\delta\rho\Delta\theta(\underline{q}^{*} - \underline{q}_2^{SS}) - \delta(1 - \rho)(\underline{\Pi}(\underline{q}^{*}) - \underline{\Pi}(\underline{q}_2^{SS}))$, which is the black solid line. As a result of this combined effect in two periods, when $\rho > \rho_0$ $(\rho < (1/(2 - \alpha)))$, the revenue in period 2 in the intertemporal revenue exceeds that in period 1. Finally, the semiseparated contract is optimal.

Similarly, the brand's revenue in period 1 under the separated contract is higher than that under the pooling contract which is $(1/2)(\underline{\theta})^2$. Because the separated contract pays too much information rent in period 2, the brand's revenue in period 2 under the separated contract is smaller than that under the pooling contract. Therefore, when

$\delta \le \delta_0$ $(0 < \rho < (1/\ (2 - \alpha)))$, the separated contract in period 1 dominates, and it is more beneficial to choose the separated contract.

In summary, when $0 < \rho < (1/(2 - \alpha))$ and $\delta \ge \delta_4$, the semiseparated contract is optimal for the brand. Otherwise, the separated contract is the best choice.

Compared with the conclusion in the previous section, it is found that from the perspective of the brand, the brand prefers to separate the dealers earlier. But from the perspective of the supply chain, when $(1/2) < \rho < 1$ and $0 < \delta \le \delta_2$, it also prefers the pooling contract. When the high-type agent is the majority and the intertemporal discount factor is small, the system pays more attention to the benefits of period 1. In order to reduce the information rent paid to $\overline{\theta}$ dealer, the brand has to distort the quality (type) of $\underline{\theta}$ dealer downwards, and the pooling contract can mitigate the distortion of low-quality (type) agents in the first stage.

6. Conclusion

This paper discusses three different separation rhythm information screening models (separation contracts, semiseparation contracts, and mixed contracts) in the secondary supply chain to examine the impact of dealer separation rates on supply chain member returns. We found that under asymmetric information conditions, brand owners (franchisers) tend to separate dealers (franchisees) earlier. Semiseparation contracts help brand owners to more flexibly control the separation rate of dealers and maximize the profits of dealers in order to achieve higher returns. The system, however, may prefer a mixed contract: under certain conditions, the mixed contract can also increase the overall profit of the entire supply chain and improve the overall allocation efficiency of the supply chain.

This study contributes to the supply chain relationship and screening contract literatures and practice in different ways. Based on the application practice of long-term cooperation among supply chain members, the separation contract of the classic information screening model is not completely applicable. This paper discusses the multistage gradual separation of private information of supply chain members in a multicycle situation, which has supplemented and improved the existing asymmetric information model. On the basis of this paper, further research can be done in the following aspects: (1) to compare the impact of separation speed on supply chain members in the case of full commitment and proof-renegotiation; (2) to consider moral risk in the model and to analyze different situations integrating with actual conditions, the optimal separation rate, and the degree of influence of the dealer's separation speed on supply chain members; (3) to extend supply chain cooperation from two-stage to multiple stages, and to analyze the similarities and differences.

Appendix

A. Proof of Theorem 2

We use backward induction to solve the problem under the semiseparated contract. Formula (10) is the optimal revenue problem of the brand in period 2. We substitute the participant constraint ($\underline{U}_2^{SS} \ge 0$) and the incentive constraint ($\overline{U}_2^{SS} \ge \underline{U}_2^{SS} + \Delta\theta \underline{q}_2^{SS}$) into the objective function. Then, we get the allocation in period 2 as follows:

$$\begin{aligned} \overline{q}_2^{SS} &= \overline{q}^*, \\ \underline{q}_2^{SS} &= \underline{\theta} - \frac{\alpha\rho}{1-\rho}\Delta\theta. \end{aligned} \tag{A.1}$$

Then, we substitute what we get in (A.1) into formula (12) and get the allocation in period 1 as follows:

$$\begin{aligned} \overline{q}_1^{SS} &= \overline{q}^*, \\ \underline{q}_1^{SS} &= \underline{\theta} - \frac{\rho-\alpha\rho}{1-\rho+\alpha\rho}\Delta\theta. \end{aligned} \tag{A.2}$$

B. Proof of Proposition 1

Compare the supply chain revenue under the separated contract and the semiseparated contract as shown in the following equation:

$$\begin{aligned} V^{SS} - V^{S} &= \tilde{V}\left(\overline{q}^*, \underline{q}_1^{SS}\right) + \delta V\left(\overline{q}^*, \underline{q}_2^{SS}\right) - V\left(\overline{q}^*, \overset{sb}{\underline{q}}\right) \\ &\quad - \delta V\left(\overline{q}^*, \overset{*}{\underline{q}}\right) = -\frac{\alpha\rho\left[1-2\rho+\delta\alpha\rho(1-\rho+\alpha\rho)\right]}{2(1-\rho)(1-\rho+\alpha\rho)}(\Delta\theta)^2. \end{aligned} \tag{B.1}$$

Formula (B.1) is a monotone decreasing function along with δ. When $\delta = 0$, we have

$$-\frac{\alpha\rho(1-2\rho)}{2(1-\rho)(1-\rho+\alpha\rho)}(\Delta\theta)^2. \tag{B.2}$$

We discuss it in two ways in the following.

When $0 < \rho < (1/2)$, formula (B.2) is less than 0, i.e., no matter what δ is, $V^{SS} - V^{S} < 0$ is always established. While $(1/2) < \rho < 1$, (B.2) is more than 0. Let $V^{SS} - V^{S} = 0$; we have

$$\delta_1 = \frac{2\rho-1}{\alpha\rho(1-\rho+\alpha\rho)}. \tag{B.3}$$

Therefore, when $\delta < \delta_1$, the supply chain prefers the semiseparated contract. Otherwise, the supply chain prefers the separated contract.

Similarly, we compare the semiseparated contract with the pooling contract as shown in the following equation:

$$V^{SS}-V^{P}=\widetilde{V}\left(\overline{q}^{*},\underline{q}_{1}^{SS}\right)+\delta V\left(\overline{q}^{*},\underline{q}_{2}^{SS}\right)-V\left(\underline{q}^{*},\underline{q}^{*}\right)-\delta V\left(\overline{q}^{*},\underline{q}^{Sb}\right)$$
$$=\frac{(1-\alpha)\rho[(1-2\rho)(1-\rho)+\delta\rho(1+\alpha)(1-\rho+\alpha\rho)]}{2(1-2\rho)(1-\rho+\alpha\rho)}(\Delta\theta)^{2}. \tag{B.4}$$

Formula (B.4) is a monotone increasing function along with δ. When $\delta=0$, we have

$$\frac{\rho(1-\alpha)(1-2\rho)}{2(1-\rho+\alpha\rho)}(\Delta\theta)^{2}. \tag{B.5}$$

We discuss it in the following two cases.

When $0<\rho<(1/2)$ formula (B.5) is more than 0, i.e., no matter what δ is, $V^{SS}-V^{P}>0$ is always established. While $(1/2)<\rho<1$, formula (B.5) is less than 0. Let $V^{SS}-V^{P}=0$; we have

$$\delta_{2}=\frac{(2\rho-1)(1-\rho)}{\rho(1+\alpha)(1-\rho+\alpha\rho)}\in(0,1). \tag{B.6}$$

It is easy to prove $(2\rho-1)(1-\rho)-\rho(1+\alpha)(1-\rho+\alpha\rho)=-(1-\rho)^{2}-\alpha\rho-\alpha^{2}\rho^{2}<0$. Therefore, when $\delta>\delta_{2}$, the semiseparated contract is optimal for supply chain. Otherwise, the pooling contract is optimal.

Then, we compare the revenue of supply chain under the separated contract and the pooling contract.

$$V^{S}-V^{P}=V\left(\overline{q}^{*},\underline{q}^{Sb}\right)+\delta V\left(\overline{q}^{*},\underline{q}^{*}\right)-V\left(\underline{q}^{*},\underline{q}^{*}\right)-\delta V\left(\overline{q}^{*},\underline{q}^{Sb}\right)$$
$$=\frac{\rho(1-2\rho+\delta\rho)}{2(1-\rho)}(\Delta\theta)^{2}. \tag{B.7}$$

Formula (B.7) is a monotone increasing function along with δ. Let $V^{S}-V^{P}=0$; we have

$$\delta_{3}=2-\frac{1}{\rho}. \tag{B.8}$$

When $\delta>\delta_{3}$, formula (B.7) is more than 0, i.e., from the perspective of supply chain, the separated contract is better than the pooling contract. Otherwise, the pooling contract is much better than the separated contract.

Finally, we need to ensure the relations between δ_{1}, δ_{2}, and δ_{3}.

When $0<\rho<(1/2)$, δ_{1}, δ_{2}, and δ_{3} are less than 0. While $(1/2)<\rho<1$, we have

$$\delta_{2}-\delta_{3}=-\frac{\alpha(2\rho-1)(1+\alpha\rho)}{\rho(1+\alpha)(1-\rho+\alpha\rho)}<0,$$
$$\delta_{1}-\delta_{3}=\frac{(1-\alpha)(2\rho-1)(1+\alpha\rho)}{\alpha\rho(1-\rho+\alpha\rho)}>0. \tag{B.9}$$

Therefore, we have

$$\delta_{1}>\delta_{3}>\delta_{2}. \tag{B.10}$$

C. Proof of Proposition 2

Firstly, compare the brand's revenue under the separated contract and the semiseparated contract as shown in the following equation:

$$\Gamma^{SS}-\Gamma^{S}=V^{SS}-\overline{U}^{SS}-\left(V^{S}-\overline{U}^{S}\right)$$
$$=-\frac{\alpha\rho[1-\delta\rho(2-\alpha)(1-\rho+\alpha\rho)]}{2(1-\rho)(1-\rho+\alpha\rho)}(\Delta\theta)^{2}. \tag{C.1}$$

Formula (C.1) is a monotone increasing function along with δ. Let $\Gamma^{SS}-\Gamma^{P}=0$; we have

$$\delta_{4}=\frac{1}{\rho(2-\alpha)(1-\rho+\alpha\rho)}. \tag{C.2}$$

From the perspective of the brand, when $\delta<\delta_{4}$, the separated contract is better than the semiseparated contract.

Then, compare the brand's revenue under the semiseparated contract and the pooling contract as shown in the following equation:

$$\Gamma^{SS}-\Gamma^{P}=V^{SS}-\overline{U}^{SS}-\left(V^{P}-\overline{U}^{P}\right)$$
$$=\frac{\rho(1-\alpha)[1-\rho-\delta\rho(1-\alpha)(1-\rho+\alpha\rho)]}{2(1-\rho)(1-\rho+\alpha\rho)}(\Delta\theta)^{2}. \tag{C.3}$$

Formula (C.3) is a monotone decreasing function along with δ. Let $\Gamma^{SS}-\Gamma^{P}=0$; we have

$$\delta_{5}=\frac{1-\rho}{\rho(1-\alpha)(1-\rho+\alpha\rho)}. \tag{C.4}$$

From the perspective of the brand, when $\delta<\delta_{5}$, the semiseparated contract is better than the pooling contract.

Thirdly, compare the brand's revenue under the separated contract and the pooling contract as shown in the following equation:

$$\Gamma^{S}-\Gamma^{P}=V^{S}-\overline{U}^{S}-\left(V^{P}-\overline{U}^{P}\right)=\frac{\rho(1-\delta\rho)}{2(1-\rho)}(\Delta\theta)^{2}. \tag{C.5}$$

Formula (C.5) is a monotone decreasing function along with δ. Let $\Gamma^{S}-\Gamma^{P}=0$; we have

$$\delta_{0}=\frac{1}{\rho}. \tag{C.6}$$

From the perspective of the brand, when $\delta<\delta_{0}$, the separated contract is better than the pooling contract.

Finally, we ensure the relations between δ_{0}, δ_{4}, and δ_{5}. When $0<\rho<(1/2-\alpha)$, we have

$$\delta_{5}>\delta_{0}>\delta_{4}. \tag{C.7}$$

Otherwise, we have

$$\delta_{4}>\delta_{0}>\delta_{5}. \tag{C.8}$$

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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