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WIN-WIN REGION OF WHOLESALE PRICING WHEN A RETAILER CARES ABOUT FAIRNESS

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Abstract. *Cui et al. and Caliskan-Demirag et al. have shown that a coordinating wholesale price contract can be designed when the retailer is concerned about fairness. One necessary required condition of coordination in their result is* $\beta \geq \frac{1}{1+\gamma}$. *It means that the condition for coordination requires extreme generosity from the retailer. There exist some questions deserved to be considered. When supply chain is coordinated, whether profits of both parties are improved compared to the traditional supply chain case. Besides, in practice this rather extreme generosity from the retailer is hard to be achieved, and then whether moderate generosity from the retailer can improve supply chain performance and get win-win scenarios. This paper is to explore win-win region of wholesale pricing when the retailer cares about fairness. According to Cui et al. and Caliskan-Demirag et al., we derive win-win parameter region for a dyadic channel composed of a supplier and a retailer under linear demand and nonlinear demand, respectively. Our results reveal that win-win scenarios can be achieved under some certain conditions, which are given via six propositions.*
Keywords: Supply chain management, Fairness, Wholesale price contract, Win-win region

1. **Introduction.** In traditional decentralized two-level supply chain system with wholesale price contract, each of supply chain members aims at maximizing their own interests, which often leads to the well-known problem: double marginalization [1]. Wholesale price contract is one of the simplest contracts in supply chain system and it is widely used in practice. Since the execution of wholesale price contract is simple and it saves administrative costs for the enterprises, to study supply chain performance under wholesale price contract is necessary. Lariviere and Porteus [2] give a detailed explanation on wholesale price contract and supply chain operations. Yu and Liu [3] study the impact on supply chain performance based on the pricing power transferring of the wholesale price and find that the efficiency of supply chain system is improved. In two decades, researches in behavioral economics [4,5] have shown that community and social pressures often motivate firms to act in ways other than that prescribed by pure profit maximization. Firms, like individuals, are inspired by concerns of fairness in business relationships, including channel relationships. Boniface [16] shows that the stronger the buyer-seller relationship is, the more efficient and sustainable the supply chain is. The related studies in economics and marketing [6-11,19] reveal that fairness plays an important role in developing and maintaining channel relationships. To examine how firms' concerns about fairness affect the nature of optimal contracts in a marketing channel, Cui et al. [12] introduce the members' fairness concerns into channel and study the supply chain performances analytically. They find that a coordinating wholesale price contract can be designed when only the retailer or both parties are concerned about fairness. And experimental work finds support for their analytical results [17,18]. Caliskan-Demirag et al. [13] extend the results

of Cui et al. [12] to other nonlinear demand functions and discover that the exponential demand function requires less stringent conditions to achieve coordination when only the retailer is fairness-concerned. Bi et al. [14] study the stochastic demand function and realize that when the retailer is under advantageous aversion, the supply chain system can be coordinated. Wu and Niederhoff [15] study the impact of fairness concerns on supply chain performance in the two-party newsvendor setting and explore the win-win conditions for the channel. They discover that in order for the retailer's fairness concern to improve expected profits of both parties compared to the traditional supply chain case (win-win), the demand uncertainty cannot be too low; the retailer is not very averse to disadvantageous inequity, and his ideal allocation to the supplier is within a specific range.

For Cui et al. [12] and Caliskan-Demirag et al. [13], they do not explore the win-win conditions for the retailer and the supplier. In this paper, our objective is to investigate win-win parameter region of wholesale pricing when the retailer cares about fairness. We analyze the supply chain system with liner demand and nonlinear demand, respectively. Based on the win-win parameter region of wholesale pricing when the retailer cares about fairness, we can achieve a win-win wholesale price contract to improve profits of both parties compared to the traditional supply chain case, which has a certain practical significance.

The rest of the paper is organized as follows. Next section shows the model description of wholesale pricing in supply chain system. In Section 3, the win-win region of wholesale pricing when a retailer cares about fairness is explored and six propositions are given to explain the detailed cases. Finally, some conclusions are reported.

2. **Model Description.** Consider the standard dyadic channel where a single supplier sells its product to consumers through a single retailer. The supplier moves first and charges a constant wholesale price w with a unit production cost c. Then, taking the wholesale price w as given, the retailer sets his price p. We analyze the linear demand function $D(p) = a - bp$, where $a > 0$, $b > 0$, and the nonlinear demand function $D(p) = Ae^{-bp}$, where $A > 0$, $b > 0$, respectively. In traditional supply chain without considering fairness, given a wholesale price w, the retailer chooses the optimal retail price p^* to maximize his profit function $\pi_r = (p - w)D(p)$. While the supplier sets a wholesale price w^* to maximize his profit function $\pi_s = (w - c)D(p)$. However, when the retailer cares about fairness, he maximizes a utility function $U_r(w, p)$ that considers his own profit as well as his concern about fairness through setting his price, while the supplier sets wholesale price to maximize his profit function $\Pi_s = (w - c)D(p)$. $U_r(w, p)$ can be written as the following:

$$U_r(w, p) = \Pi_r(w, p) + f_r(w, p)$$

where $\Pi_r(w, p) = (p - w)D(p)$. Here, $\Pi_r(w, p)$ represents the monetary profit of retailer and $f_r(w, p)$ denotes the retailer's disutility due to unfairness or inequity. And the disutility function of the retailer can be written as

$$f_r(w, p) = -\alpha \max\{\gamma\Pi_s(w, p) - \Pi_r(w, p), 0\} - \beta \max\{\Pi_r(w, p) - \gamma\Pi_s(w, p), 0\}$$

where α is retailer's disadvantageous inequality parameter, β is retailer's advantageous inequality parameter, and γ is retailer's equitable payoff parameter. $\beta \leq \alpha$, $0 < \beta < 1$. Note that the disutility function can only take nonpositive values.

3. Win-Win Region of Wholesale Pricing When a Retailer Cares about Fairness.

3.1. Linear demand. In traditional supply chain with linear market demand function $D(p) = a - bp$, the wholesale pricing contract leads to double marginalization. The supplier's optimal wholesale price is $\frac{a+bc}{2b}$ and the optimal retail price is $\frac{3a+bc}{4b}$. Then, the resulting profit of supplier is $\pi_s = \frac{(a-bc)^2}{8b}$, the retailer's profit is $\pi_r = \frac{(a-bc)^2}{16b}$ and the supply chain profit is $\frac{3(a-bc)^2}{16b}$. To achieve win-win scenarios, profits of both parties should be improved. Referring to Cui et al. [12], the globally optimal wholesale price and profits are shown in Table 1. Based on the results of Cui et al. [12], we derive win-win parameter region.

Table 1. Wholesale price and profits of the supplier when the retailer cares about fairness

Feasible region	w^*	Π_s^*
$0 < \beta \le \frac{1-2\gamma}{1+\gamma}$ and $\alpha \ge \beta$	$\bar{w}_I = \frac{(a+bc)(1-\beta)-2bc\beta\gamma}{2b(1-\beta-\beta\gamma)}$	$\frac{(a-bc)^2(1-\beta)}{8b(1-\beta-\beta\gamma)}$
$\frac{1-2\gamma}{1+\gamma} < \beta < \frac{1}{1+\gamma}$ and $\beta \le \alpha < \bar{\alpha}$	$\bar{w}_{III} = \frac{(a+bc)(1+\alpha)+2bc\alpha\gamma}{2b(1+\alpha+\alpha\gamma)}$	$\frac{(a-bc)^2(1+\alpha)}{8b(1+\alpha+\alpha\gamma)}$
$\frac{1-2\gamma}{1+\gamma} < \beta < \frac{1}{1+\gamma}$ and $\alpha \ge \max\{\bar{\alpha}, \beta\}$	$w_2 = \frac{a-ab-bc\beta\gamma+2bc\gamma}{b(1-\beta-\beta\gamma+2\gamma)}$	$\frac{(a-bc)^2(1-\beta)\gamma}{b(1-\beta-\beta\gamma+2\gamma)^2}$
$\beta = \frac{1}{1+\gamma}$ and $\beta \le \alpha < \frac{\gamma-1}{1+\gamma}$	$\bar{w}_{III} = \frac{(a+bc)(1+\alpha)+2bc\alpha\gamma}{2b(1+\alpha+\alpha\gamma)}$	$\frac{(a-bc)^2(1+\alpha)}{8b(1+\alpha+\alpha\gamma)}$
$\beta = \frac{1}{1+\gamma}$ and $\alpha \ge \max\left\{\frac{\gamma-1}{1+\gamma}, \beta\right\}$	$w_2 = \frac{a-ab-bc\beta\gamma+2bc\gamma}{b(1-\beta-\beta\gamma+2\gamma)}$	$\frac{(a-bc)^2}{4b(1+\gamma)}$
$\frac{1}{1+\gamma} < \beta < 1$ and $\beta \le \alpha < \frac{\gamma-1}{1+\gamma}$	$\bar{w}_{III} = \frac{(a+bc)(1+\alpha)+2bc\alpha\gamma}{2b(1+\alpha+\alpha\gamma)}$	$\frac{(a-bc)^2(1+\alpha)}{8b(1+\alpha+\alpha\gamma)}$
$\frac{1}{1+\gamma} < \beta < 1$ and $\alpha \ge \max\left\{\frac{\gamma-1}{1+\gamma}, \beta\right\}$	$\bar{w}_{II} = \frac{a+bc+2bc\gamma}{2b(1+\gamma)}$	$\frac{(a-bc)^2}{4b(1+\gamma)}$

where $\bar{\alpha} = \frac{(1-\beta-\beta\gamma-2\gamma)^2-8\beta\gamma^2}{8\gamma^2-(1-\beta-\beta\gamma-2\gamma)^2}$

From Table 1, we know that under $w^* = \bar{w}_{III}$, the supplier's profit Π_s^* equals $\frac{(a-bc)^2(1+\alpha)}{8b(1+\alpha+\alpha\gamma)}$, which is less than $\pi_s = \frac{(a-bc)^2}{8b}$. Therefore, the second, fourth and sixth cases in Table 1 cannot lead to win-win scenarios. Besides, when the condition $w^* = \bar{w}_I = \frac{(a+bc)(1-\beta)-2bc\beta\gamma}{2b(1-\beta-\beta\gamma)}$ holds, the supplier's profit Π_s^* equals $\frac{(a-bc)^2(1-\beta)}{8b(1-\beta-\beta\gamma)}$, which is more than $\frac{(a-bc)^2}{8b}$. While the optimal retail price p^* corresponds to $\frac{a+b\bar{w}_I}{2b} - \frac{\beta\gamma(\bar{w}_I-c)}{2(1-\beta)}$, which is equal to $\frac{3a+bc}{4b}$. So, the supply chain profit equals $\frac{3(a-bc)^2}{16b}$ and the retailer's profit π_r^* is less than $\frac{(a-bc)^2}{16b}$. It means that the first case in Table 1 also cannot achieve win-win scenarios. We mainly focus on the third, fifth and seventh situations in Table 1 to find out the win-win parameter region for both the supplier and the retailer. Proposition 3.1 gives the win-win region of the third situation in Table 1 under $\gamma \le \frac{1}{2}$ and Proposition 3.2 shows the win-win region of the third situation in Table 1 under $\gamma > \frac{1}{2}$. Proposition 3.3 gives the win-win region of fifth and seventh situations in Table 1.

Proposition 3.1. *If retailer's equitable payoff parameter is $\frac{1}{3} < \gamma \le \frac{1}{2}$, and $\forall\gamma \in \left(\frac{1}{3}, \frac{1}{2}\right]$, there exists resulting region of β and α that holds*

$$\beta(\gamma) < \beta < \frac{1}{1+\gamma}, \text{ and } \alpha \ge \max\{\bar{\alpha}, \beta\} \quad (1)$$

then, the profits of both parties are improved compared to the traditional case, where $\bar{\alpha} = \frac{(1-\beta-\beta\gamma-2\gamma)^2-8\beta\gamma^2}{8\gamma^2-(1-\beta-\beta\gamma-2\gamma)^2}$, $\beta(\gamma)$ is a function with respect to γ, it satisfies $\frac{(1-\beta(\gamma))\gamma^2}{(1-\beta(\gamma)-\beta(\gamma)\gamma+2\gamma)^2} = \frac{1}{16}$, and $\beta(\gamma)$ decreases in γ.

Proof: From the third case in Table 1, when $\frac{1-2\gamma}{1+\gamma} < \beta < \frac{1}{1+\gamma}$ and $\alpha \geq \max\{\bar{\alpha}, \beta\}$, then $w^* = w_2 = \frac{a-ab-bc\beta\gamma+2bc\gamma}{b(1-\beta-\beta\gamma+2\gamma)}$, and the resulting profit of supplier is $\Pi_s^* = \frac{(a-bc)^2(1-\beta)\gamma}{b(1-\beta-\beta\gamma+2\gamma)^2}$. The resulting profit of retailer is $\Pi_r^* = (p-w_2)D(p) = \frac{(a-bc)^2(1-\beta)\gamma^2}{b(1-\beta-\beta\gamma+2\gamma)^2}$, where $p = \frac{a+bw_2}{2b} - \frac{\beta\gamma(w_2-c)}{2(1-\beta)}$ and $D(p) = a - bp$. One knows that in the traditional case, the profit of supplier is $\pi_s = \frac{(a-bc)^2}{8b}$, and the retailer's profit is $\pi_r = \frac{(a-bc)^2}{16b}$. To achieve win-win scenarios, $\Pi_s^* > \pi_s$, $\Pi_r^* > \pi_r$ should be met. It means $f(\beta,\gamma) = \frac{(1-\beta)\gamma}{(1-\beta-\beta\gamma+2\gamma)^2} > \frac{1}{8}$, $g(\beta,\gamma) = \frac{(1-\beta)\gamma^2}{(1-\beta-\beta\gamma+2\gamma)^2} > \frac{1}{16}$. When $\gamma \leq \frac{1}{2}$, if $g(\beta,\gamma) > \frac{1}{16}$ satisfies, then $f(\beta,\gamma) > \frac{1}{8}$ certainly holds. Hence, we only need to seek out the region where $g(\beta,\gamma) > \frac{1}{16}$ holds. By taking first partial derivatives of the $g(\beta,\gamma)$, one knows $g'_\beta = \frac{\gamma^2(1-\beta-\beta\gamma)}{(1-\beta-\beta\gamma+2\gamma)^3}$. Obviously, $g'_\beta > 0$ under $\beta < \frac{1}{1+\gamma}$. Similarly, one finds $g'_\gamma = \frac{2\gamma(1-\beta)(1-\beta-\beta\gamma+2\gamma)(1-\beta)}{(1-\beta-\beta\gamma+2\gamma)^4}$. When $\beta < \frac{1}{1+\gamma}$, $g'_\gamma > 0$ always holds. And when $\beta = \frac{1-2\gamma}{1+\gamma}$, $\gamma = \frac{1}{2}$, one gets $g(\beta,\gamma) = \frac{1}{16}$. Besides, when $\beta = \frac{1}{1+\gamma}$, $\gamma = \frac{1}{3}$, one knows $g(\beta,\gamma) = \frac{1}{16}$. So, under $\frac{1}{3} < \gamma \leq \frac{1}{2}$, owing to $f'_\beta > 0$ and $f'_\gamma > 0$, there exists a resulting $\beta(\gamma)$, when $\beta > \beta(\gamma) > \frac{1-2\gamma}{1+\gamma}$, it satisfies $g(\beta,\gamma) > \frac{1}{16}$, where $\beta(\gamma)$ satisfies $\frac{(1-\beta(\gamma))\gamma^2}{(1-\beta(\gamma)-\beta(\gamma)\gamma+2\gamma)^2} = \frac{1}{16}$. Since $f'_\beta > 0$ and $f'_\gamma > 0$, $\beta(\gamma)$ decreases in γ. This completes the proof.

Proposition 3.2. *If retailer's equitable payoff parameter is* $\frac{1}{2} < \gamma < 1$*, and* $\forall \gamma \in \left(\frac{1}{2}, 1\right)$*, there exists corresponding region of* β *and* α *that satisfies*

$$\beta(\gamma) < \beta < \frac{1}{1+\gamma}, \text{ and } \alpha \geq \max\{\bar{\alpha}, \beta\} \tag{2}$$

then, the profits of both parties are improved compared to the traditional case, where $\bar{\alpha} = \frac{(1-\beta-\beta\gamma-2\gamma)^2-8\beta\gamma^2}{8\gamma^2-(1-\beta-\beta\gamma-2\gamma)^2}$*,* $\beta(\gamma)$ *is a function in regard to* γ*, it holds* $\frac{(1-\beta(\gamma))\gamma}{(1-\beta(\gamma)-\beta(\gamma)\gamma+2\gamma)^2} = \frac{1}{8}$*, and* $\beta(\gamma)$ *increases in* γ*.*

Proof: Analogous to the proof of Proposition 3.1, in order to achieve win-win scenarios, $\Pi_s^* > \pi_s$, $\Pi_r^* > \pi_r$ should be held. It means $f(\beta,\gamma) = \frac{(1-\beta)\gamma}{(1-\beta-\beta\gamma+2\gamma)^2} > \frac{1}{8}$, $g(\beta,\gamma) = \frac{(1-\beta)\gamma^2}{(1-\beta-\beta\gamma+2\gamma)^2} > \frac{1}{16}$. When $\gamma \geq \frac{1}{2}$, if $f(\beta,\gamma) > \frac{1}{8}$ satisfies, then $g(\beta,\gamma) > \frac{1}{16}$ surely holds. Hence, we only need to find out the region in which $f(\beta,\gamma) > \frac{1}{8}$ holds. Through taking first partial derivatives of the $f(\beta,\gamma)$, one finds $f'_\beta = \frac{\gamma(1-\beta-\beta\gamma)}{(1-\beta-\beta\gamma+2\gamma)^3}$. Obviously, $f'_\beta > 0$ under $\beta < \frac{1}{1+\gamma}$. Likewise, one realizes $f'_\gamma = \frac{(1-\beta)(1-\beta+\beta\gamma-2\gamma)}{(1-\beta-\beta\gamma+2\gamma)^3}$. Apparently, $f'_\gamma < 0$ holds when $\frac{1}{2} < \gamma < 1$. When $\beta = \frac{1}{1+\gamma}$ and $\gamma = 1$, one can find that $f(\beta,\gamma) = \frac{1}{8}$. So, under $\frac{1}{2} < \gamma < 1$, because of $f'_\beta > 0$ and $f'_\gamma < 0$, there exists corresponding $\beta(\gamma)$ that, when $\beta > \beta(\gamma)$, it meets $f(\beta,\gamma) > \frac{1}{8}$, where $\beta(\gamma)$ satisfies $\frac{(1-\beta(\gamma))\gamma}{(1-\beta(\gamma)-\beta(\gamma)\gamma+2\gamma)^2} = \frac{1}{8}$. Since $f'_\beta > 0$ and $f'_\gamma < 0$, $\beta(\gamma)$ increases in γ. This completes the proof.

Proposition 3.3. *If* $\frac{1}{3} < \gamma < 1$*, and conditions*

$$\beta \geq \frac{1}{1+\gamma}, \text{ and } \alpha \geq \beta \tag{3}$$

are satisfied, then the channel can be coordinated and achieved win-win scenarios.

Proof: From the fifth and seventh cases in Table 1, under $\beta \geq \frac{1}{1+\gamma}$ and $\alpha \geq \max\left\{\frac{\gamma-1}{\gamma+1}, \beta\right\}$, one knows that $\Pi_s^* = \frac{(a-bc)^2}{4b(1+\gamma)}$, $\Pi_r^* = \frac{\gamma(a-bc)^2}{4b(1+\gamma)}$. To get win-win scenarios, it should meet the condition $\Pi_s^* > \pi_s$, $\Pi_r^* > \pi_r$, where $\pi_s = \frac{(a-bc)^2}{8b}$, $\pi_r = \frac{(a-bc)^2}{16b}$. Hence, the feasible region of γ is $\frac{1}{3} < \gamma < 1$. Since $\beta \geq \frac{1}{1+\gamma}$, and $\frac{\gamma-1}{\gamma+1} < 0$ under $\frac{1}{3} < \gamma < 1$, $\alpha \geq \max\left\{\frac{\gamma-1}{\gamma+1}, \beta\right\}$ equals $\alpha \geq \beta$. This completes the proof.

From Figure 1, when retailer's equitable payoff parameter is $\frac{1}{3} < \gamma \leq \frac{1}{2}$, $\beta(\gamma)$ that satisfies $\frac{(1-\beta(\gamma))\gamma^2}{(1-\beta(\gamma)-\beta(\gamma)\gamma+2\gamma)^2} = \frac{1}{16}$ decreases in γ. While retailer's equitable payoff parameter

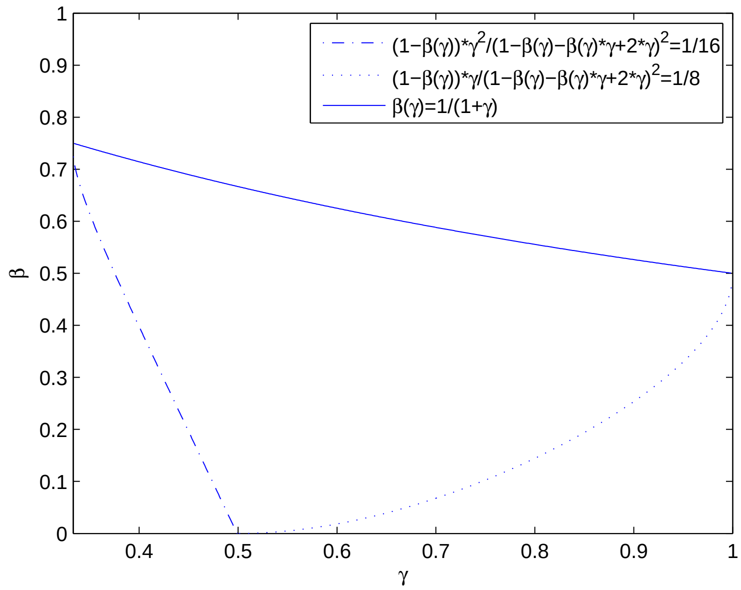

FIGURE 1. Win-win region about β and γ under linear demand

is $\frac{1}{2} < \gamma < 1$, $\beta(\gamma)$ that holds $\frac{(1-\beta(\gamma))\gamma}{(1-\beta(\gamma)-\beta(\gamma)\gamma+2\gamma)^2} = \frac{1}{8}$ increases in γ. So, the win-win but not coordinated region is the area surrounded by three curves. The win-win and coordinated region is the area above solid line ($\beta \geq \frac{1}{1+\gamma}$) when retailer's equitable payoff parameter is $\frac{1}{3} < \gamma < 1$. If the retailers equitable payoff parameter γ is 0.8, the retailers disadvantageous inequality parameter α is 0.3, and the retailers advantageous inequality parameter β is 0.2, we know that the channel can be improved and achieved win-win scenarios based on Figure 1. Furthermore, when $(\gamma, \alpha, \beta) = (0.8, 0.8, 0.7)$, the channel can be coordinated and achieved win-win scenarios. It means that when the fairness parameters of (γ, α, β) are given, the performance of the channel can be known.

3.2. **Nonlinear demand.** In the traditional decentralized setting under the nonlinear market demand function $D(p) = Ae^{-bp}$, the supplier's optimal wholesale price is $c + \frac{1}{b}$ and the retailer's optimal retail price is $c + \frac{2}{b}$. Hence, the corresponding profit for each member is $\frac{A}{b}e^{-(bc+2)}$ and the supply chain profit is $\frac{2A}{b}e^{-(bc+2)}$. Hence, to get win-win scenarios, profits of both parties under the retailer's fairness concern should be more than $\frac{A}{b}e^{-(bc+2)}$. Depending on the outcomes of Caliskan-Demirag et al. [13], we derive the win-win parameter region under nonlinear demand. According to Caliskan-Demirag et al. [13], the supplier's optimal strategy when the retailer cares about fairness is given in Table 2. And the information of equilibrium prices, profit, and utility when the retailer is concerned about fairness is shown in Table 3.

From Table 3, obviously, when the supplier's optimal price equals w_I or w_{III}, the supply chain cannot achieve win-win scenarios. Because the corresponding profit of supplier is less than the traditional profit of supplier. Hence, we only need to focus on the cases when the supplier's optimal price is w_2 or w_{II}.

Proposition 3.4. *If retailer's equitable payoff parameter is* $\frac{1}{e-1} < \gamma \leq 1$, *and* $\forall \gamma \in \left(\frac{1}{e-1}, 1\right]$, *there exists resulting region of* β *and* α *that meets*

$$\beta(\gamma) < \beta < \frac{1}{1+\gamma}, \text{ and } \alpha \geq \beta \tag{4}$$

then, the profits of both parties are improved compared to the traditional case, where $\beta(\gamma)$ *is a function with respect to* γ, *it meets* $(1-\beta(\gamma))e^{2-(1-\beta(\gamma))\left(1+\frac{1}{\gamma}\right)} = 1$, *and* $\beta(\gamma)$ *decreases in* γ.

TABLE 2. The supplier's optimal strategy when the retailer cares about fairness

Feasible region	w^*
$\gamma \le 1$, $\beta < \frac{1-\gamma}{1+\gamma}$ and $\alpha \ge \beta$	w_I
$\gamma \le 1$, $\beta \in \left[\frac{1-\gamma}{1+\gamma}, \frac{1}{1+\gamma}\right)$ and $\alpha \ge \beta$	w_2
$\gamma \le 1$, $\beta \ge \frac{1}{1+\gamma}$ and $\alpha \ge \beta$	w_{II}
$\gamma \in (1,2]$, $\beta < \frac{\gamma-1}{1+\gamma}$ and $\alpha \in \left[\beta, \frac{\gamma-1}{1+\gamma}\right)$	$\arg\max\left\{\Pi_{s,1}(w_2)^{\Upsilon}, \Pi_{s,3}(w_{III})\right\}$
$\gamma \in (1,2]$, $\beta < \frac{\gamma-1}{1+\gamma}$ and $\alpha \ge \max\left\{\beta, \frac{\gamma-1}{1+\gamma}\right\}$	w_2
$\gamma \in (1,2]$, $\beta \in \left[\frac{\gamma-1}{1+\gamma}, \frac{1}{1+\gamma}\right)$ and $\alpha \ge \max\left\{\beta, \frac{\gamma-1}{1+\gamma}\right\}$	w_2
$\gamma \in (1,2]$, $\beta \ge \frac{1}{1+\gamma}$ and $\alpha \ge \beta$	w_{II}
$\gamma > 2$, $\beta < \frac{1}{1+\gamma}$ and $\alpha \in \left[\beta, \frac{\gamma-1}{1+\gamma}\right)$	$\arg\max\left\{\Pi_{s,1}(w_2)^{\Upsilon}, \Pi_{s,3}(w_{III})\right\}$
$\gamma > 2$, $\beta < \frac{1}{1+\gamma}$ and $\alpha \ge \max\left\{\beta, \frac{\gamma-1}{1+\gamma}\right\}$	w_2
$\gamma > 2$, $\beta \ge \frac{1}{1+\gamma}$ and $\alpha \in \left[\beta, \frac{(1+\gamma)-e}{(e-1)(1+\gamma)}\right)$	w_{III}
$\gamma > 2$, $\beta \ge \frac{1}{1+\gamma}$ and $\alpha \ge \left\{\beta, \frac{(1+\gamma)-e}{(e-1)(1+\gamma)}\right\}$	w_{II}

$^{\Upsilon}$ Note that $\Pi_{s,1}(w_2) = \Pi_{s,2}(w_2)$ and we write $\Pi_{s,1}(w_2)$ without loss of generality.

TABLE 3. Wholesale price and profits of the supplier when the retailer cares about fairness

w^*	p^*	Π_s^*	U_r^*
$w_I = \frac{1-\beta}{b(1-\beta-\beta\gamma)} + c$	$c + \frac{2}{b}$	$\frac{A(1-\beta)}{b(1-\beta-\beta\gamma)} e^{-(bc+2)}$	$\frac{A(1-\beta)}{b} e^{-(bc+2)}$
$w_2 = \frac{1-\beta}{b\gamma} + c$	$c + \frac{(1-\beta)(1+\gamma)}{b\gamma}$	$\frac{A(1-\beta)}{b\gamma} e^{-\left(bc+\frac{(1-\beta)(1+\gamma)}{\gamma}\right)}$	$\frac{A(1-\beta)}{b} e^{-\left(bc+\frac{(1-\beta)(1+\gamma)}{\gamma}\right)}$
$w_{II} = \frac{1}{b(1+\gamma)} + c$	$c + \frac{1}{b}$	$\frac{A}{b(1+\gamma)} e^{-(bc+1)}$	$\frac{A\gamma}{b(1+\gamma)} e^{-(bc+1)}$
$w_{III} = \frac{1+\alpha}{b(1+\alpha+\alpha\gamma)} + c$	$c + \frac{2}{b}$	$\frac{A(1+\alpha)}{b(1+\alpha+\alpha\gamma)} e^{-(bc+2)}$	$\frac{A(1+\alpha)}{b} e^{-(bc+2)}$

Proof: From Table 3, one knows that when $w^* = w_2$, then $\Pi_s^* = \frac{A(1-\beta)}{b\gamma} e^{-\left(bc+\frac{(1-\beta)(1+\gamma)}{\gamma}\right)}$ and $\Pi_r^* = \frac{A(1-\beta)}{b} e^{-\left(bc+\frac{(1-\beta)(1+\gamma)}{\gamma}\right)}$. To achieve win-win scenarios, both Π_s^* and Π_r^* should be more than $\frac{A}{b} e^{-(bc+2)}$. When $\gamma \le 1$, if $\Pi_r^* > \frac{A}{b} e^{-(bc+2)}$ meets, then $\Pi_s^* > \frac{A}{b} e^{-(bc+2)}$ surely satisfies. So, we only need to find out the region in which $\Pi_r^* > \frac{A}{b} e^{-(bc+2)}$ holds. It means that $f(\beta,\gamma) = (1-\beta) e^{2-(1-\beta)\left(1+\frac{1}{\gamma}\right)} > 1$. By taking the first partial derivatives of the $f(\beta,\gamma)$, one finds that $f'_\beta = \left[\left(1+\frac{1}{\gamma}\right)(1-\beta) - 1\right] e^{2-(1-\beta)\left(1+\frac{1}{\gamma}\right)}$, which is strictly positive when $\beta < \frac{1}{1+\gamma}$. Similarly, one can know that $f'_\gamma = \frac{(1-\beta)^2}{\gamma^2} e^{2-(1-\beta)\left(1+\frac{1}{\gamma}\right)}$, which is always positive. When $\beta = \frac{1-\gamma}{1+\gamma}$ and $\gamma = 1$, one knows that $f(\beta,\gamma) = 1$. Besides, when $\beta = \frac{1}{1+\gamma}$, $\gamma = \frac{1}{e-1}$, one gets $f(\beta,\gamma) = 1$. Hence, under $\frac{1}{e-1} < \gamma \le 1$, on account of $f'_\beta > 0$ and $f'_\gamma > 0$, there exists resulting $\beta(\gamma)$ that, when $\beta > \beta(\gamma) > \frac{1-\gamma}{1+\gamma}$, it always satisfies $f(\beta,\gamma) > 1$, where $\beta(\gamma)$ satisfies $(1-\beta(\gamma)) e^{2-(1-\beta(\gamma))\left(1+\frac{1}{\gamma}\right)} = 1$. Since $f'_\beta > 0$ and $f'_\gamma > 0$, $\beta(\gamma)$ decreases in γ. This completes the proof.

Proposition 3.4 reveals the win-win region of the second case in Table 2. And the win-win region of the fifth and sixth cases in Table 2 are presented by Proposition 3.5. The proof of Proposition 3.5 also shows that the supplier's optimal price $w^* = w_2$ of the ninth case in Table 2 cannot lead to win-win scenarios.

Proposition 3.5. *If retailer's equitable payoff parameter is $1 < \gamma < e-1$, and $\forall\gamma \in (1, e-1)$, there exists corresponding region of β and α that satisfies*

$$\beta(\gamma) < \beta < \tfrac{1}{1+\gamma}, \text{ and } \alpha \geq \max\left\{\beta, \tfrac{\gamma-1}{1+\gamma}\right\} \tag{5}$$

then, the profits of both parties are improved compared to the traditional case, where $\beta(\gamma)$ is a function in regard to γ, it satisfies $\frac{1-\beta(\gamma)}{\gamma}e^{2-(1-\beta(\gamma))\left(1+\frac{1}{\gamma}\right)} = 1$, and $\beta(\gamma)$ increases in γ.

Proof: To achieve win-win scenarios, both Π_s^* and Π_r^* should be more than $\frac{A}{b}e^{-(bc+2)}$. Under $1 < \gamma < e-1$, if $\Pi_s^* > \frac{A}{b}e^{-(bc+2)}$ holds, then, $\Pi_r^* > \frac{A}{b}e^{-(bc+2)}$ always meets. Hence, we only need to seek out the region where $\Pi_s^* > \frac{A}{b}e^{-(bc+1)}$ holds. It means $g(\beta,\gamma) = \frac{1-\beta}{\gamma}e^{2-(1-\beta)\left(1+\frac{1}{\gamma}\right)} > 1$. By taking the first partial derivatives of the $g(\beta,\gamma)$, one finds that $g'_\beta = \frac{1}{\gamma}\left[\left(1+\frac{1}{\gamma}\right)(1-\beta) - 1\right]e^{2-(1-\beta)\left(1+\frac{1}{\gamma}\right)}$, which is strictly positive under $\beta < \frac{1}{1+\gamma}$. Similarly, one can realize that $g'_\gamma = \left(\frac{1-\beta}{\gamma} - 1\right)\frac{(1-\beta)}{\gamma^2}e^{2-(1-\beta)\left(1+\frac{1}{\gamma}\right)}$, which is always negative under $1 < \gamma$. When $\beta = \frac{1}{1+\gamma}$ and $\gamma = e-1$, $g(\beta,\gamma) = 1$. Hence, under $1 < \gamma < e-1$, owing to $g'_\beta > 0$ and $g'_\gamma < 0$, there exists a corresponding $\beta(\gamma)$; when $\beta > \beta(\gamma)$, it always satisfies $g(\beta,\gamma) > 1$, where $\beta(\gamma)$ satisfies $\frac{1-\beta(\gamma)}{\gamma}e^{2-(1-\beta(\gamma))\left(1+\frac{1}{\gamma}\right)} = 1$. Since $g'_\beta > 0$ and $g'_\gamma < 0$, $\beta(\gamma)$ increases in γ. Besides, when $\beta = \frac{1}{1+\gamma}$ and $\gamma = 2$, $g(\beta,\gamma) = \frac{1}{1+2}e < 1$. So, the ninth case of Table 2 cannot lead to win-win scenarios. This completes the proof.

Proposition 3.6. *If $\frac{1}{e-1} < \gamma < e-1$, and conditions*

$$\beta \geq \tfrac{1}{1+\gamma}, \text{ and } \alpha \geq \beta \tag{6}$$

are satisfied, then the channel can be coordinated and achieved win-win scenarios.

Proof: From Table 3, one knows that when $w^* = w_{II}$, then $\Pi_s^* = \frac{A}{b(1+\gamma)}e^{-(bc+1)}$ and $\Pi_r^* = \frac{A\gamma}{b(1+\gamma)}e^{-(bc+1)}$. To achieve win-win scenarios, both Π_s^* and Π_r^* should be more than $\frac{A}{b}e^{-(bc+2)}$. So, the feasible region of γ is $\frac{1}{e-1} < \gamma < e-1$. This completes the proof.

From Figure 2, when retailer's equitable payoff parameter is $\frac{1}{e-1} < \gamma \leq 1$, the $\beta(\gamma)$ that satisfies $(1-\beta(\gamma))e^{2-(1-\beta(\gamma))\left(1+\frac{1}{\gamma}\right)} = 1$ decreases in γ. While retailer's equitable payoff parameter is $1 < \gamma < e-1$, the $\beta(\gamma)$ that holds $\frac{1-\beta(\gamma)}{\gamma}e^{2-(1-\beta(\gamma))\left(1+\frac{1}{\gamma}\right)} = 1$ increases in γ. So, the win-win but not coordinated region is the area surrounded by three curves. The win-win and coordinated region is the area above solid line $\left(\beta \geq \frac{1}{1+\gamma}\right)$ when retailer's equitable payoff parameters is $\frac{1}{e-1} < \gamma < e-1$. If the retailers equitable payoff parameter γ is 0.8, the retailers disadvantageous inequality parameter α is 0.5, and the retailers advantageous inequality parameter β is 0.4, we know that the channel can be improved and achieved win-win scenarios based on Figure 2. Furthermore, when $(\gamma,\alpha,\beta) = (0.8, 0.8, 0.7)$, the channel can be coordinated and achieved win-win scenarios. It means that when the fairness parameters of (γ,α,β) are given, the performance of the channel can be obtained.

4. **Conclusion.**

In the paper, we derive the win-win region of wholesale pricing when the retailer cares about fairness. We find that when the retailer is extreme generosity $\left(\beta \geq \frac{1}{\gamma}\right)$, the channel can be coordinated and achieved win-win scenarios under certain

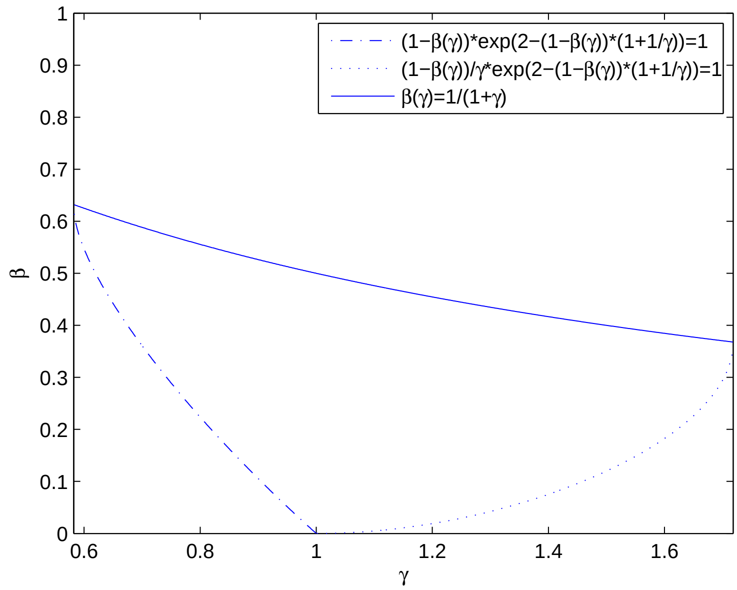

Figure 2. Win-win region about β and γ under exponential demand

conditions (Proposition 3.3 and Proposition 3.6). While the retailer is moderate generosity $\left(\beta < \frac{1}{\gamma}\right)$, the channel can be improved and achieved win-win scenarios under certain conditions (Propositions 3.1, 3.2, 3.4 and 3.5) compared to traditional supply chain case. Furthermore, our research can be further extended to explore the win-win region of wholesale pricing when both the retailer and the supplier care about fairness, which will be studied in the future.

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