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Abstract. The paper considers the impact of consumer environmental awareness (CEA) and manufacturer's fairness concern on wholesale price and retail price in supply chain. We discuss two decision scenarios: decentralized model (scenario 1), manufacturer is concerned about disadvantageous inequity (scenario 2). Our analysis shows that: (1) when manufacturer is fair-minded, he wants to risk losses in favor of splitting the channel profit equally; (2) without fairness concern, both members' profits increase with CEA; however, with fairness concern, both members' profits may decrease with CEA; (3) compared with decentralized model, in case 2, manufacturer's profits decline inevitably while retailer's profits have half the chance to increase; manufacturer will not remove unfairness, but even risk losses.

1. Introduction

Environmental problems have caused many inconveniences to people's lives and the "resource-saving and environment-friendly society" construction has become people's consensus, thence more and more consumers pay more attentions to environment quality. As more and more consumers have become environmentally conscious, researchers started to consider the impact of consumer environmental awareness (CEA) in a supply chain. Liu et al. (2012) introduced environmental quality as a demand enhancement factor in the product demand function. Zhang et al. (2015) explored how CEA impacts supply chain coordination. Xiong et al. (2016) analyzed the effect of carbon tax and CEA on carbon emissions and profits. Above literature discussed the impact of CEA on supply chain, and assume that

decision-makers are completely rational. While, fairness concern as an irrational behavior is also a new important factor need to be considered in a supply chain. Fehr & Schmidt (1999) mentioned decision-makers are not entirely rational to maximize their profits but very fair-minded of the whole supply chain. With fairness concern, Caliskan-Demirag et al. (2010) explored channel coordination under fairness concerns and nonlinear demand.

In this study, we introduce fairness concern to discuss manufacturer's and retailer's strategies when the manufacturer produces green products, and we explore the impact of both CEA and manufacturer's fairness concern on each party's strategy of the supply chain. We mainly discuss the following questions: (1) how to price the green products with CEA and manufacturer's fairness concern. (2) how the manufacturer's fairness concern affects the wholesale prices and retail prices of green products with CEA. (3) how the retailer's and manufacturer's profits change with CEA and manufacturer's fairness concern.

2. Model assumptions and formulation

2.1 Basic model assumptions

We assume that manufacturer produces green products. Price and environmental quality are two attributes influencing consumer demand. Product demand increases with environmental quality, and decreases with its price. The demand function (denoted as D) for green products can be presented as follows:

$$D = a - p + \tau e$$

where a is initial market potential, τ represents consumer environmental awareness. CEA affects consumer willingness to pay for green products, the higher CEA implies higher willingness to pay. Table 1 summarizes the major notations we will use in our model development.

Table 1. Model parameters and Decision variables

Parameter	Implication
c	unit production cost of the manufacturer of product
e	environmental quality of product
a	initial market potential
τ	consumer environmental awareness (CEA)
α_0, β_0	disadvantageous inequality and advantageous inequality
μ	the equitable ratio for the manufacturer (defines what is considered to be a fair
π_r, π_m	retailer's and manufacturer's profits, respectively
Decision variables	
p	the green product's retail price
w	the unit wholesale price of green product charged by the manufacturer

2.2 Decentralized model without fairness concern

We develop this model that neither the manufacturer nor the retailer is fair-minded as the benchmark model. Manufacturer moves first and determines wholesale price of green products to maximize his own profits. As the follower, retailer determines the order quantity and retail price to maximize his own profits. In this case, the profits of retailer and manufacturer are given as follows respectively:

$$\pi_{dr}(p) = (p - w)D,$$

$$\pi_{dm}(w) = (w - c)D.$$

Theorem 1. In the decentralized model, the optimal retail price and the optimal wholesale price of the green products are given as follows:

$$p_d = \frac{3(a + e\tau) + c}{4} \quad (1)$$

$$w_d = \frac{a + c + e\tau}{2} \quad (2)$$

Proposition 1. In the decentralized model, the wholesale prices w_d and retail price p_d increase with τ (CEA).

Proposition 2. In decentralized model,

(i) manufacturer's profit and retailer's profit increase with CEA.

(ii) manufacturer's profit increases more significantly with CEA than retailer's profit .

3. Manufacturer is concerned about fairness

In this section, we consider that the manufacturer is fair-minded. The manufacturer maximizes his utility whereas the retailer maximizes his own profits. Similar to Caliskan-Demirag et al. (2010) we capture fairness in the manufacturer's objective function through the following utility function:

$$U_m = \pi_m + f_m$$

where π_m denotes the manufacturer's monetary profit and f_m represents manufacturer's disutility due to unfairness. Let $\mu\pi_r$ be the equitable outcome of the manufacturer, where $\mu > 0$ is the equitable ratio for the manufacturer. When $\pi_m < \mu\pi_r$, manufacturer feels disadvantageous inequality. When $\pi_m > \mu\pi_r$, manufacturer feels advantageous inequality. The disutility function of the manufacturer can be written as:

$$f_m = -\alpha_0(\mu\pi_r - \pi_m)^+ - \beta_0(\pi_m - \mu\pi_r)^+$$

Note that the f_m can only take non-positive values: α_0 is the coefficient of disadvantageous inequality. β_0 is the coefficient of advantageous inequality . Many studies have shown that subjects suffer more from their disadvantage inequity that is to their monetary disadvantage than from inequity that is to their monetary advantage, thus $\beta_0 < \alpha_0$, $0 < \beta_0 < 1$. For a given wholesale price, the manufacturer's utility function is as follows:

$$U_m = (w - c)D - \alpha_0[\mu(p - w)D - (w - c)D]^+ - \beta_0[(w - c)D - \mu(p - w)D]^+ \quad (3)$$

Du to space limitations, we only discuss when manufacturer cares about disadvantageous inequity ($\pi_m < \mu\pi_r$). it means that a fair-minded manufacturer finds himself at an outcome which bring lower profits than what he believes equitable. From Equation (3), we could obtain that when $\pi_m < \mu\pi_r$, $(\pi_m - \mu\pi_r)^+ = 0$. Therefore, manufacturer's utility function reduces to:

$$U_{1,m} = (w - c)D - \alpha_0[\mu(p - w)D - (w - c)D]$$

Theorem 2. When the manufacturer is fair-minded and incurs an unfavorable disutility , the optimal retail price and wholesale price with the disadvantageous inequality (α_0) and the fairness degree (μ) are given as follows:

$$p_1^* = \begin{cases} \frac{a + w + e\tau}{2}, & w < \frac{\mu(a + e\tau) + 2c}{2} \\ \frac{(1 + \mu)w - c}{\mu}, & w \geq \frac{\mu(a + e\tau) + 2c}{2} \end{cases} \quad (4)$$

$$w_1^* = \begin{cases} \frac{\mu(a + e\tau) + 2c}{2}, & 0 < \mu \leq \mu_1 \\ \frac{(1 + \alpha_0)(a + c + e\tau) + \alpha_0\mu(a + e\tau)}{\alpha_0(2 + \mu) + 2}, & \mu > \mu_1 \text{ and } 0 < \alpha_0 < \alpha_0' \\ \frac{\mu(a + e\tau) + 2c}{2}, & \mu > \mu_1 \text{ and } \alpha_0 \geq \alpha_0' \end{cases} \quad (5)$$

$$\text{Where } \alpha_0' = \frac{2(a + e\tau - c) - 2\mu(a + e\tau)}{2(c - a - e\tau) + 2c\mu + \mu^2(a + e\tau)}, \quad \mu_1 = 1 - \frac{c}{a + e\tau}.$$

Proposition 3. When the manufacturer is fair-minded and incurs an unfavorable disutility,

(i) the retail price p_1^* and the wholesale price w_1^* increase with CEA (τ);

(ii) (a) w_1^* and p_1^* increase with α_0 , when $\mu > \mu_1, 0 < \alpha_0 < \alpha_0'$;

(b) w_1^* and p_1^* keeps constant with α_0 , when $\mu > \mu_1, \alpha_0 > \alpha_0'$ or $0 < \mu < \mu_1$.

Proposition 3 shows that when the manufacturer cares about his disadvantageous inequity, both the optimal retailer price and wholesale price still increase with CEA; when the manufacturer earns more than retailer and cares less about his disadvantageous inequity, he will increase the wholesale price to make more profits; in response to manufacturer, retailer will also increase his retail price in order to keep the previous profits. But it is noteworthy that when manufacturer's fairness concern degree exceeds the certain point (α_0'), both manufacturer and retailer will not increase their prices. This means that when manufacturer pays attention to fairness, he makes wholesale price of green products tends to be conservative, and the greater the fairness concern degree, the more conservative decisions he makes.

Proposition 4. When manufacturer is fair-minded and incurs an unfavorable disutility,

(i) the retailer's profit $\pi_{1,r}^*$ increases with τ ;

(ii) (a) manufacturer's profit $\pi_{1,m}^*$ increases with τ , when $\mu > \mu_1, 0 < \alpha_0 < \alpha_0'$;

(b) manufacturer's profit $\pi_{1,m}^*$ decreases with τ , when $\mu > \mu_1, \alpha_0 \geq \alpha_0'$ or $0 < \mu < \mu_1$.

We define α_0' as the danger point in Proposition 4-6.

Proposition 4 shows that when the manufacturer cares about his unfavorable inequity, retailer's profits still increase with CEA, but manufacturer's profits increase with CEA, when his fairness concern degree within the danger point, and then decrease with CEA when his fairness concern degree exceeds the danger point. Therefore, once manufacturer's fairness concern degree exceeds the danger point, the manufacturer will not make more effort to marketing the green product, but the retailer still have the incentive to invest in improving CEA.

Proposition 5. When manufacturer is fair-minded and incurs an unfavorable disutility ,

- (i) manufacturer's profit $\pi_{1,m}^*$ and retailer's profit $\pi_{1,r}^*$ decrease with α_0 , when $\mu > \mu_1$ and $0 < \alpha_0 < \alpha_0'$; (ii) $\pi_{1,m}^*, \pi_{1,r}^*$ keep a constant with α_0 , when $\mu > \mu_1$ and $\alpha_0 \geq \alpha_0'$ or $0 < \mu < \mu_1$.

Proposition 5 shows that when manufacturer cares about his disadvantage inequity, if his fairness concern degree within the danger point (α_0'), both manufacturer's and retailer's profits will decrease with his fairness concern degree. When manufacturer's fairness concern degree exceeds the danger point, both members' profits drop to the lowest and not decrease any more. This shows that manufacturer's fairness concern makes its profits significantly decrease while reducing the retailer's profits. Due to great investment in green products, manufacturer will pay more attention to the fairness of profits distribution. However, the fairness concern makes manufacturers tend to make their decisions conservative and pay more attention to the immediate benefits and make their decisions deviate from the rational optimal decision. In the long run, manufacturer's behavior will reduce efficiency and lose his profits. Although manufacturer suffers a loss of profits, his share of supply chain profits is increasing significantly.

For convenience, according to Proposition 3 and Proposition 4, we present the change of prices, profits in Table 2.

Table 2. Equilibrium prices and profits change with τ and α_0

Feasible region		parameters	w_1^*	P_1^*	$\pi_{1,m}^*$	$\pi_{1,r}^*$
$0 < \mu < \mu_1$		τ	↑	↑	↓	↑
		α_0	--	--	--	--
$\mu > \mu_1$	$0 < \alpha_0 < \alpha_0'$	τ	↑	↑	↑	↑
		α_0	↑	↑	↓	↓
	$\alpha_0 \geq \alpha_0'$	τ	↑	↑	↓	↑
		α_0	--	--	--	--

Proposition 6. Compare with the decentralized model, when manufacturer is fair-minded and incurs an unfavorable disutility ,

- (i) $\pi_{1,m}^* < \pi_{dm}^*$;
(ii) (a) $\pi_{1,r}^* > \pi_{dr}^*$, if $0 < \mu < \mu_1$ or $\mu \geq 3\mu_1$ and $\alpha_0 \geq \alpha_0'$; (b) $\pi_{1,r}^* < \pi_{dr}^*$, if $\mu > \mu_1$ and $0 < \alpha_0 < \alpha_0'$ or $\mu_1 \leq \mu < 3\mu_1$ and $\alpha_0 \geq \alpha_0'$.

Proposition 6 shows that when manufacturer cares about his disadvantageous inequity, affected by manufacturer's fairness concern and CEA together, manufacturer's profits get less than that of decentralized model. When manufacturer earns much more or less than that of retailer and cares too much fairness, manufacturer's fairness concern makes retailer's profits increase with CEA more significantly than decrease with fairness concern and retailer will earn more than that of decentralized model. This can further reflect manufacturer's fairness concern damages his own profits even worse than damages retailer's profits. This is because

fairness concern as an individual attributes let manufacturer make their decisions conservative and deviate from the rational optimal decision. Manufacturer invests more to care fairness while reducing the quality of green products, especially when his fairness concern degree exceeds the danger point, due to the poor green products' quality, his profits decrease with CEA. At last, manufacturer risks losses but obtain fairness of profit allocation.

4. Discussion and conclusion

We assume that the monopoly manufacturer is fair-minded and provides green products in the marketplace. This study explores the impact of manufacturer's fairness concern and CEA on wholesale price and retail price of the green product in supply chain. The study reveals that: (1) when manufacturer is fair-minded, the fairness concern may change the trend of the both members' profits with CEA. When there is no fairness concern, both members' profits increase with CEA; however, with fairness concern, both members' profits may decrease with CEA. In other words, manufacturer's fairness concern may affect both members' incentive to invest to improve CEA. (2) when the manufacturer cares about his disadvantage inequity, both member's profits decrease with the fairness concern, manufacturer will not only remove unfairness, but also make both members suffer loss. In this case, the fairness concern makes manufacturers tend to make their decisions conservative and pay more attention to the immediate benefits and make their decisions deviate from the rational optimal decision. In summary, when manufacturer cares about disadvantageous inequity, in order to gain fairness of profit allocation, he will probably make irrational decisions and greatly reduce his own profits. So, it is worthless for manufacturer to sacrifice for fairness.

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