Hindawi
Mathematical Problems in Engineering
Volume 2018, Article ID 7621039, 8 pages
https://doi.org/10.1155/2018/7621039

Research Article

Pricing Strategies of a Traditional Retailer and a Direct Distributor When Consumers Hold Channel Preferences

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Received 31 March 2017; Accepted 21 February 2018; Published 28 March 2018

Academic Editor: Josefa Mula

This paper studies the price game between a traditional retailer and a direct distributor who have different channel preferences. Both of the decision makers' objectives are to maximize their individual expected utilities. We formulate the two decision makers' utility functions and find out their corresponding equilibrium solutions after a game process. We conclude that the traditional retailer has an advantage over the direct distributor in the market full of unconstrained competition. The traditional retailer's equilibrium price increases with the reduction of its consumer's purchasing-intention sensitiveness to the distance of consumption. Based on the result, we find that the game is not able to arrive at the Nash equilibrium solution in certain situations. Moreover, the transportation cost and bargain cost strongly influence the equilibrium solutions of the price game if the market constraints become tighter. Along with the increasing tightness of the market constraints, it appears that both the traditional retailer and the direct distributor dynamically adjust their solutions according to the same strategy. Finally, we draw a conclusion and suggest the potential directions for future research.

1. Introduction

The rapid development of e-commerce has changed the traditional shopping patterns of consumers and the mode of traditional supply chain management. The traditional retail channel and the emerging Internet direct sales channel have gradually gained the attention of more consumers, manufacturers (such as the Haier Group), and operators (such as Suning). With the popularity of network information technology and smartphones and the improvement of national income levels, consumers' consideration of sales price, time cost, and other factors has undergone great changes. For example, to some consumers, the direct sales channel with low prices is more attractive, while other consumers prefer the traditional channel, which allows them to have a try of the product and to buy it immediately. So, consumers' preferences of sales channel will affect the market share of the traditional retailer and the direct distributor and thus significantly impact the price game between them.

2. Literature Review

From the perspective of supply chain management, the research in the field of multichannel sales is divided into two main categories: the dual-channel game between the manufacturer and the traditional retailer and the dual-channel game between the direct sales channel and the retail channel; the main difference between the two games lies in whether market competition in the supply chain is vertical or horizontal.

There are abundant researches about vertical competition in supply chain. Under the supply chain constituted by the upstream manufacturer and the downstream retailer, Chiang et al. [1] have analyzed the "one to one" game between the manufacturer and the retailer by characterizing the consumer market from two dimensions and by considering influences of the direct sales channel on manufacturers at different levels of consumption; these authors concluded that, compared to single-channel marketing, the multichannel model has lower

retail prices and more demand and brings more profits for manufacturers. Boyaci [2] has utilized the random function to characterize consumer demand by adding the factor of inventory to the model, which leads to the increase of complexity in the model, and the corresponding price factor thus becomes the exogenous variable. Chiang and Feng [3] used the pricing and lot-sizing decisions of the Economic Order Quantity (EOQ) model to explore the strategic interactions between upstream and downstream supply chain members. In a paper that employed the Hotelling model to describe the consumer market, Cattani et al. [4] classified consumer preferences according to the traditional channel and the direct sales channel. Esteves and Vasconcelos [5] studied the interaction between horizontal mergers and price discrimination by citing the repeated purchase model with two periods and three firms, wherein firms may engage in Behavior-Based Price Discrimination (BBPD). Panda et al. [6] explored pricing and replenishment policies for a high-tech product in a dual-channel supply chain that consisted of a brick-and-mortar channel and an Internet channel. Besides analyzing the effect of imperfect quality product on optimal decisions, the paper depicted the hybrid contract mechanism so that all units quantity discount with franchise fee resolved channel conflicts though unable to achieve win-win situation [7]. There are many papers also examining the effect of the degree of concern of the manufacturer regarding corporate social responsibility on product compatibility and discussing feasibility of the successful operation of a dual-channel supply chain [8].

In contrast, researches in the field of supply chain horizontal competition are not sufficient. Salop [9] has introduced the concept of circular market. Consumers are uniformly distributed on the circumference of the circle, and it is assumed that every consumer in the same section of the market needs a unit of standardized product. Based on this model, Balasubramanian [10] has established a model of competition between the direct sales channel and the retail channel. Under the condition of sufficient market information, the equilibrium market share and equilibrium price are obtained, and every retailer will compete with the direct sales channel rather than with the adjacent retailer. Ma et al. [11] examined two noncooperative models (Stackelberg and Nash game) and proposed a cost sharing contract to investigate channel competition of dual-channel supply chain. The dominant power between manufacturers and retailers and the effect of channel competition strategy on price are mainly discussed. Wei and Li [12] investigated the impact of heterogeneous consumers' behavior on optimal pricing decisions under dual-channel supply chain competition. Due to the complexity of heterogeneous consumers' decision behavior [13], traditional mathematical analysis for the pricing problem becomes quite challenging. Sana [14] established an EOQ model over an infinite time horizon for perishable items where demand was dependent on price and partial backorder was permitted. And he studied a finite time-horizon deterministic EOQ model where the rate of demand decreased quadratically with selling price [15]. Furthermore, some studies considered decision makers' individual preference or behaviors in their decisions (Han and Dong 2017). For example, Fu and Han [16] studied the information sharing process considering trust in a two-tier supply chain with one upstream agent and two retailers, in which the retailers competed with each other, and its extending studies focused on designing mechanisms to supply chain coordination [17].

This study focuses on two aspects: (1) Under what conditions does the Nash equilibrium strategy exist in the price game between the traditional retailer and the direct distributor based on the consumers' channel preferences? (2) What are the impacts on the price game between the retailer and the direct distributor and on their respective profits caused by different channel preferences of consumers, friction cost, and transportation cost? Compared with the previous studies, there are two main contributions in this paper. First, we consider a pricing competing problem considering the consumers' channel preference, which exists in practice. Thus, one of our contributions is solving a pricing problem with a more practical circumstance. Second, we analytically present the supply chain partners' optimal solutions. Following the solutions, we arrive at some managerial insights, which are helpful to industries.

3. Model Description

Based on the classic Hotelling [18] linear city model, this paper considers the price game model between the traditional retailer and the distributor under different channel preferences of consumers.

According to consumers' different preferences for sales channels, we study two types of consumers. One is called a conservative consumer, who is only interested in the retail channel. The number of this type of consumer depends on the distance from the consumer to the retail store, and the closer they are, the larger the number is. With the increase of the distance to the retail store, the transportation cost of shopping increases, and the number of conservative consumers consequently declines. The other type of consumers is called emerging consumers, who do purchasing from both the retail outlet and the direct channel.

We assume that the consumers are uniformly distributed in the interval $[0, 1]$, in which 0 and 1 represent the two respective ends of the city. Without losing generality, we locate the retailer in the city center, namely, at the point of $1/2$. Considering the symmetrical distribution of consumers before and behind the retailer, the retailer is assumed at the origin for the convenience of derivation. We use the straight line $y = 1 - \alpha x$ to characterize the proportion of conservative consumers and emerging consumers, namely, the channel preferences of consumers. In this function, α is a constant that indicates the conservative consumer's sensitivity to distance, and the bigger α is, the more sensitive the conservative consumer is to distance. x represents the distance between the consumer and the retail store, as shown in Figure 1.

The traditional retailer and the direct distributor sell the same products. We assume that the consumer market is completely covered and that the purchasing utility is infinite to ensure that the emerging consumer would make a choice between only the retail channel and the direct sales channel. The direct distributor and the retailer of equal status share

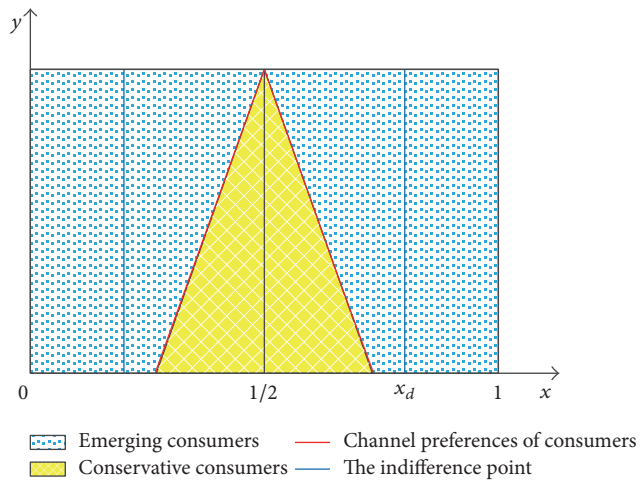

Figure 1: The proportion of conservative consumers and emerging consumers.

the market and compete to attract more consumers, and winning the group of emerging consumers is the key to their competition. An increase in price will boost the profits of per unit of goods, at the expense of losing some consumers to the other channel. Therefore, the price game will be the major concern of the retailer and the distributor.

The assumptions and indications of this paper's parameters are described below.

(1) P_r: the retailer's selling price per unit;

(2) P_d: the direct distributor's selling price per unit;

(3) V: the value of utility arising from purchasing single item;

(4) t: the consumer's transport cost per unit of distance;

(5) μ: friction cost arising from purchasing through direct sales channel, such as the cost caused by the consumer's lack of experience of the direct distributor's products or the consumer's uncertainty about the product quality;

(6) x_d: the indifferent point where there is no difference for the emerging consumer to purchase through the traditional retail channel or through the Internet direct sales channel, that is, the point at which the consumer's utility values through the two channels are equal;

(7) π_1: the traditional retailer's profit function;

(8) π_2: the direct distributor's profit function;

(9) $P_{\max}$: the selling price when the two retailers reach Nash equilibrium in the Hotelling model under a perfectly competitive market, that is $P_{\max} = t$, which is the upper limit of the selling price that the consumer can accept. When the market price exceeds this price, consumers will not buy the products.

4. Model Analysis

Since the retail store is at the Hotelling linear city center, it is the same case at the right side and the left side of the retail store. Therefore, we only need to analyze the case at a single side of the retail store, and the case at the other side is obtained for the same reason. For the emerging consumer at the position of x, we can obtain the respective utility functions when he adopts different sales channels.

The utility function generated from purchasing through the retail channel is $V - tx - P_r$.

The utility function generated from purchasing through the direct sales channel is $V - \mu - P_d$.

When $V - tx - P_r = V - \mu - P_d$, it is of equal utility for the consumer to purchase through the retail channel and the direct sales channel. At this time, $x = x_d = (\mu + P_d - P_r)/t$, and it is also the indifferent point of consumption for the emerging consumer.

As the traditional retailer has a fixed number of conservative consumers, he is bound to be in a leading position in the price competition in the market. The emerging consumer's behavior is determined by $\max[V - tx - P_r, V - \mu - P_d]$. To ensure the competitive advantage of the existence of the direct sales channel, at least $V - tx_{\max} - P_r < V - \mu - P_d$ needs to be satisfied, that is, $tx_{\max} \geq \mu$, that is, $2\mu \leq t$.

The value of α will affect the proportion of conservative consumers and emerging consumers. At different intervals, due to the different points of intersection between the straight line passing through the indifferent consumption point through different channels and the straight line $y = 1 - \alpha x$, several cases will occur in the segmentation of the consumer market. When $\alpha \geq 2$, we discuss different values of μ and t below.

We consider the optimal price response strategies adopted correspondingly by the traditional retailer and direct distributor when they know the prices given by each other. When the direct distributor gives the expected price P_d, the traditional retailer's price P_r is expressed as a function of P_d, namely, $P_r = f(P_d)$, and the corresponding profit function is $\pi_1 = f_1(P_r, P_d{}^*)$. Similarly, when the traditional retailer gives the expected price P_r, the distributor's price P_d is expressed as a function of P_r, that is, $Pd = g(P_r)$, and the corresponding profit function is $\pi_2 = g_1(P_d, P_r{}^*)$. Given that the profit function depends on the location of the intersection between x_d and $y = 1 - \alpha x$, two cases need to be discussed further.

4.1. The Traditional Retailer's Optimal Response Strategy When the Direct Distributor's Expected Price P_d Is Given. (1) When $x_d \geq 1/\alpha$, the numbers of consumers purchasing via traditional channel and emerging consumers purchasing via direct sales channel are determined only by the value of x_d and have nothing to do with α. The consumer groups purchasing via the retail channel and the direct sales channel are shown in Figure 2. At this time, $x_d = (\mu + P_d - P_r)/t \geq 1/\alpha$; then, we derive that P_r meets the condition $P_r \leq \mu + P_d - t/\alpha$. The number of consumers purchasing via retail channel is $D_r = 2x_d$. The retailer's profit function is $\pi_1 = 2P_r \cdot x_d = 2P_r \cdot (\mu + P_d - P_r)/t$.

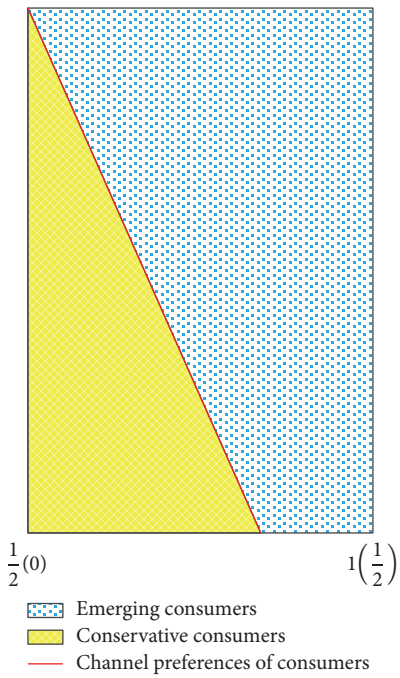

Figure 2: The distribution of consumers under two channels when $x_d \geq 1/\alpha$.

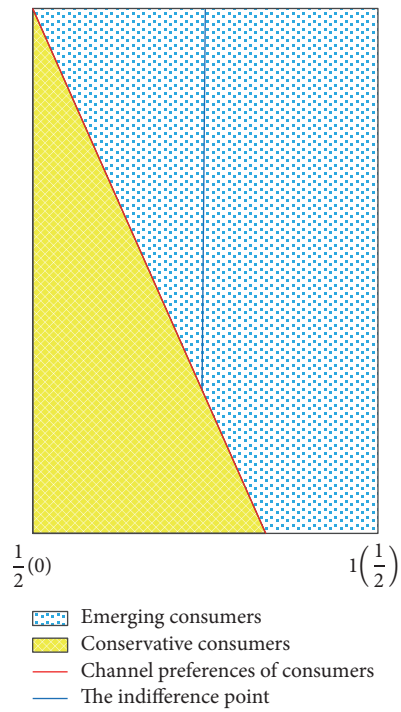

Figure 3: The distribution of consumers under two channels when $x_d < 1/\alpha$.

(2) When $x_d < 1/\alpha$, the numbers of consumers purchasing via traditional channel and emerging consumers purchasing via direct sales channel are determined not only by the value of x_d but also by the value of α. The consumer groups purchasing via the retail channel and the direct sales channel are shown in Figure 3. At this time, $x_d = (\mu+P_d-P_r)/t < 1/\alpha$; that is, P_r meets the condition $P_r > \mu+P_d-t/\alpha$. The number of consumers purchasing via retail channel is $D_r = \alpha \cdot x_d^2 + 1/\alpha$. The retailer's profit function is $\pi_1 = (\alpha x_d^2 + 1/\alpha) \cdot P_r = P_r/\alpha + \alpha \cdot (((\mu + P_d - P_r)^2 \cdot P_r)/t^2)$.

Both findings represented in Figures 2 and 3 suggest that the consumer's indifferent point x_d directly influences the consumer's choice between the traditional channel and the direct selling channel. However, the conservative consumers' channel preference is not affected by their sensitivity to distance at some situations. At this time, opening more shops close to the conservative consumers is not effective, and the efficient strategies might be improving the shopping conditions or providing more services to enhance consumers' shopping experience.

In summary, the traditional retailer's profit function is

$$\pi_1 = \begin{cases} 2P_r \cdot \dfrac{\mu + P_d - P_r}{t} & P_r \leq \mu + P_d - \dfrac{t}{\alpha} \\ 2P_r \cdot \left(\dfrac{1}{2\alpha} + \dfrac{\alpha}{2} \cdot x_d^2\right) & P_r > \mu + P_d - \dfrac{t}{\alpha}. \end{cases} \quad (1)$$

When $P_d = 0.8$, $\alpha = 3$, $\mu = 1$, and $t = 3$, the traditional retailer's profit function is shown in Figure 4.

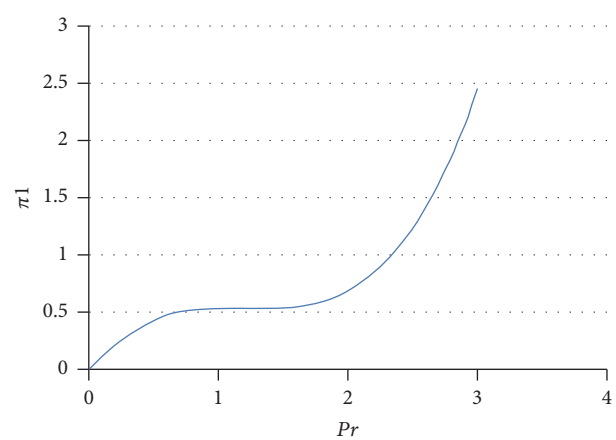

Figure 4: The traditional retailer's profit function when P_d is given.

Conclusion 1. Under the condition of $1/\alpha \leq 1/2$ and with the expected price P_d given by the direct distributor, when $(\mu + P_d)/2t \geq 1/\alpha$, the traditional retailer's optimal response strategy is $(\mu + P_d)/2$ or $P_{\max}$; when $(\mu + P_d)/2t < 1/\alpha$, the optimal response strategy is ${P_{r2}}^*$ or $P_{\max}$.

(a) When $P_r \leq \mu + P_d - t/\alpha$, $\pi_1 = 2P_r \cdot (\mu + P_d - P_r)/t$.

We differentiate π_1 with respect to P_r and obtain the maximum ${P_{r1}}^* = (\mu + P_d)/2$.

When the given parameters satisfy $(\mu+P_d)/2t \geq 1/\alpha$, then $\pi_{11_{\max}} = f((\mu + P_d)/2) = (\mu + P_d)^2/2t$.

When the given parameters satisfy $(\mu + P_d)/2t < 1/\alpha$, the local maximum of the traditional retailer's profit function is at the point of $P_r = \mu + P_d - t/\alpha$ and $\pi_{12_{\max}} = f(\mu + P_d - t/\alpha)$.

(b) When $P_r > \mu+P_d-t/\alpha$, then $\pi_1 = 2P_r \cdot (1/2\alpha+\alpha/2 \cdot x_d^2)$.

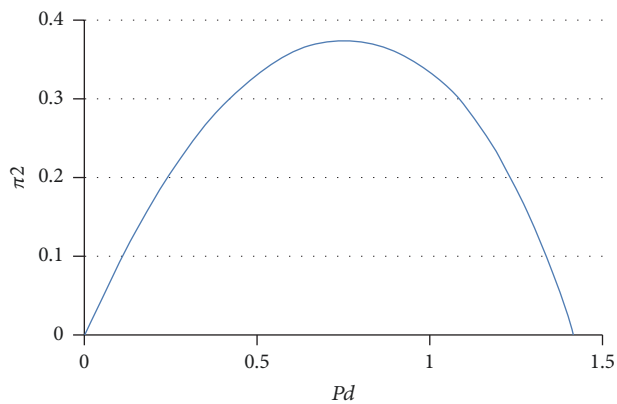

Figure 5: The direct distributor's profit function when P_r is given.

We differentiate π_1 with respect to P_r and obtain the maximum of the function at the point of $P_{r2}{}^* = (2(\mu + P_d) - \sqrt{(\mu + P_d)^2 - 3(t^2/\alpha^2)})/3$.

When the given parameters satisfy $(\mu + P_d)/2t \geq 1/\alpha$, we can derive $P_{r2}{}^* \leq \mu + P_d - t/\alpha$ which is in contradiction to $P_r > \mu + P_d - t/\alpha$, and at this time, the retailer's profit function cannot reach the maximum at the point of $P_{r2}{}^*$. The global maximum is at the endpoint of $P_{r1}{}^* = \mu + P_d - t/\alpha$. When the given parameters satisfy $(\mu + P_d)/2t < 1/\alpha$, we derive $P_{r2}{}^* > \mu + P_d - t/\alpha$, and the local maximum is at the point of $P_{r2}{}^*$ or $P_r \to P_{\max}$.

4.2. The Direct Distributor's Optimal Response Strategy When the Traditional Retailer's Expected Price P_r Is Given. (1) When $x_d \geq 1/\alpha$, $P_d \geq P_r - \mu + t/\alpha$.

The number of consumers purchasing via direct channel is $D_d = 1 - 2x_d$.

The direct distributor's profit function is $\pi_2 = (1/2 - x_d) \cdot 2P_d = 2(1/2 - (\mu + P_d - P_r)/t) \cdot P_d$.

(2) When $x_d \leq 1/\alpha$, P_d satisfies $P_d < P_r - \mu + t/\alpha$.

The number of consumers purchasing via direct channel is $D_d = 1 - 1/\alpha - \alpha \cdot x_d^2$.

The direct distributor's profit function is $\pi_2 = (1 - 1/\alpha - \alpha x_d^2) \cdot P_d = [1 - 1/\alpha - \alpha((\mu + P_d - P_r)/t)^2] \cdot P_d$.

In summary, according to the assumption, when $1/\alpha \leq 1/2$, the direct distributor's profit function can be expressed as

$$\pi_2 = \begin{cases} 2P_d \cdot \left(\dfrac{1}{2} - \dfrac{\mu + P_d - P_r}{t}\right) & P_d \geq P_r - \mu + \dfrac{t}{\alpha} \\ P_d \cdot \left(1 - \dfrac{1}{\alpha} - \alpha {x_d}^2\right) & P_d < P_r - \mu + \dfrac{t}{\alpha}. \end{cases} \quad (2)$$

When $P_r = 1$, $\alpha = 3$, $\mu = 1$, and $t = 3$, the direct distributor's profit function is shown in Figure 5.

Conclusion 2. Under the condition of $1/\alpha \leq 1/2$ and with the expected price P_r given by the traditional retailer, when $1/4 + (\mu - P_r)/2t \geq 1/\alpha$, the direct distributor's optimal price response strategy is $(t - 2(\mu - P_r))/4$; when $1/4 + (\mu - P_r)/2t < 1/\alpha$, the optimal price response strategy is $P_{d2}{}^* = (-2(\mu - P_r) + \sqrt{(\mu - P_r)^2 - (3t^2/\alpha^2)(1 - \alpha)})/3$.

(a) When $P_d \geq P_r - \mu + t/\alpha$, then $\pi_2 = 2P_d \cdot (1/2 - (\mu + P_d - P_r)/t)$.

We differentiate π_2 with respect to P_d and obtain the maximum $P_{d1}{}^* = (t - 2(\mu - P_r))/4$.

In other words, when the given parameters satisfy $1/4 + (\mu - P_r)/2t \geq 1/\alpha$, then $\pi_{21_{\max}} = f((t - 2(\mu - P_r))/4) = (1 - (t + 2\mu - 2P_r)/2t) \cdot (t + 2P_r - 2\mu)/4$; when the given parameters satisfy $1/4 + (\mu - P_r)/2t < 1/\alpha$, the local maximum is at the point of $P_d = P_r - \mu + t/\alpha$ and $\pi_{22_{\max}} = f(P_r - \mu + t/\alpha)$.

(b) When $P_d < P_r - \mu + t/\alpha$, then $\pi_2 = P_d \cdot (1 - 1/\alpha - \alpha {x_d}^2)$.

We differentiate π_2 with respect to P_d and obtain the function maximum $P_{d2}{}^* = (-2(\mu - P_r) + \sqrt{(\mu - P_r)^2 - (3t^2/\alpha^2)(1 - \alpha)})/3$.

When the given parameters satisfy $1/4 + (\mu - P_r)/2t \geq 1/\alpha$, then $-2(\mu - P_r) + \sqrt{(\mu - P_r)^2 - (3t^2/\alpha^2)(1 - \alpha)} \geq 0$, and thus we derive $P_{d2}{}^* > P_r - \mu + t/\alpha$. Since the maximum of the retailer's profit function cannot be $P_{d2}{}^*$ when $P_d < P_r - \mu + t/\alpha$, the global maximum is at the endpoint of $P_d = P_r - \mu + t/\alpha$ (the other endpoint is 0; when $P_d \to 0$, $\pi_2 \to 0$), and $\pi''_{2_{\max}} = f(P_r - \mu + t/\alpha)$.

When the given parameters satisfy $1/4 + (\mu - P_r)/2t < 1/\alpha$, we derive $P_{d2}{}^* > P_r - \mu + t/\alpha$, and the global maximum is at the point of $P_{d2}{}^*$, and $\pi''_{2_{\max}} = f((-2(\mu - P_r) + \sqrt{(\mu - P_r)^2 - (3t^2/\alpha^2)(1 - \alpha)})/3)$.

Conclusion 3. According to the Nash equilibrium existence theorem, in the strategic game of n persons, if each participant's pure strategy space S_i is a nonempty bounded convex set on Euclidean space and if the payment function $U_i(s_i)$ is continuous and quasiconcave with respect to s_i, then in this strategy group, there exists a pure strategy Nash equilibrium [19]. Given that the profit function of the traditional retailer is not strictly quasiconcave, a strict Nash equilibrium solution may not exist in the competition between the traditional retailer and the direct distributor. This finding highlights that the direct distributor and traditional retailer continuously compete without a clear strategy, and their decisions vary over time. In addition, it partly explains why the direct distributor, like Amway and Herbalife, changes their competing strategy and pricing decisions from time to time in different competing situations.

4.3. Summary and Analysis. We discuss the conditions below for the existence of the Nash equilibrium. Moreover, under the premise of the Nash equilibrium's existence between the traditional retailer and the direct distributor, we further discuss the impact of the corresponding parameters on the traditional retailer's and the direct distributor's formulations of pricing strategy, as shown in Table 1 .

We discuss the solutions in each case below.

Case 1 (if the constraints of $(\mu + P_d)/2t \geq 1/\alpha$ and $1/4 + (\mu - P_r)/2t \geq 1/\alpha$ are both satisfied). (1) When $0 < \mu/t \leq 1/2$ and $\mu/3t + 1/6 \geq 1/\alpha$ are both satisfied, there exists a Nash equilibrium, in which the optimal response strategies of the traditional retailer and the direct distributor are $P_r{}^* = (t + 2\mu)/6$ and $P_d{}^* = (t - \mu)/3$, respectively, and the corresponding

Table 1: The optimal pricing strategy which may arise between the traditional retailer and the direct distributor.

Cases	Constraints (P_d is given)	Constraints (P_r is given)	The optimal pricing strategy of $P_r{}^*$ (P_d is given)	The optimal pricing strategy of $P_d{}^*$ (P_r is given)
Case 1	$(\mu + P_d)/2t \geq 1/\alpha$	$1/4+(\mu-P_r)/2t \geq 1/\alpha$	$(\mu + P_d)/2$	$(t - 2(\mu - P_r))/4$
Case 2	$(\mu + P_d)/2t < 1/\alpha$	$1/4+(\mu-P_r)/2t \geq 1/\alpha$	$P_{r2}{}^*$ or $P_{\max}$	$(t - 2(\mu - P_r))/4$
Case 3	$(\mu + P_d)/2t \geq 1/\alpha$	$1/4+(\mu-P_r)/2t < 1/\alpha$	$(\mu + P_d)/2$	$P_{d2}{}^*$
Case 4	$(\mu + P_d)/2t < 1/\alpha$	$1/4+(\mu-P_r)/2t < 1/\alpha$	$P_{r2}{}^*$ or $P_{\max}$	$P_{d2}{}^*$

maximum profits are thus $\pi_{r\max} = (2/t)(t/6 + \mu/3)^2$ and $\pi_{d\max} = 2(t/9 - 2\mu/9 + \mu^2/9t)$, respectively (proof omitted).

(2) When $\mu/t > 1/2$ is satisfied, it will be in contradiction to the model's initial hypothesis $\mu/t \leq 1/2$, which means that the frictional cost exceeds transport cost and the Internet sales channel almost completely loses its advantage in competition. Therefore, there is no point to further discuss $\mu/t > 1/2$.

Property 4. When both $\mu \leq t/2$ and $\mu/3t + 1/6 > 1/\alpha$ are satisfied and when the conservative consumer's sensitivity to consumer distance and friction cost remain constant, with the increase of transportation cost, the market share of the traditional retailer decreases, whereas the direct distributor increases. To maintain high profits, the retailer must increase prices, and so does the direct distributor; consequently, the profits of both the retailer and direct distributor will rise.

Property 5. When both $\mu \leq t/2$ and $\mu/3t + 1/6 > 1/\alpha$ are satisfied and when the conservative consumer's sensitivity to consumer distance and transportation cost remain constant, with the increase of friction cost, the market share of the direct distributor decreases, whereas the traditional retailer's increases. To maintain high profits, the direct distributor must lower prices, while the traditional retailer will raise prices because of its advantage in the market share. Consequently, the profits of the retailer will rise, and the direct distributor's will decline.

Property 6. When both $\mu \leq t/2$ and $\mu/3t + 1/6 > 1/\alpha$ are satisfied, only the changes of the conservative consumer's sensitivity to consumer distance will not have direct influences on the prices of the retailer and the direct distributor.

Case 2 (when the constraints of both $(\mu + P_d)/2t < 1/\alpha$ and $1/4 + (\mu - P_r)/2t \geq 1/\alpha$ are satisfied). This means the contradictory constraints of $P_r \geq P_d - \mu + t/\alpha$ and $P_d \geq P_r + \mu - t/\alpha$ must be satisfied at the same time. Therefore, there are no solutions for Case 2.

Case 3 (when the constraints of both $(\mu + P_d)/2t \geq 1/\alpha$ and $1/4 + (\mu - P_r)/2t < 1/\alpha$ are satisfied). This means the contradictory constraints of $P_r \geq P_d - \mu + t/\alpha$ and $P_d \geq P_r + \mu - t/\alpha$ must be satisfied at the same time. Therefore, there are no solutions for this case either.

Case 4 (if the constraints of both $(\mu + P_d)/2t < 1/\alpha$ and $1/4 + (\mu - P_r)/2t < 1/\alpha$ are satisfied). When the traditional retailer continually increases the retail prices, the profits will keep going up. Apparently, in this case, a strict Nash equilibrium does not exist. The reason for this situation is the existence of a proportion of conservative consumers in the market, who put the retailer in a dominant position in the price competition. Meanwhile, the direct distributor finds that if the price keeps increasing continually, the profits will raise, which results in extra burden for consumers. Obviously, this happens due to lack of market regulation.

To enhance the regulation of the selling price per unit as well as protect new direct sales channel, the market now introduces the constraint $P_r \leq 2(\mu + Pd)/3$ to limit the traditional retailer's prices to some extent. Thus, the traditional retailer's selling prices cannot reach $P_{\max}$. It can be proven that the traditional retailer's profit function is strictly quasiconcave after the introduction of the constraint $P_r \leq 2(\mu + Pd)/3$.

At this time, the optimal response strategies of the traditional retailer and the distributor are $P_r{}^* = P_{r2}{}^* = (2(\mu + P_d) - \sqrt{(\mu + P_d)^2 - 3(t^2/\alpha^2)})/3$ and $P_d{}^* = P_{d2}{}^* = (-2(\mu - P_r) + \sqrt{(\mu - P_r)^2 - (3t^2/\alpha^2)(1-\alpha)})/3$, respectively. Given that, in Case 1, the optimal solution can be obtained if the constraint of $2\mu + t \geq 6t/\alpha$ is satisfied, then in Case 4, at least the constraints of $\mu/t \leq 1/2$ and $2\mu + t \leq 6t/\alpha$ need to be satisfied, then we obtain $P_r{}^* = (-6\alpha^2\mu + \alpha^3\mu + M)/8(\alpha^3 - 2\alpha^2)$ and $P_d{}^* = (1/3)(-2\mu - 3\alpha^2\mu/2(-2\alpha^2 + \alpha^3) + \alpha^3\mu/4(-2\alpha^2 + \alpha^3) + M/4(-2\alpha^2 + \alpha^3) + \sqrt{N}$, where $M = \sqrt{-32t^2\alpha^2 - 16t^2\alpha^3 + 8t^2\alpha^4 + 4t^2\alpha^5 + 4\alpha^4\mu^2 + 4\alpha^5\mu^2 + \alpha^6\mu^2}$ and $N = (1/\alpha^2)(-3t^2 + 3t^2\alpha + \alpha^2\mu^2 - \alpha^2\mu(-6\alpha^2\mu + \alpha^3\mu + M)/4(-2\alpha^2 + \alpha^3) + \alpha^2(-6\alpha^2\mu + \alpha^3\mu + M)^2/64(-2\alpha^2 + \alpha^3)^2)$, and the corresponding maximum profits are

$$\pi_{r\max} = \frac{-6\alpha^2\mu + \alpha^3\mu + M}{4(-2\alpha^2 + \alpha^3)}\left(\frac{1}{2\alpha} + \frac{1}{2t^2\alpha}\left(\mu - \frac{-6\alpha^2\mu + \alpha^3\mu + M}{8(-2\alpha^2 + \alpha^3)} + \frac{1}{3}\left(-2\mu - \frac{3\alpha^2\mu}{2(-2\alpha^2 + \alpha^3)} + \frac{\alpha^3\mu + M}{4(-2\alpha^2 + \alpha^3)}\right.\right.\right.$$

$$+\sqrt{\frac{1}{\alpha^2}\left(-3t^2+3t^2\alpha+\alpha^2\mu^2-\frac{\alpha^2\mu\left(-6\alpha^2\mu+\alpha^3\mu+M\right)}{4\left(-2\alpha^2+\alpha^3\right)}+\frac{\alpha^2\left(-6\alpha^2\mu+\alpha^3\mu+M\right)^2}{64\left(-2\alpha^2+\alpha^3\right)^2}\right)}\Bigg)\Bigg)^2\Bigg),$$

$$\pi_{d\max}=\frac{1}{3}\Bigg(-2\mu-\frac{3\alpha^2\mu}{2\left(-2\alpha^2+\alpha^3\right)}+\frac{\alpha^3\mu+M}{4\left(-2\alpha^2+\alpha^3\right)}$$

$$+\sqrt{\frac{1}{\alpha^2}\left(-3t^2+3t^2\alpha+\alpha^2\mu^2-\frac{\alpha^2\mu\left(-6\alpha^2\mu+\alpha^3\mu+M\right)}{4\left(-2\alpha^2+\alpha^3\right)}+\frac{\alpha^2\left(-6\alpha^2\mu+\alpha^3\mu+M\right)^2}{64\left(-2\alpha^2+\alpha^3\right)^2}\right)}\Bigg)\cdot\Bigg(1-\frac{1}{\alpha}-\frac{1}{t^2}\alpha\Bigg(\mu$$

$$-\frac{-6\alpha^2\mu+\alpha^3\mu+M}{8\left(-2\alpha^2+\alpha^3\right)}+\frac{1}{3}\Bigg(-2\mu-\frac{3\alpha^2\mu}{2\left(-2\alpha^2+\alpha^3\right)}+\frac{\alpha^3\mu+M}{4\left(-2\alpha^2+\alpha^3\right)}$$

$$+\sqrt{\frac{1}{\alpha^2}\left(-3t^2+3t^2\alpha+\alpha^2\mu^2-\frac{\alpha^2\mu\left(-6\alpha^2\mu+\alpha^3\mu+M\right)}{4\left(-2\alpha^2+\alpha^3\right)}+\frac{\alpha^2\left(-6\alpha^2\mu+\alpha^3\mu+M\right)^2}{64\left(-2\alpha^2+\alpha^3\right)^2}\right)}\Bigg)\Bigg)^2\Bigg).\tag{3}$$

Property 7. When both $\mu/t \le 1/2$ and $2\mu + t \le 6t/\alpha$ are satisfied and the transportation cost and friction cost remain constant, with the decrease of the conservative consumer's sensitivity to distance, the number of the traditional consumers increases, and the market share of the traditional retailer thus increases; then, the market share of the direct distributor decreases. The direct distributor has to lower prices to maintain a stable proportion of consumers. Yet the traditional retailer's profits increase with the increase of the number of conservative consumers. Therefore in the equilibrium strategy, the traditional retailer will raise prices correspondingly.

Property 8. When both $\mu/t \le 1/2$ and $2\mu + t \le 6t/\alpha$ are satisfied and the proportion of consumers and friction cost remain constant, with the increase of the transportation cost, the market share of the direct distributor increases, yet the market share of the traditional retailer decreases. The equilibrium prices of the retailer and the direct distributor will rise.

Property 9. When both $\mu/t \le 1/2$ and $2\mu + t \le 6t/\alpha$ are satisfied and when the proportion of consumers and transportation cost remain constant, with the increase of friction cost, the market share of the direct distributor decreases, whereas the traditional retailer's increases. The equilibrium prices of the retailer and the direct distributor will decrease.

In summary, the retailer's and direct distributor's pricing decisions vary from time to time based on different situations (Table 1) and it is extremely worthwhile for both parties to timely adjust their selling prices by identifying and analyzing the competing circumstance. This explains why lots of market consulting companies are in bad need to dig out the consumers' preference and market competing circumstance.

5. Conclusion

Based on the traditional Hotelling model, we explore the price game strategy between the traditional retailer and the direct distributor by introducing the concept of conservative consumers. This study finds that, in the unconstrained market environment, the conservative consumer puts the traditional retailer in an advantageous position to a certain degree in the price competition against the direct distributor. With the decrease of the conservative consumer's sensitivity to distance, the traditional retailer is more inclined to continuously raise prices to gain more profits, which might result in the failure to reach a Nash equilibrium in the two sides' price game.

In the case of enhancing market constraints, we can see that the changes in transportation cost and friction cost will impact the price game between the two sides, and both sides will adopt the same coping strategy to adjust prices to gain equilibrium.

A future research of this paper is to consider the Nash equilibrium strategy adopted by the traditional retailer and the direct distributor when the conservative consumer's sensitivity to distance increases exponentially as the distance increases and also to consider how the Nash equilibrium will change when the distributor and the retailer are subject to the regulation of the same manufacturer.

Disclosure

Xiao Fu also works in the Research Center of Information Technology & Economic and Social Development.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This work was supported in part by Zhejiang Provincial Natural Science Foundation (no. LQ18G010003), Zhejiang Provincial Philosophy and Social Science Program (no. 18NDJC043YB), Scientific Research Starting Foundation of Hangzhou Dianzi University (no. KYS395617020), National Natural Science Foundation of China (nos. 71501128 and 71632008), and Shandong Natural Science Foundation (ZR2015GM001). The authors are also very grateful to Baoxin Gao for his valuable suggestions and efforts.

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