Research Article

Dynamic Pricing for Dual-Channel Supply Chain considering Consumers with Double-Entry Mental Accounting

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Based on double-entry mental accounting theory, we explore the effects of different payment schemes in the regular selling period and the sales period of two channels on the firm’s profits. Studies in psychology and behavioral sciences show that strategic consumers have a significant impact on firms’ profits. In this paper, dynamic pricing problems are considered to analyse the effects of strategic consumer double-entry mental accounting on firms’ profits. We first analyse the perceived values of consumers under different payment schemes in the regular selling period and the sales period from two channels. Based on this, we derive the optimal price and optimal profit. The results show that double-entry mental accounting of consumers has a greater impact on the retailer than on the manufacturer. To solve the loss caused by strategic consumers, it is recommended that the retailer lowers the price to stabilize the profit. The postpayment scheme is preferred by the manufacturer, but the high coefficient of pleasure attenuation would hurt the manufacturer. The general payment scheme is preferred by the retailer, but the high coefficient of pain buffering would hurt the retailer.

1. Introduction

Dynamic pricing is a strategy that sells the same product to different consumers or different market segments at different prices based on market demand and supply capacity to maximize revenue, which has been a notable success in many retailing industries. However, due to the different prices for the same product, some consumers have noticed this phenomenon and responded accordingly. Consumers today have largely been trained to wait for sales, which is a general consensus and widely accepted by practitioners and academics. They will strategically “wait-and-see,” waiting for the opportunity to buy in the trend of expected lower prices. Besanko and Winston [1] found that if the strategic behavior of consumers was not taken into account, the firm’s earnings could fall by 50%.

At the end of December 2015, 32.6% of Chinese enterprises had carried out online sales business, and to significantly improve the firms’ revenue, research on dual-channel dynamic pricing has become increasingly urgent. Consumers can strategically choose to purchase from the manufacturer’s direct e-channel or from the retailer. In addition, different kinds of payment are available, for example, cash, debit card, credit card, or other overdraft payments. This would lead to the separation of pay and consumption due to the shipping time or the billing time. Prelec and Loewenstein [2] introduced a double-entry mental accounting theory proposing two coupling coefficients, the pleasure of consumption and the pain of payment, in which one set of entries recorded the “net” utility derived from consumption after subtracting the disutility of associated payments and the other set recorded the “net” disutility of payments after subtracting the utility of associated consumption. The utility is an economic term that refers to the satisfaction received from consuming a good or service. Based on this, the utility of the consumer would be adjusted to the perceived utility due to the separation of paying and consuming derived from different payments. Although the importance of strategic consumer behavior is widely acknowledged, there has been little research studying double-entry mental accounting in supply chain management. In view of this gap in the literature, this paper has three main
objectives. First, we would like to develop a modelling framework to study the double-entry mental accounting of the strategic consumer in supply chains. Second, our objective is to use this model to investigate the impact of double-entry mental accounting on supply chain performance. The third objective is prescriptive: when consumers are strategic with double-entry mental accounting, how can we better manage the dual-channel supply chain?

Our model is based on the two-period dual-channel supply chain. In the regular selling period, consumers could purchase goods from the retailer in the store or from the manufacturer online, but in the sales period, only the manufacturer provides the goods. When overdraft payment is not allowed, consumers pay with cash or a debit card. In other words, paying and consuming are happening at the same time when consumers purchase from the store, and paying precedes consuming when consumers purchase online due to the shipping time. This is called general payment. Specifically speaking, the former is called pay per use, and the latter is called prepay. When overdraft payment is allowed only online, consumers can pay by credit card or other overdraft methods online. In other words, consumption precedes paying when consumers purchase online due to the billing time. This is called postpayment online or postpay. Then, we derive the optimal price under different payment schemes and verify through numerical analysis. The results show that the general payment scheme is preferred by the retailer, but the high coefficient of pain buffering would hurt the retailer. The postpayment scheme is preferred by the manufacturer, but the high coefficient of pleasure attenuation would hurt the manufacturer.

The subsequent materials of this study are organized in this way: Section 2 provides the related work. Section 3 introduces the basic dynamic pricing model for the dual-channel supply chain. Then, the model is extended by involving double-entry mental accounting in Section 4. Section 5 derives the optimal decisions. Numerical studies are performed to test how strategic consumers and double-entry mental accounting influence the profits of retailers and manufacturers in Section 6. This work is summarized in Section 7.

2. Related Work

This section is dedicated to reviewing the previous work that is closely related to the present paper. First, we mention dynamic pricing for the dual-channel supply chain. Second, we discuss strategic consumer behavior.

2.1. Dynamic Pricing. Many articles have studied the pricing strategy of retailers. Zhang and Wang [3] investigated two dynamic pricing strategies in a dual-channel supply chain and analyzed the evolution of the system under the long-term price forecasting mechanism. Chen et al. [4] devoted to designing an effective dynamic discount pricing strategy and their results were confirmed to be positively correlated with marketing profit. Zhang and Zhu [5] established a game model with a dual-channel recycling structure and used dynamic theory to analyse dynamic price decisions and services. Some scholars also studied the strategy of dynamic pricing in different environments [6, 7] and different consumers [8, 9]. Chen and Chang [10] dealt with the management of two differentiated versions of the same product using dynamic programming schemes in a closed-loop supply chain. The results showed that the proposed pricing strategy is an effective mechanism to get a greater profit stream during the product lifecycle. Bao et al. [11] studied the short-term and long-term repeated game behaviors of two parallel supply chains involving duopoly vehicle manufacturers producing BEVs and fuel vehicles, taking consumers’ low-carbon preference and government subsidy scheme into account. Alquthami et al. [12] studied the strategy of price-based demand response and considered the real-time electricity pricing policy to calculate incentives in terms of reduced cost. Shao [13] developed a two-period dynamic game framework to explore optimal pricing and upgrade channel choice when the supplier introduces new upgraded products to a market populated by strategic consumers. Nasiry and Popescu [14] studied dynamic pricing based on peak-end memory mode and found that consistent pricing policies are optimal for the corresponding dynamic pricing problem. They suggested that behavioral regularities limit the benefits of varying prices. Ma and Xie [15] developed dynamic game models under different channel power structures and uncertain demand in the dual-channel supply chain. Xie et al. [16] investigated the buyback contract for the supply chain where the buyer faces uncertain yield and demand. Ma et al. [17] discussed how the electric vehicle and the fuel vehicle competed in the performance of the product in the delayed pricing decision under the strategic consumer. Pricing strategies for seasonal products and energy were studied by Jia and Tong [18]. Yao and Liu [19] considered the price competition between retail and e-retail distribution channels and proved the existence of an optimal wholesale price that could encourage the retailer to accommodate the additional e-retail channel. This article offers a new perspective on the study of pricing for the dual-channel supply chain under different payment schemes.

2.2. Strategic Consumer Behavior. The strategic consumer is a universal phenomenon in the market. They forecast the future price before making a purchase decision, and this phenomenon will lead to a great difference from the results of traditional research. Strategic consumer behavior has recently been studied by operations management researchers. Kermer et al. [20] surveyed the developments in the literature and reviewed possible operational strategies to counteract the adverse impact of strategic consumer behavior. Pricing strategies considering strategic consumers have been widely documented in the literature, for example, Kremer et al. [20], Dong et al. [21], Chen et al. [22], and Su [23]. Quan et al. [24] further investigated the conditions for the effectiveness of quantity commitment strategy with strategic customers with disappointment aversion. Jacobson and Obermiller [25] thought a consumer’s expectation of the future price of a brand plays a crucial role in the decision to
buy now or later and conducted research on this. Wang et al. [26] studied the pricing strategies of a seller with budget constraints facing two types of strategic consumers and proposed pricing strategies to motivate consumers to visit shop. Ye and Sun [27] derived the optimal decisions of the newsvendor assuming that all consumers are strategic according to the newsvendor model. Farshbaf-Geramanyeh and Zaccour [28] developed a multiperiod model to investigate pricing and advertising decisions in a supply chain, in the presence of myopic and strategic consumers. Zhen et al. [29] established a Stackelberg game model in which a manufacturer produces and sells products through direct online channels and a retailer sells directly to consumers through online and offline channels. The manufacturer’s concern about fairness and the retailer’s concern about fairness are considered. Coase [30] argued that price commitment policies in the presence of strategic customers are an effective way to exercise market power. How to set an optimal price considering strategic consumers is also studied by Mersereau and Zhang [31] and Papanastasiou and Savva [32]. Ma et al. [33] studied an electric vehicle supply chain system focusing on a pricing model considering strategic customers.

Some studies have been conducted on double-entry mental accounting for strategic consumers. A mental accounting theory was proposed by Thaler [34], which examines the psychological cognitive processes of the individual in making purchase decisions. An individual is considered a pleasure machine, with gains that yield pleasure and losses that yield pain. It has attracted the attention of behavioral decision-making researchers, and in recent years, researchers have introduced mental accounting theory into operational management. Heilman et al. [35] found that consumers in the hesitation stage of searching products would form an income illusion after obtaining coupons, resulting in unplanned purchases due to the existence of psychological accounts. Erat and Bhaskaran [36] focused on a consumer’s mental account of the base product and its role in her additional purchase decisions. Chen et al. [37] investigated how the payment scheme influences inventory decisions in the newsvendor problem with retailers’ mental accounting. Li et al. [38] further developed the concept of double-entry mental accounting theory based on Prelec and Loewenstein [2]. Specifically, we use $\alpha$ and $\beta$ to calculate the effect of this mental accounting on consumers’ decisions, a more specific explanation can be found in the studies by Quan et al. [39], Li and Ling [40], Swachalech and Solarz [41], and Fels [42]. In addition, some scholars studied the effects and application of double-entry mental accounting. Xiao and O’Neill [43] examined characteristics of budgeting behavior from the perspective of mental accounting. Li et al. [44] explored the impact of double-entry mental accounting on resident willingness to pay for green housing to reduce building energy consumption. Wang et al. [45] proved that the utility of tasks obtained in different ways is not fungible and people’s preferences of behavior are inconsistent based on mental accounting theory. With the presence of strategic consumers, consumer behavior will show great uncertainty. In our paper, we divide consumers into two types, namely, strategic consumers and myopic consumers, and introduce mental accounting to signify this uncertainty. Hu et al. [46] investigated dynamic pricing problems for single-flight and multiple-flight settings, respectively, where passengers may be affected by mental accounting. Li et al. [47] established two period models to study discount pricing strategies of a platform with strategic consumers and examined how the percentage of strategic consumers and the degree of consumer penitence interact with the choice of platform strategy. Thaler [48] summarized the current state of mental accounting activities and showed that mental accounting influences consumer choice. Credit card payment is a typical payment after consumption, which will reduce the payment pain of consumers [49]. Rietveld [50] found that late payment would cause certain negative reactions. Consumers pain before payment is low, but they will feel a greater sense of loss when they really need to pay, which can reduce the perception of utility and the utilization rate of previously consumed products.

Our study follows those trends, but from a different perspective. As an important part of strategic consumer behavior, double-entry mental accounting is mainly studied in the areas of consumer behavior, psychology, and marketing. However, it also plays an important role in supply chain management. To make results more practical, our paper introduces double-entry mental accounting into the supply chain for further research. The perceived value and perceived price of the customers are influenced by the double-entry mental accounting. We formulate the perceived utility under two payment schemes based on customers’ happiness of future consumption and the pain of payment. The time discount factor is also depicted due to the gap between consumption and pay. Based on the above, we try to help the manufacturer and retailer make the optimal pricing decisions and to optimize their profit. Our work contributes to the literature on behavioral operation management for pricing in dual-channel supply chain management. This paper models double-entry mental accounting in an operational context and provides prescriptive information for firm pricing decisions. Double-entry mental accounting has been used to explain market behavior. In a similar spirit, we use this model, in dynamic pricing for a dual-channel supply chain, to derive optimal pricing for both retailers and manufacturers responding to double-entry mental accounting markets.

### 3. Dual-Channel Dynamic Pricing Model

The dual-channel supply chain studied in this paper is shown in Figure 1. We assume that there are only one manufacturer and one retailer. The product cost is $c$ for the manufacturer. In the regular selling period, the manufacturer sells the products to the retailer at the wholesale price $w$ and the retailer sells the products at price $p_1$ or the manufacturer sells the products directly to the consumers directly online at price $p_2$.

In the sales period, only the manufacturer sells the product at the sales price $p_2$. The residual value of the
remaining products is zero at the end. The total number of consumers is $N$. For consumers, offline purchases can obtain products immediately, while online purchases must wait for product shipping.

The main assumptions of this model are as follows.

(a) Manufacturer’s products are sold in the regular selling period and sales period at the price of $p_1$ and $p_2$, respectively. The retailer only sells during the regular selling period. Product cost is $c$.

(b) Only one product can be purchased per person, and everyone has their own product valuation for the product. Assume that the product valuations of all consumers are uniformly distributed on $[V_L, V_H]$.

(c) Consumers are divided into strategic consumers and myopic consumers, the proportion of strategic consumers is $\theta$, and they can purchase during both periods and through both channels. The proportion of myopic consumers is $(1 - \theta)$, and they only purchase from the retailer during the regular selling period.

(d) When consumers purchase online, there will be a time delay for actual consumption due to shipping time. On the basis of this, a time discount for product valuation should be considered. We use the parameter $r$ to represent the time discount rate for the product valuation. $t$ represents the time between the regular selling period and the sales period, $t_1$ indicates shipping time, that is, the waiting time for actual consumption during the regular selling period. $t_2$ indicates waiting time for actual consumption during the sales period, $t_2 = t + t_1, e^{-rt}$ indicates the time discount factor (Figure 2).

(e) Due to the risk of out-of-stock, assume that the probability that a strategic consumer will obtain a product during sales period is $q$, $0 < q < 1$.

(f) The following relationships exist between retailers, manufacturers, and consumers: $c \leq p_2 \leq w \leq p_1 \leq p_r$.

We shall adopt the following sequence of events, as shown in Figure 3. First, in the regular selling period, the manufacturer determines the cost, wholesale price $w$, and full price, and the retailer obtains the product from the manufacturer at the wholesale price $w$ and then sells it to the consumers at the retail price of $p_r$. Myopic consumers decide to buy or leave the market. When making the purchase decision, myopic consumers only consider two factors: their own perceived values $v$ and retailer’s price $p_r$. If perceived value $v \geq p_r$, they will buy, otherwise exit the market. Strategic consumers decide which channel to buy or wait for the sales period. They take a comprehensive look at the following six factors when making decisions: perceived value $v$, manufacturer’s regular selling price $p_1$, retailer’s regular selling price $p_r$, manufacturer’s sales price $p_2$, the time $t$ between regular selling period and the sales period, and the probability $q$ of obtaining the product during the sales period.

### 4. Dual-Channel Dynamic Pricing Model

#### 4.1. Perceived Utility Function with Double-Entry Mental Accounting

As mentioned before, there are two payment schemes: general payment and postpayment online.

Under general payment scheme, when purchasing from a manufacturer online, the actual consumption will occur after the consumers receives the shipping package. This indicates that payment is made earlier than consumption. Consumers will take into account the happiness of future consumption, and payment pain will be alleviated; the coefficient of pain buffering $\beta$ is used to indicate the degree of pain relief during payment, $0 \leq \beta \leq 1$.

Under the postpayment online scheme, when purchasing from a manufacturer online, the actual consumption will happen before the consumers pay the bill in the future. This indicates that consumption is earlier than payment. Consumers will take into account the pain caused by future payments, and happiness at the time of consumption will be weakened; the coefficient of pleasure attenuation $\alpha$ represents the degree to which happiness at the time of consumption is reduced, $0 \leq \alpha \leq 1$. The utility function is shown in Table 1.

#### 4.1.1. General Payment

Under the general payment scheme, payment and consumption occur at the same time when consumers purchase from a retailer instore; the perceived value and the perceived price are $v$ and $p_r$. When consumers purchase from a manufacturer online, there is a time delay due to shipping, so consumers pay first and then consume. When paying, consumers will consider the happiness derived from future consumption, and then, the pain of payment will be alleviated, so the consumer’s perceived price is $(1 - \beta)p_1$ during period one and $(1 - \beta)p_2$ during period two. Taking into account the time discount, consumers’ perceived values are $e^{-rt_1}v$ and $e^{-rt_2}v$ during periods one and two, respectively.

#### 4.1.2. Postpayment

In the postpayment scheme, consumers will consider the pain caused by future payment when purchasing, and then, the happiness of consumption will erode, so the perceived value of consumers is $(1 - \alpha)v$ in both periods. Considering the time discount for product valuation, consumers’ perceived price is $e^{-rt_1}p_1$ in period one and $e^{-rt_2}p_2$ in period two.

#### 4.2. Profits of Manufacturer and Retailer under Two Payment Schemes

We use $V_1$ to indicate the indifference curve between purchasing from the retailer in the regular selling period or the manufacturer in the sales period. $V_2$ indicates the indifference curve between the manufacturer’s regular selling period and the sales period. Strategic consumers will make decisions based on the following scenarios:

1. $v \geq V_1$, purchase from retailer in the regular selling period
(2) \( V_2 \leq v \leq V_1 \), purchase from manufacturer in the regular selling period

(3) \( v \leq V_2 \), wait for the sales period

In the sales period, consumers will determine whether to buy based on the sales price at that time and their own perceived values or leave.
When \((1 - \beta)p_1/e^{-\tau_1} \leq v \leq V_2\) or \(e^{-\tau_1}p_2/(1 - \alpha) \leq v \leq V_2\), customers will buy; otherwise, they exit the market.

### 4.2.1. Profits of Manufacturer and Retailer under General Payment

Based on Table 1, \(V_1\) and \(V_2\) can be calculated as follows:

\[
V_1 = \frac{p_r - (1 - \beta)p_1}{1 - e^{-\tau_1}},
\]
\[
V_2 = \frac{(1 - \beta)p_1 - q(1 - \beta)p_2}{e^{-\tau_1} - qe^{-\tau_2}}. \tag{1}
\]

The number of myopic consumers who purchase in the regular selling period from a retailer is \(1 - \theta N(V_1 - V_2)/(V_H - V_L)\), and the number of strategic consumers who purchase in the regular selling period from a retailer is \(\theta N(V_H - V_1)/V_H - V_1\). The number of strategic consumers who purchase in the regular selling period from the manufacturer is \(\theta(N - V_1 - V_2)/V_H - V_L\), and the number of strategic consumers who purchase in the sales period from the manufacturer is \(\theta N((V_2 - (1 - \beta/e^{-\tau_1})p_2)/(V_H - V_L)\).

Thus, we can get the retailer’s profit \(\pi_r\), the profit of the manufacturer in the regular selling period \(\pi_1\), and the manufacturer’s profit in the sales period \(\pi_2\):

\[
\pi_r = \frac{N}{V_H - V_L} (V_H - \theta V_1 - (1 - \theta)p_r)(p_r - w),
\]
\[
\pi_1 = \frac{N}{V_H - V_L} \left[ \theta(V_1 - V_2)(p_1 - c) + (V_H - \theta V_1 - (1 - \theta)p_r)(w - c) \right], \tag{2}
\]
\[
\pi_2 = \frac{N}{V_H - V_L} q\theta \left( V_2 - \frac{1 - \beta}{e^{-\tau_1}}p_2 \right)(p_2 - c).
\]

The total profit of the manufacturer can be calculated as follows:

\[
\pi_m = \pi_1 + \pi_2. \tag{3}
\]

### 4.2.2. Profits of Manufacturer and Retailer under Postpayment

Similarly, we can find the following:

\[
\pi_1^{\text{post}} = \left. p_r^{\text{post}} \right|_{t=1} - \left. e^{-\tau_1}p_1^{\text{post}} \right|_{t=1} \cdot \frac{\alpha}{1 - \alpha},
\]
\[
\pi_2^{\text{post}} = \left. e^{-\tau_1}p_1^{\text{post}} \right|_{t=2} - \left. qe^{-\tau_2}p_2^{\text{post}} \right|_{t=2} \cdot \frac{(1 - \alpha) - q(1 - \alpha)}{1 - \alpha}. \tag{4}
\]

The profit of a retailer is

\[
\pi_r^{\text{post}} = \frac{N}{V_H - V_L} (V_H - \theta V_1^{\text{post}} - (1 - \theta)p_r^{\text{post}})(p_r^{\text{post}} - w^{\text{post}}). \tag{5}
\]

The profit of the manufacturer in the regular selling period is

\[
\pi_1^{\text{post}} = \frac{N}{V_H - V_L} \left[ \theta(V_1^{\text{post}} - V_2^{\text{post}})(p_1^{\text{post}} - c) + (V_H - \theta V_1^{\text{post}} - (1 - \theta)p_r^{\text{post}})(w^{\text{post}} - c) \right]. \tag{6}
\]

The profit of the manufacturer in the sales period is

\[
\pi_2^{\text{post}} = \frac{q\theta N}{V_H - V_L} \left( V_2^{\text{post}} - \frac{1 - \beta}{e^{-\tau_1}}p_2^{\text{post}} \right)(p_2^{\text{post}} - 325c). \tag{7}
\]

The total profit of the manufacturer is

\[
\pi_m^{\text{post}} = \pi_1^{\text{post}} + \pi_2^{\text{post}}. \tag{8}
\]

### 5. Optimal Decisions

#### 5.1. Optimal Decisions under General Payment

In the general payment scheme, the manufacturer’s profit in the sales period is \(\pi_2\); to find the optimal sales price, let \((\partial \pi_2/\partial p_2) = 0\) and get

\[
p_2 = \frac{1}{2} \left( e^{-\tau_1}p_1 + c \right) \tag{9}
\]

To find the optimal regular price for retailer, let \((\partial \pi_r/\partial p_r) = 0\) and get

\[
p_r = \frac{1}{2} \left[ 1 - e^{-\tau_1}p_1 + \frac{\theta(1 - \beta)}{V_H + e^{-\tau_1}(\theta e^{-\tau_1}p_1 + w)} \right]. \tag{10}
\]

The total profit of the manufacturer is \(\pi_m = \pi_1 + \pi_2\).
To find the price at the optimal profit of manufacturer, let \((\partial \pi_m / \partial w) = 0\), \((\partial \pi_m / \partial p_m) = 0\) and get

\[
\begin{align*}
\pi_m &= \frac{N}{V_H - V_L} \left[ \left( \frac{p_m - (1 - \beta) p_1}{1 - e^{-r_H}} - \frac{1 - \beta}{e^{r_H} - q e^{-r_H}} \right) (p_1 - c) + \left( \frac{V_H - \theta}{\theta (1 - \beta)} \left( \frac{1 - \beta}{e^{r_H} - q e^{-r_H}} \right) (p_1 - c) \right) \right]
\end{align*}
\]

The total profit of the retailer is

\[
\pi_r = \frac{N}{V_H - V_L} \left( V_H - \theta \frac{p_r - (1 - \beta) p_1}{1 - e^{-r_H}} - (1 - \theta) p_r \right) (p_r - w).
\]

The total profit of the manufacturer is

\[
\begin{align*}
\pi_m &= \frac{N}{V_H - V_L} \left[ \left( \frac{p_m - (1 - \beta) p_1}{1 - e^{-r_H}} - \frac{1 - \beta}{e^{r_H} - q e^{-r_H}} \right) (p_1 - c) + \left( \frac{V_H - \theta}{\theta (1 - \beta)} \left( \frac{1 - \beta}{e^{r_H} - q e^{-r_H}} \right) (p_1 - c) \right) \right]
\end{align*}
\]

5.2. Optimal Decisions under Postpayment. Similarly, we can find the following results.

The optimal sales price for manufacturer \(p^{\text{post}}_2\) and retailer \(p^{\text{post}}_r\):

\[
\begin{align*}
p^{\text{post}}_2 &= \frac{1}{2} \left[ \frac{c}{\theta e^{-r_H}} + \frac{p^{\text{post}}_1}{e^{-r_H}} \right],
p^{\text{post}}_r &= \frac{1}{2} \left[ \frac{\alpha}{\alpha + \theta (1 - \alpha)} V_H + \frac{\theta e^{-r_H}}{\alpha + \theta (1 - \alpha)} p^{\text{post}}_1 + w^{\text{post}} \right].
\end{align*}
\]

Manufacturer’s optimal wholesale price:

\[
\begin{align*}
w^{\text{post}} &= \frac{1}{2} \left[ \frac{\alpha}{\alpha + (1 - \alpha) \theta} V_H + \frac{\alpha (1 - \theta)}{\alpha + (1 - \alpha) \theta} c + \frac{\theta}{\alpha + (1 - \alpha) \theta} p^{\text{post}}_1 \right].
\end{align*}
\]

Manufacturer’s optimal regular selling price:

\[
\begin{align*}
p^{\text{post}}_r &= \left( \frac{3 \theta + \theta e^{-r_H} / 4 (\alpha + \theta (1 - \alpha)) V_H + \left( \frac{\theta}{\alpha + \theta (1 - \alpha)} \right) c + \left( \frac{\theta}{\alpha + \theta (1 - \alpha)} \right) c \right) \left( \frac{1 - \alpha - q (1 - \alpha)}{2 \alpha} \right) \left( 1 - \alpha - q (1 - \alpha) \right)
\end{align*}
\]

Total profit of retailer \(\pi^{\text{post}}_r\) and manufacturer \(\pi^{\text{post}}_m\).
\[
\begin{align*}
\pi_{r}^{\text{post}} &= \frac{N}{V_{H} - V_{L}} \left( V_{H} - \theta p_{1}^{\text{post}} e^{-r t_{1}} - e^{-r t_{1}} p_{1}^{\text{post}} \right) (p_{r}^{\text{post}} - w^{\text{post}}) \left( p_{r}^{\text{post}} - (1 - \theta)p_{r}^{\text{post}} \right), \\
\pi_{m}^{\text{post}} &= \frac{N}{V_{H} - V_{L}} \left[ q \theta \left( e^{-r t_{1}} p_{1}^{\text{post}} - q e^{-r t_{2}} p_{2}^{\text{post}} \right) - e^{-r t_{1}} p_{1}^{\text{post}} \right] \left( 1 - \alpha \right) \left( p_{1}^{\text{post}} - c \right) \\
&+ \alpha \left( e^{-r t_{1}} p_{1}^{\text{post}} - q e^{-r t_{2}} p_{2}^{\text{post}} \right) \left( 1 - \alpha \right) \left( p_{1}^{\text{post}} - c \right) \\
&+ \left( V_{H} - \theta p_{1}^{\text{post}} e^{-r t_{1}} - e^{-r t_{1}} p_{1}^{\text{post}} \right) \left( 1 - \theta \right) p_{r}^{\text{post}} \left( w^{\text{post}} - c \right)
\end{align*}
\]

6. Numerical Studies

To better illustrate how strategic consumers and double-entry mental accounting influence the profits of retailers and manufacturers and to derive managerial insights, we numerically compare the profits of manufacturers and retailers under different payment schemes.

6.1. Values of Parameters. For the parameters, we initially set \( N = 1000, V_{L} = 15, V_{H} = 25, c = 8, q = 0.3, \theta = 0.1, \alpha = 0.04, \beta = 0.1, r = 0.013, t_{1} = 8, t_{2} = 27, \) and \( t_{2} = 35.\)

It should be noted that we focus mainly on the parameters of \( \beta, \alpha, \) and \( \theta.\) The values of \( \alpha \) and \( \beta \) depend on the product features and the characteristics of the customers, and the value of \( \beta \) is greater than that of \( \alpha.\) It has been shown that \( \alpha \) is greater for luxury and hedonic products [49], and \( \beta \) is greater for necessities and durable goods. In addition, misers have a greater \( \alpha \) and spendthrifts have a great \( \beta \) [2]. In this paper, we ignore the characteristics of the product and the characteristics of the customer, and generally, the value of \( \beta \) is greater than that of \( \alpha.\) So, we assume \( \alpha = 0.04 \) and \( \beta = 0.1 \) (the sensitivity analysis of \( \alpha \) and \( \beta \) will be tested in 6.2 and 6.3).

Assume that the products would transfer to the sales period within one month, which is consistent with operations in practice, for example, the fast moving consumer goods. So, we assume \( t_{1} = 8, t_{2} = 27, \) and \( t_{2} = 35.\) And as for the time discount factor, we assume \( r = 0.013 \) [51].

We kept the other parameters unchanged and varied \( \beta, \alpha, \) and \( \theta \) to see the impacts of the coefficient of pain buffering \( \beta, \) the coefficient of pleasure attenuation \( \alpha, \) and the proportion of strategic consumers \( c \) on the pricing and profit of manufacturers and retailers under different payment schemes.

6.2. The Effect of Coefficient of Pain Buffering under General Payment. As for the change of coefficient of pain buffering \( \beta, \) the change of selling price \( p_{1} \), sales price \( p_{2} \) of the manufacturer, and at the same time, the manufacturer’s price would increase in both periods. Figure 5 shows that the retailer will get a lower profit as the coefficient of pain buffering increases and the higher profit for the manufacturer holds. The general payment scheme is beneficial to the manufacturer if the pain buffering coefficient is larger. A high coefficient of pain buffering would hurt the retailer.

6.3. The Effect of Coefficient of Pleasure Attention under Postpayment. As for the change of coefficient of pleasure attenuation \( \alpha, \) the change of selling price \( p_{1}^{\text{post}}, \) sales price \( p_{2}^{\text{post}}, \) of the manufacturer, and wholesale price \( w^{\text{post}} \) and retail price \( p_{r}^{\text{post}} \) are shown in Figure 6. The changes in total profit \( \pi_{m}, \pi_{m}^{\text{post}}, \) of the manufacturer and total profit \( \pi_{r}, \pi_{r}^{\text{post}}, \) of the retailer are shown in Figure 7.

Figure 4 shows the impacts of the pain buffering coefficient on the optimal price of the retailer and the manufacturer under the general payment scheme. The coefficient of pain buffering exists only under the general payment scheme, so the results hold for the general payment scheme. As the pain buffering coefficient increases, the optimal retailer’s price would remain unchanged and the manufacturer’s price would increase in both periods. Figure 5 shows that the retailer will get a lower profit as the coefficient of pain buffering increases and the higher profit for the manufacturer holds. The general payment scheme is beneficial to the manufacturer if the pain buffering coefficient is larger. A high coefficient of pain buffering would hurt the retailer.

6.4. The Impact of the Proportion of Strategic Consumers. As the ratio of strategic consumers \( \theta \) changes, the change of selling price \( p_{1}, \) sales price \( p_{2} \) of the manufacturer, and wholesale price \( w \) and retail’s selling price \( p_{r} \) under two payment schemes are shown in Figure 8. The change in change from manufacturer and retailer is shown in Figure 9.
Figure 8 shows the impact of the proportion of strategic consumers on the optimal price of the retailer and the manufacturer. Figures 8(a) and 8(b) show that the optimal price of the retailer under the general payment scheme is higher than that under the postpayment scheme and decreases as the proportion of strategic consumers increases. The manufacturer’s selling price is increasing as the proportion of strategic consumers becomes larger. Figure 9 shows that as the proportion of strategic consumers increases, the optimal profit of the retailer decreases, and the optimal profit of the manufacturer increases. For the retailer, the optimal profit under the general payment scheme is larger than that under the postpayment scheme. And it is the opposite for the manufacturer. Based on those results, the retailer will lower the price to make more profits in order to attract myopic consumers. The manufacturer would benefit more even if taking no measures as the proportion of strategic consumers increases. The reason is that more strategic consumers would...
Figure 6: Impact of the coefficient of pleasure attenuation on optimal prices.

Figure 7: Impact of the coefficient of pleasure attenuation on optimal profits.
strategically wait for the selling period. The postpayment scheme is preferred by manufacturers and the general payment scheme is preferred by retailers.

7. Conclusion

In this paper, the double-entry mental accounting of strategic consumers was introduced in the dual-channel dynamic pricing model. In the regular selling period, the manufacturer sells the products to the retailer and the retailer sells the products to customers or the manufacturer sells the products to the consumers directly online in the sales period. Customers are strategic, and their perceived utility is influenced by double-entry mental accounting, which affects manufacturer and retailer’s pricing decision making. Based on the above, we formulated the profit model under two different payment schemes and obtained the optimal decisions. We applied numerical studies to test the impact of the proportion of strategic consumers, the coefficient of pleasure attenuation, and the coefficient of pain buffering on the optimal profit of the retailer and the manufacturer. The results are as follows: to solve the loss caused by strategic consumers, it is recommended that the retailer lowers the price to stabilize the profit. The postpayment scheme is preferred by the manufacturer, but the high coefficient of pleasure attenuation would hurt the manufacturer. The general payment scheme is preferred by the retailer, but the high coefficient of pain buffering would hurt the retailer.

For future research, an extension is to involve the retailer in the sales period. In addition, consumers have other strategic behaviours in addition to a double-entry mental account. It is important to study how other typical strategic behaviours affect the decision making of the retailer and the manufacturer [52].

Data Availability

The data used to support the findings of the study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.
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References

[33] J. H. Ma, Y. M. Hou, W. H. Yang, and Y. Tian, “A time-based pricing game in a competitive vehicle market regarding the


