# Channel Strategies for Dual-channel Firms to Counter Strategic Consumers

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## Abstract

Nowadays some giant firms have attempted to sell products through different channels over different periods to mitigate channel conflict. This paper considers a dual-channel firm who has access to online/Clicks (C) and offline/Bricks (B) channels in the presence of strategic consumer behavior. We focus on the two-period selling setting where the firm could sell products through one of these channels in each period and mainly investigate four channel structures: (1) selling products through the pure online channel over two periods (Channel CC); (2) selling products first through the online channel and then through the offline channel (Channel CB); (3) selling products through the pure offline channel over two periods (Channel BB); (4) selling products first through the offline channel and then through the online channel (Channel BC). The main novelty of this paper is twofold. Theoretically, this study develops four intertemporal channel operations models and explores the optimal pricing and channel strategies for dual-channel firms over two periods by considering strategic consumers. Practically, the research results suggest that dual-channel firms should adopt the preannounced pricing strategy instead of the dynamic pricing strategy in terms of countering strategic consumers. More importantly, Channel CB can be used as a tactic to effectively alleviate consumers' strategic consumer behavior. Specifically, when the differentiation between the online and offline channels is relatively high, Channel CB is performing better than Channel BB, and vice versa.

**Keywords:** Channel strategy; Pricing strategy; Dual-channel operations; Two-period selling; Strategic consumer behavior.

## 1. Introduction

With the maturity and sustained development of information and data acquisition technologies, nowadays, consumers can more conveniently understand the prices and functional value of products in a variety of ways, thereby breeding more and more strategic consumers (Bernstein and Martínez-de-Albéniz, 2017; Farshbaf-Geranmayeh and Zaccour, 2021). The term "strategic consumer behavior" has been widely used in the marketing and management literature to describe the rational and forward-looking people who strategically make inter-temporal purchasing decisions to seek their utility maximization (Papanastasiou and Savva, 2017; Wu et al., 2022). Compared to the myopic consumers who make purchase decisions just considering the current value of products, strategic consumers prefer to wait for the expected discount price later instead of buying the current products at a regular or higher price (Lin et al., 2018). An increasing number of works on strategic consumer behavior and its influences on companies' optimal decisions and operational performance have stemmed from seminal work (Lobel et al., 2016). Some scholars have confirmed that strategic consumer behavior has a profound and lasting effects on enterprises' production operations and marketing strategies. More importantly, ignorance of strategic consumer behavior would lead to immense losses for enterprises in various industries (Li et al., 2014; Khouja et al., 2020). Thus it can be seen that when strategic consumer behavior occurs, how to design appropriate marketing strategies is a realistic and severe problem faced by more and more enterprises.

Owing to the popularity of electronic commerce and the increasing growth of consumers' acceptance towards online channel, an increasing number of firms such as HP, Epson and Lenovo have sold their products through online channels in addition to relying on the brick-and-mortar stores for capturing bigger market sizes. Nevertheless, many practitioners and researchers have argued that dual-channel structure would give rise to serious channel conflict between upstream and downstream enterprises (Xu et al., 2014; Zhang et al., 2017; Liu et al., 2022). To overcome the negative impacts of dual-channel, many researchers have developed various coordination contracts, such as quantity discount contract, profit/revenue sharing contract, two-part tariff contract, and so on (Chen et al., 2012; Chen et al., 2022; He et al., 2022a). Recently, some researchers have demonstrated that using different channels to sell different types of products such as different generations, new and remanufactured products separately, would effectively alleviate channel conflict (Yan et al., 2015; Gan et al., 2017). On the other hand, some companies would strategically employ the online channel as an

advanced selling tool or a market clear tool in real business life (Lim and Tang, 2013). Put it differently, enterprises may utilize different selling channels (e.g., online or offline channels) during different periods, especially considering the product value loss (Dong et al., 2018).

Motivated by the above practical business operational cases, this paper considers a dual-channel firm with the possibility of developing different channel strategies over two periods (e.g., the regular and markdown selling season periods) to distribute its products. We employ the first letter C of Clicks and B of Bricks to represent the firm's marketing strategies of online and offline selling channels, respectively. Thus, four common channel settings will be investigated. The first one is Channel CC where the firm would always sell products through an online channel over two periods. The second is referred to as Channel BB, which indicates that the firm always sells products to the end consumers through an offline channel over two periods. The Channel CC and BB can be widely found in practice (e.g., the pure online/offline shop). The third is Channel CB where the firm would utilize the online channel in the first period and then switch to the offline channel in the second period. Examples of this channel structure could be commonly found in the garment and food industries. For example, some clothing enterprises may conduct clearance sales through the professional offline discount (broken code) stores (e.g., Outlets) and some food enterprises sell expired snacks through offline channels (e.g., HitGoo). The last one is called Channel BC, which means that the firm may first sell products through the offline channel and then through the online channel over two periods, respectively. For instance, Apple often launches its smartphone only in the offline physical store. After selling offline for a period of time, consumers can buy it from other channels (e.g., online flagship store or marketplace shop). Another example would be the situation where some firms would employ the online shop or special price websites (e.g., Barneys Warehouse and Vip.com) to clear their outdated/prior products (Choi et al., 2019). Based on these possible channel components, we aim to examine the strengths or weaknesses of each channel structure to deal with strategic consumers.

It is well known that pricing strategy is a critical decision that could largely affect consumers' purchase decisions, especially the strategic consumers' purchase time decisions when firms sell products over two periods (Dasu and Tong, 2010; Papanastasiou and Savva, 2017). Extensive literature has studied pricing strategy from different perspectives such as joint pricing between two competitive or complementary enterprises (Wei et al., 2013; Karray and Sigue, 2016; He et al., 2022b), the inconsistent or consistent pricing strategy in dual-channel supply chains (Lu and Liu, 2013; Wang et al., 2017). In terms of the timing of

price announcement and pricing commitment, many scholars have discussed the advantages of the dynamic pricing strategy and the preannounced pricing strategy, separately (Liu et al., 2018). With respect to the two-period game, the dynamic pricing strategy means that firms announce their prices, including the first-period price and the second-period price, in each period respectively. While the preannounced pricing strategy is referred to as a pricing commitment where the firms would announce their sales prices for two periods in the first period to encourage strategic consumers to buy as early as possible. Based on the previous studies, another one of our important research themes is to examine the role of each pricing strategy under different two-period channel structures.

Specifically, the aforementioned real business operational problems and evidence stimulate us to address the following research questions in the presence of strategic consumers:

(1) Whether or not a dynamic channel selling policy could help the dual-channel firm benefit more when facing strategic consumers?

(2) Which channel and pricing strategies are the best joint strategies for the dual-channel firm?

(3) How do the system factors such as strategic consumer proportion, consumers' online channel preference and value discount perception impact the firm's pricing and channel decision-makings, as well as the consumer surplus?

To provide some management implications for the dual-channel operational firms, this study develops four analytical mathematic models to explore the optimal channel and pricing strategies for a monopolist firm who faces with a population of strategic consumers. We also extend the benchmark models to consider the effects of channel switching cost. The main research findings suggest an alternative region in the firm's optimal channel policy when considering myopic and strategic customers. Namely, it is advisable for the dual-channel firm to adopt Channel CB when the gap between two channels is sufficiently high, and vice versa. This channel structure could reduce the incentive of strategic consumers to wait for a lower price. In contrast to the traditional wisdom that the dynamic pricing strategy can enhance firms' profitability, it suggests that a dual-channel firm should announce its second-period product price in advance so as to encourage more strategic customers to buy early.

This study could contribute to the existing literature and business practices in several dimensions. Firstly, this work enriches the literature on channel management, which usually assumes that consumers are myopic (i.e., no inter-temporal choice). We specifically propose

four stylized models that incorporate strategic consumer behavior. This is done by using a two-period game approach, from which we derive the optimal channel strategy for the dual-channel firm. In doing this, the current study combines strategic consumer behavior with channel decisions over time, thereby extending the traditional channel selection models into the time dimension. Additionally, we develop and compare the dynamic and preannounced pricing strategies in the context of inter-temporal channel structures by considering different types of consumers, viz., myopic and strategic consumers. Lastly, we further examine the behavior interaction between the dual-channel firm and strategic consumers by considering the time dimension.

The remaining of this paper is organized as follows. Section 2 reviews the relevant literature and highlights the gaps between this study and the prior research. We describe the dual-channel firm's pricing and channel choice problems and further present the modelling assumptions and notation used throughout this paper, as well as the demand formation in Section 3. Section 4 outlines the firm's pricing decisions under four channel structures and identifies the firm's optimal channel and pricing strategies. The effects of some crucial system factors on the firm's profit and consumer surplus are examined in Section 5. We extend the basic models to discuss the effects of channel switching cost in Section 6. The last section concludes the paper by reporting the main research results and some potential future research directions.

## 2. Literature review

There exist three main streams of literature closely related to the current study, i.e., channel operations, two-period pricing, and strategic consumers.

### *2.1. Channel operations*

The first stream of literature is very related to the studies rooted in channel operations in the e-commerce age. The impacts of different channel structures on supply chains' operational performance have been examined empirically and theoretically in the literature (e.g., Zhang et al., 2019; Zhang and Hezarkhani, 2021; Jena and Meena, 2022). Most channel researchers believe that the manufacturers' direct channel would be threatening to the downstream retailers and result in serious channel conflict (Xu et al., 2014; Wang et al., 2016; Alaei et al., 2022). To alleviate this negative effect, many scholars have designed all kinds of coordination contracts to improve supply chain performance (Pei et al., 2021; Chen et al., 2022). From the

viewpoint of upstream firms (e.g., manufacturers or suppliers), a large body of literature has examined their channel encroachment strategy and its effects on the downstream firms' operational performance (He et al., 2022a). By contrast, some scholars focus on the optimal channel strategy by analyzing the impacts of some key factors from the retailer's perspective. For example, Wang et al. (2016) examine the effects of the operating cost gap between the online and offline channels on the retailer's channel choices. Zhang et al. (2017) investigate how the consumers' online channel acceptance affects the dominated retailer's channel selections. Some works explore the channel strategy in various industries by considering other factors, such as network externality, power structure, information sharing, and carbon reduction. For instance, Chen and Wang (2015) consider a smartphone supply chain with two channels, i.e., a free channel or a bundled channel. They indicate that power structure would significantly affect the firms' and the whole supply chain's channel preferences. Dong et al. (2018) discuss a firm's different selling channel strategies (i.e., direct and agent selling modes) under asymmetric market and product information over two periods. They highlight that both selling modes may be the optimal channel strategy in both periods, which would be influenced by the benefit of the additional market information. Yang et al. (2018) examine a manufacturer's joint decisions of channel selection and carbon emission reduction by considering the carbon emission constraints and show that the products' properties and consumers' channel preference strongly affect the manufacturer's channel choices. Khorshidvand et al. (2021) consider the supply chain members can use two channels (i.e., online and in-person) to sell their products. They point out the optimal pricing, greening, and advertising decisions in both channels. By contrast, fewer papers explore the closed-loop supply chain members' forward channel selections (Yan et al., 2015; Gan et al., 2017) while a lot of papers concerning remanufacturing focus on the recovery channel choice (Chuang et al., 2014; Zheng et al., 2021).

The aforementioned studies have well documented the issues of channel selection, especially the manufacturers' online channel open strategies. All almost of them constrain their research to the single selling period. Unlike these studies, we focus on exploring the optimal channel strategy for a dual-channel firm over two periods. The work of Dong et al. (2018), which also considers the dynamic selling strategy over two periods, is closely relevant to the current research. However, they are interested in distinguishing the direct selling mode and agent selling mode instead of an offline channel. Besides, this paper also incorporates the strategic consumer behavior into the research framework under different pricing strategies as

today's consumers are becoming smarter and smarter.

### *2.2. Two-period pricing*

There is a growing body of literature on the two-period pricing settings (He et al., 2019b; Li et al., 2020). So far, a considerable number of studies have investigated the two-period pricing issues from the perspective of closed-loop supply chains (Li et al., 2021; Zhao et al., 2021; Ke and Yan, 2022). For example, Chen and Chang (2013) investigate the two-period pricing strategy for a manufacturer's two differentiated versions of one product in a closed-loop supply chain. They firstly explore the static pricing strategy and then two-period pricing decisions, and finally extend to the multi-period setting. Genc and Giovanni (2017) explore the joint decisions of pricing and recovery channel choice in a closed-loop supply chain where the return rate is dependent on price and quality under the two-period selling setting. They confirm that price competition plays a crucial role in both forward and backward channels' operations. Liu et al. (2018) look into the optimal pricing setting of an innovative firm who sets up trade-in programs to encourage consumers' repeat purchasing. They develop and compare two pricing strategies, i.e., dynamic and preannounced pricing strategies. They uncover that when consumers are very strategic, the firm should adopt the preannounced pricing strategy if the new generation products' innovation value and the old generation products' salvage are low enough.

Some scholars investigate the dynamic pricing issues by considering different product marketing strategies under different market circumstances (Yu et al., 2017; Huang et al., 2019; Li et al., 2020). Particularly, Zhou et al. (2015) explore the optimal two-period pricing and new fashion style launching strategies considering consumers' satiation effect. They present the firm's best retailing prices over two periods and identify the condition under which they should adopt a specific launching strategy. Maiti and Giri (2017) discuss a manufacturer's two wholesale pricing strategies, namely, the same or different wholesale prices for both selling periods under the price-dependent demand. They indicate that if the supply chain members periodically review their prices, it contributes to increasing their demands and profits. Yu et al. (2017) investigate how the hunger marketing strategy influences a supply chain's optimal pricing and coordination over two periods. They confirm that the hunger marketing strategy can improve the performance of the whole supply chain but aggravate the double marginalization effect. Huang et al. (2019) develop game-theoretical models to explore the joint optimal pricing and quality decisions for an international manufacturer who wants to

counter parallel importers over two periods. They indicate that the manufacturer can use quality and pricing designs, as well as the distribution strategies to alleviate the parallel importers' negative impacts. Zhao et al. (2021) examine wholesale pricing and quality decisions with or without two-period information sharing. Karray et al. (2022) study the joint pricing and advertising decisions in a two-period supply chain.

From the above literature, it can be concluded that most of prior papers study the two-period pricing issues by considering product competition and assume that the supply chain members always utilize the same channel over two periods. Nowadays, it is very common that manufacturers with two channels may use different channels to sell products over different periods. In this paper, we attempt to identify the optimal dynamic channel strategy for a firm with the online and offline channels over two periods. To the best of our knowledge, this is the first study to address similar issues in the context of dual-channel retailing. It is also a new attempt to specifically examine the impacts of strategic consumers on intertemporal channel and pricing decisions at the same time.

### *2.3. Strategic consumers*

The last stream of literature on "strategic consumers" widely used in production operations and marketing to describe the consumers who make purchase decisions considering both the current and the future purchasing surpluses has increasingly become a hot research theme in recent years (Lim and Tang, 2013; Lin et al., 2018; Khouja et al., 2020; Chaab et al., 2022). A great number of existing papers demonstrate that customers waiting to buy markdown price products would hurt sellers heavily (Hu et al., 2016; Zhao et al., 2020). Some empirical investigations have provided the practice evidence of strategic consumer behavior in airline industries (Li et al., 2014; Mantin and Rubin, 2016). A flood of literature on pricing strategy in production operations and marketing management reveals that companies' pricing decisions are largely influenced by strategic consumer behavior. For instance, Tilson and Zheng (2014) study the issue of how demand volatility affects the manufacturers' production and pricing decisions in the presence of strategic consumers. The findings show that when each period's demand is independent and identically distributed, it is beneficial for the manufacturer to apply a simple myopic policy. Ahmadi et al. (2016) consider a supply chain consisting of one manufacturer and one retailer who may sell products to a domestic gray market including some strategic consumers. They find that the gray market would reduce the effectiveness of the wholesale price contract so that they

propose a sophisticated contract depending on a price-dependent quantity discount contract to coordinate it. Ke et al. (2016) explore the group-buying mechanism in the presence of strategic consumers and divide the market into three parts: strategic, spot-purchasing, and group-buying consumers. They confirm that strategic consumer behavior can significantly affect the group-buying success rate, the retailer's profit and consumer surplus. Li and Yu (2016) investigate the impacts of strategic consumers on the performance of a supply chain comprised of a manufacturer and a newsvendor retailer. The results demonstrate that the supply chain efficiency will become worse due to the strategic consumer behavior and the buyback contract is used to coordinate the supply chain successfully. Bernstein and Martínez-de-Albéniz (2017) consider a retailer's optimal product-rotation policy and pricing settings with considering strategic customers. They show that the optimal policy strongly depends on product-rotation cost and capacity constraint. Khouja et al. (2020) investigate whether or not to sell products to an off-price retailer when consumers have strategic behaviors. Their results indicate that the retailer can get better when the off-price retailer has larger own potential consumers. Zhao et al. (2020) explore firms' quality disclosure strategy when strategic consumers have no product quality information. They suggest that firms should disclose quality if the products' real quality is very high. Huang et al. (2022) explore the effects of strategic consumers on the platform supply chain's online selling mode choice. They show that higher strategic consumer behavior makes the platform has lower motivation to introduce a store brand.

Although extensive research has discussed the influences of strategic consumer behavior on production and marketing decisions from a great variety of perspectives, none has tried to explore its effects on firms' channel selection over two periods, especially under the dynamic and preannounced pricing strategies, which is another core research question of this paper that largely differs from the prior works.

## 3. Model framework

This section first describes the main research problems of a dual-channel firm in terms of channel and pricing strategies over two periods. Then, we propose the modelling assumptions in Subsection 3.2 and present the demand formation in Subsection 3.3.

### *3.1. Problem description*

This paper considers that a monopolist firm who has access to online and offline

channels sells its products to the end market consisting of myopic and strategic consumers over two periods. The dual-channel firm may utilize different channel in each period. Considering two selling periods yields the following four pairs of channel selling models, namely, Models CC, CB, BC, and BB (see Fig. 1). For example, Model CB means that the firm first uses the online channel and then utilizes the offline channel over two periods. One of the important operational problems for the dual-channel firm is to determine which channel should be used in each period, viz., the online channel or the offline channel?

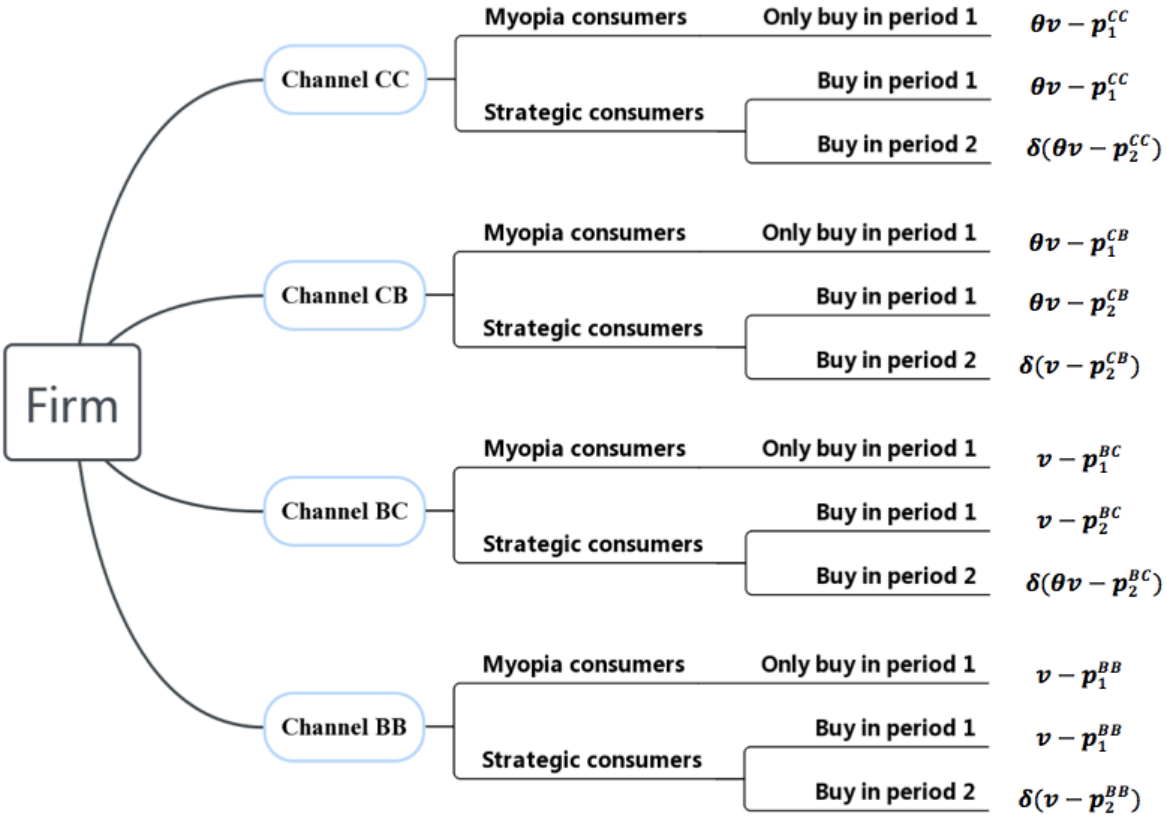
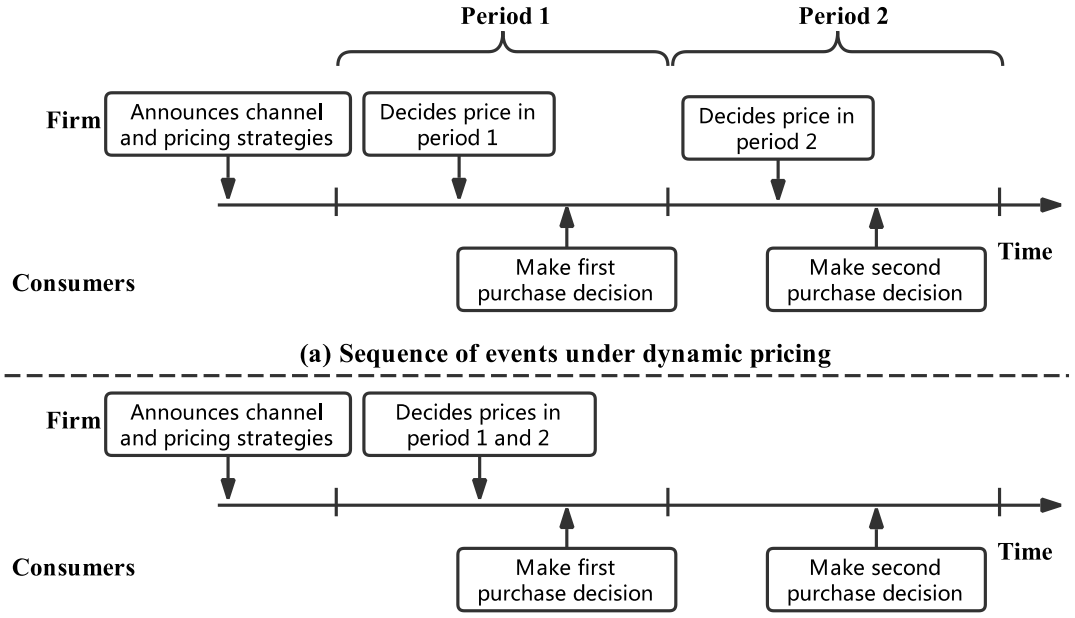



**Fig. 1.** Firm's channel strategies and consumers' purchase decisions.

When it comes to two-period marketing, pricing strategy is also a significant decision-making for a firm to lure consumers to buy in different periods. In other words, the firm could choose either Dynamic or Preannounced pricing strategy (i.e., Strategy D or P) at the beginning of the overall selling season period (Liu et al., 2018). Under different pricing strategies, the firm's decision-making sequences are different. Fig. 2 summarizes the main difference between two pricing strategies. The firm would decide its different period prices before different selling periods under Strategy D. By contrast, the firm would determine all prices in the first period under Strategy P.




**(a) Sequence of events under dynamic pricing**




**(b) Sequence of events under preannounced pricing**

**Fig. 2.** Decision sequences under different pricing strategies.

### *3.2. Modelling assumptions*

**Table 1.** Notation and explanations.

| Notation | Explanations |
|---|---|
| $p_i^j$ | Retail price of products in period $i$ under channel $j$ (decision variables), $i = 1,2$ and $j = CC, CB, BB, BC$. |
| $d_{li}^j$ | Product demand of different types of consumers in period $i$ under channel $j$, $l = m, s$. |
| $\rho$ | Strategic consumers' proportion, $0 < \rho \leq 1$. |
| $\theta$ | Channel preference of consumers towards online channel, $0 < \theta \leq 1$. |
| $\delta$ | Strategic consumers' value discount on second-period purchasing surplus, $0 < \delta \leq 1$. |
| $v$ | Perceived value of consumers for products. |
| $U_{li}^j$ | Consumer's net utility of buying product in period $i$ under channel $j$. |
| $\Pi_2^j$ | Firm's second-period profit under channel $j$ when using a dynamic pricing strategy. |
| $\Pi^j$ | Firm's total profit over two periods under channel $j$ when using a dynamic pricing strategy. |
| $\pi^j$ | Firm's total profit over two periods under channel $j$ when using a preannounced pricing strategy. |
| $f$ | Channel switching cost. |
| Else | Subscript $i$ and $l$ represent different periods and consumer types; superscript $j$ represents the different channel structures; superscript * denotes the optimal solutions. |

We summarize the notation used throughout this paper in Table 1. On the market's side, this work considers two consumer segments consisting of myopic and strategic consumers divided by proportion $\rho$ and normalizes the total potential market to one without loss of generality. Namely, there are $\rho$ unit strategic consumers and $(1-\rho)$ unit myopic consumers.

All consumers are heterogeneous with different perceived value $v$ for a product, which is assumed to distribute uniformly between 0 and 1, with the density of 1. Following most previous studies (Zhang et al., 2017; He et al., 2019a), customers would get a discount utility $\theta v$ buying from an online channel, wherein $\theta$ represents the consumers' preference towards the online channel (hereafter online channel preference). Additionally, the strategic consumers would get a surplus value discount perception $\delta \in (0,1]$ (hereafter value discount) on the product if they wait to buy in period 2 as they can't enjoy the product in time (Liu et al., 2018). Note that $\delta$ also captures how strategic consumers are. The bigger the $\delta$ is, the more strategic the consumers are. It is reasonable to assume $\theta > \delta$ as consumers are more sensitive to time. More importantly, we would like to introduce the rational expectation assumption, which has been widely used in various previous research (Cachon and Swinney, 2011; Huang et al., 2018). Namely, the firm and customers play the best response with rational expectation prices, which are consistent with the equilibrium outcome.

It is supposed that there is no channel switching cost when the firm chooses to change its channel at the beginning of the second period (i.e., Channel CB and BC) because the lump sum channel switching cost is often regarded as a sunk cost. We will relax this assumption to examine its impact in Section 6. It is not uncommon to assume that the firm is risk-neutral and aims to maximize its own profit. We also assume that all consumers arrive at the beginning of the first period (Khouja and Liu, 2021). Please note that $\theta > \overline{\theta}_0 = [4\delta + \rho - \delta\rho(2-\delta)]/4$ is required to ensure positive demands in two periods throughout the paper and the existence of optimal solutions. This assumption is very reasonable and realistic because the extremely low online channel preference means that the firm would never have any willingness to adopt an online channel. We exclude this trivial situation to focus on the co-existence of two periods.

### *3.3. Demand formation*

Under Channel CC, the myopic customers may buy in period 1, while the strategic customers may buy in period 1 or 2. Given the selling prices $p_1^{CC}$ and $p_2^{CC}$, a myopic or strategic customer's utility buying in the first period is $U_{m1}^{CC}(v) = U_{s1}^{CC}(v) = \theta v - p_1^{CC}$ and a strategic customer's utility buying in the second period is $U_{s2}^{CC}(v) = \delta(\theta v - p_2^{CC})$, where the subscript '$m$' and '$s$' are the first letters of myopic and strategic, denoting different types of consumers. For ease of reading, we summarize all utilities of consumers under different channel structures in Fig. 1. Accordingly, a myopic consumer with perceived value $v^*$ buy

and only buy in period 1 when $U_{m1}^{CC}(v^*) \geq 0$. A strategic customer would buy a product in period 1 if and only if her utility satisfies the condition $U_{s1}^{CC}(v^*) \geq \max[U_{s2}^{CC}(v^*), 0]$, otherwise, she would wait to purchase in period 2 when $U_{s2}^{CC}(v^*) \geq \max[U_{s1}^{CC}(v^*), 0]$. Considering the market divided into two parts by proportion $\rho$, we can derive the demand functions of different types of consumers in two selling periods as follows, respectively:

$$d_{m1}^{CC} = (1-\rho)\left(1 - \frac{p_1^{CC}}{\theta}\right) \tag{1}$$

$$d_{s1}^{CC} = \rho\left[1 - \frac{p_1^{CC} - \delta p_2^{CC}}{\theta(1-\delta)}\right] \text{ and } d_{s2}^{CC} = \rho\left[\frac{p_1^{CC} - \delta p_2^{CC}}{\theta(1-\delta)} - \frac{p_2^{CC}}{\theta}\right] \tag{2}$$

Given the channel structure CB and the selling prices $p_1^{CB}$ and $p_2^{CB}$, a myopic customer can get net utility $U_{m1}^{CB}(v) = \theta v - p_1^{CB}$ in the first period and a strategic customer's utilities buying in the first and second periods are $U_{s1}^{CB}(v) = \theta v - p_1^{CB}$ and $U_{s2}^{CB}(v) = \delta(v - p_2^{CB})$. A consumer will purchase a product with the highest and non-negative utility. Similarly, a myopic consumer will buy in period 1 when $U_{m1}^{CB}(v^*) \geq 0$. A strategic customer will buy the product in period 1 if her utility satisfies $U_{s1}^{CB}(v^*) \geq \max[U_{s2}^{CB}(v^*), 0]$, she will buy in period 2 when $U_{s2}^{CC}(v^*) \geq \max[U_{s1}^{CB}(v^*), 0]$ otherwise. Taking the proportion $\rho$ into consideration, we can derive the demands in both periods as follows, respectively:

$$d_{m1}^{CB} = (1-\rho)\left(1 - \frac{p_1^{CB}}{\theta}\right) \tag{3}$$

$$d_{s1}^{CC} = \rho\left(1 - \frac{p_1^{CB} - \delta p_2^{CB}}{\theta - \delta}\right) \text{ and } d_{s2}^{CC} = \rho\left(\frac{p_1^{CB} - \delta p_2^{CB}}{\theta - \delta} - p_2^{CB}\right) \tag{4}$$

Under Channel BB, each myopic customer may buy in period 1 if $U_{m1}^{BB}(v) = v - p_1^{BB} \geq 0$. As for the strategic customers, they may buy products by comparing their net utilities obtained from periods 1 and 2. Given the selling prices $p_1^{BB}$ and $p_2^{BB}$, a strategic customer can get net utility $U_{s1}^{BB}(v) = v - p_1^{BB}$ in period 1 and $U_{s2}^{BB}(v) = \delta(v - p_2^{BB})$ in period 2. Analogously, solving the equation $U_{s1}^{BB}(v^*) = U_{s2}^{BB}(v^*)$, we can obtain the demand functions of different types of consumers in both periods as follows, respectively:

$$d_{m1}^{BB} = (1-\rho)(1 - p_1^{BB}) \tag{5}$$

$$d_{s1}^{BB} = \rho\left(1 - \frac{p_1^{BB} - \delta p_2^{BB}}{1-\delta}\right) \text{ and } d_{s2}^{BB} = \rho\left(\frac{p_1^{BB} - \delta p_2^{BB}}{1-\delta} - p_2^{BB}\right) \tag{6}$$

Under Channel BC, we can know that a myopic customer can get net utility $U_{m1}^{BC}(v) = v - p_1^{BC}$ in period 1. As for a strategic consumer, she can get net utilities $U_{s1}^{BC}(v) = v - p_1^{BC}$ in period 1 and $U_{s2}^{BC}(v) = \delta(\theta v - p_2^{BC})$ in period 2. By solving the equation $U_{s1}^{BC}(v^*) = U_{s2}^{BC}(v^*)$, we can derive the indifference $v^*$ that consumers whether to buy in period 1 or 2. Accordingly, it is easy to figure out the demands of strategic consumers in different periods.

We summarize the demand functions as below by incorporating the market segment proportion $\rho$:

$$d_{m1}^{BC} = (1-\rho)(1-p_1^{BC}) \tag{7}$$

$$d_{s1}^{BC} = \rho\left(1-\frac{p_1^{BC}-\delta p_2^{BC}}{1-\delta\theta}\right) \text{ and } d_{s2}^{BC} = \rho\left(\frac{p_1^{BC}-\delta p_2^{BC}}{1-\delta\theta}-\frac{p_2^{BC}}{\theta}\right) \tag{8}$$

## 4. Model development and analysis

This section aims to explore the dual-channel firm's different channel and pricing strategies. Because the firm may sell products through different channels at first, we start by investigating the firm's optimal pricing decisions when he first uses the online channel.

### *4.1. Selling products through online channel first*

#### *4.1.1. Model CC (No channel switching)*

Under Model CC, the firm sells its product always through the online channel. As mentioned before, the dual-channel firm has two pricing strategies, namely, dynamic and preannounced pricing strategies. We firstly explore the optimization problem of the firm under Strategy D where he first decides $p_1^{CC}$ at the beginning of period 1 and then sets $p_2^{CC}$ at the beginning of period 2. We follow the widely used backward induction approach to obtain the sub-game perfect equilibrium. Denote $\Pi_2^j$ as the firm's second-period profit. Hence, the firm's second-period pricing problem is

$$\begin{cases} \max\limits_{p_2^{CC}} \Pi_2^{CC} = p_2^{CC} d_{s2}^{CC}(p_2^{CC}|p_1^{CC}) \\ \quad s.t.\ p_2^{CC} < p_1^{CC} \end{cases} \tag{9}$$

In the first period, the firm determines $p_1^{CC}$ to maximize its total profit $\Pi^j$ over two periods by considering his optimal decision in the second period. Therefore, we can obtain the firm's first-period pricing problem as below.

$$\begin{cases} \max\limits_{p_1^{CC}} \Pi^{CC} = p_1^{CC} d_{m1}^{CC} + p_1^{CC} d_{s1}^{CC} + \Pi_2^{CC*}(p_2^{CC*}|p_1^{CC}) \\ \quad s.t. p_2^{CC*} < p_1^{CC} < \theta(1-\delta) + \delta p_2^{CC*} \end{cases} \tag{10}$$

wherein the first (second) term denotes the sale revenue obtained from myopic (strategic) consumers in period 1 and $\Pi_2^{CC*}$ is the firm's equilibrium profit in the second period under given $p_1^{CC}$.

Under Strategy P, the firm announces two prices at the start of the whole selling season. In this setting, the firm's optimal problem can be given by

$$\begin{cases} \max\limits_{p_1^{CC}, p_2^{CC}} \pi^{CC} = p_1^{CC} d_{m1}^{CC} + p_1^{CC} d_{s1}^{CC} + p_2^{CC} d_{s2}^{CC} \\ \quad s.t. p_2^{CC} < p_1^{CC} < \theta(1-\delta) + \delta p_2^{CC} \end{cases} \tag{11}$$

wherein the first term represents the selling revenue of the firm gained from myopic consumers. The second and third terms refer to the sale revenue obtained from strategic consumers in periods 1 and 2, respectively. By solving the above two optimization problems under different pricing strategies, we can have the following results.

**Lemma 1.** *Under Model CC, the equilibrium results are shown in Table 2.*

**Table 2.** The equilibrium solutions under Model CC.

| | **Strategy D** | **Strategy P** |
|---|---|---|
| $p_1^{CC*}$ | $\frac{2\theta(1-\delta)}{4(1-\delta)+\rho(2\delta-1)}$ | $\frac{2\theta}{4-(1-\delta)\rho}$ |
| $p_2^{CC*}$ | $\frac{\theta(1-\delta)}{4(1-\delta)+\rho(2\delta-1)}$ | $\frac{(1+\delta)\theta}{4-(1-\delta)\rho}$ |
| $d_{m1}^{CC*}$ | $\frac{2-2\delta(1-\rho)-\rho}{4(1-\delta)+\rho(2\delta-1)}$ | $\frac{2-(1-\delta)\rho}{4-(1-\delta)\rho}$ |
| $d_{s1}^{CC*}$ | $\frac{2-\rho-\delta(3-2\rho)}{4(1-\delta)+\rho(2\delta-1)}$ | $\frac{2-\rho-\delta(1-\rho)}{4-(1-\delta)\rho}$ |
| $d_{s2}^{CC*}$ | $\frac{1}{4(1-\delta)+\rho(2\delta-1)}$ | $\frac{1}{4-(1-\delta)\rho}$ |
| $\Pi^{CC*}/\pi^{CC*}$ | $\frac{\theta(1-\delta)}{4-2\delta(2-\rho)-\rho}$ | $\frac{\theta}{4-(1-\delta)\rho}$ |

*4.1.2. Model CB (Channel switching)*

The firm sells products through the online channel in period 1 while using the offline channel in period 2 under Model CB. Similarly, under a dynamic pricing strategy, the firm first decides the $p_1^{CB}$ in period 1 and then determines the $p_2^{CB}$ in period 2. With similar notation, we can get the firm's second-period pricing problem as below:

$$\begin{cases} \max\limits_{p_2^{CB}} \Pi_2^{CB} = p_2^{CB} d_{s2}^{CB}(p_2^{CB}|p_1^{CB}) \\ s.t.\ \theta p_2^{CB} < p_1^{CB} \end{cases} \tag{12}$$

Furthermore, the firm determines $p_1^{CB}$ to maximize his total profit $\Pi^{CB}$ in the first period. The firm's first-period pricing problem can be given by the following Eq. (13).

$$\begin{cases} \max\limits_{p_1^{CB}, p_2^{CB}} \Pi^{CB} = p_1^{CB} d_{m1}^{CB} + p_1^{CB} d_{s1}^{CB} + \Pi_2^{CB*}(p_2^{CB*}|p_1^{CB}) \\ s.t. \theta p_2^{CB} < p_1^{CB} < \theta - \delta + \delta p_2^{CB} \end{cases} \tag{13}$$

where the first (second) term denotes the sale revenue from myopic (strategic) consumers in period 1 and $\Pi_2^{CB*}$ is the firm's optimal profit in period 2.

Using the preannounced pricing strategy, the firm announces all prices at the beginning of the first period. In this setting, we can formulate the firm's optimal problem as follows.

$$\begin{cases} \max\limits_{p_1^{CB}, p_2^{CB}} \pi^{CB} = p_1^{CB} d_{m1}^{CB} + p_1^{CB} d_{s1}^{CB} + p_2^{CB} d_{s2}^{CB} \\ s.t. \theta p_2^{CB} < p_1^{CB} < \theta - \delta + \delta p_2^{CB} \end{cases} \tag{14}$$

Similarly, solving these two optimization problems under different pricing strategies

yields the following Lemma 2.

**Lemma 2.** *Under Model CB, the equilibrium prices, demands, and profits under different pricing strategies are summarized below.*

**Table 3.** The equilibrium solutions under Model CB.

| | **Strategy D** | **Strategy P** |
|---|---|---|
| $p_1^{CB*}$ | $\frac{2\theta(\theta-\delta)}{4\theta-2\delta(2-\rho)-\rho}$ | $\frac{2(\theta-\delta)\theta}{4\theta-2\delta(2-\rho)-\rho(1+\delta^2)}$ |
| $p_2^{CB*}$ | $\frac{\theta-\delta}{4\theta-2\delta(2-\rho)-\rho}$ | $\frac{(1+\delta)(\theta-\delta)}{4\theta-2\delta(2-\rho)-\rho(1+\delta^2)}$ |
| $d_{m1}^{CB*}$ | $\frac{2\theta-2\delta-\rho(1-2\delta)}{4\theta-2\delta(2-\rho)-\rho}$ | $\frac{2\delta-2\theta+\rho-2\delta\rho+\delta^2\rho}{4\delta-4\theta+\rho-2\delta\rho+\delta^2\rho}$ |
| $d_{s1}^{CB*}$ | $\frac{2\theta-3\delta-\rho(1-2\delta)}{4\theta-2\delta(2-\rho)-\rho}$ | $\frac{2\theta-\delta(3-2\rho)+\delta^2(1-\rho)-\rho}{4\theta-2\delta(2-\rho)-\rho(1+\delta^2)}$ |
| $d_{s2}^{CB*}$ | $\frac{\theta}{4\theta-2\delta(2-\rho)-\rho}$ | $\frac{(1-\delta)\theta}{4\theta-2\delta(2-\rho)-\rho(1+\delta^2)}$ |
| $\Pi^{CB*}/\pi^{CB*}$ | $\frac{\theta(\theta-\delta)}{4\theta-2\delta(2-\rho)-\rho}$ | $\frac{\theta(\theta-\delta)}{4\theta-2\delta(2-\rho)-\rho(1+\delta^2)}$ |

According to Lemmas 1 and 2, we can obtain the following results by comparing the profits of the firm under Models CC and CB in terms of distinct pricing strategy, which shows the channel switching incentive of the dual-channel firm.

**Proposition 1.** *When the firm firstly uses the online channel to sell products,*

*(1) Under dynamic pricing strategy: if* $\delta \leq 1/2$ *he always has an incentive to change his selling strategy into an offline channel (i.e.,* $\Pi^{CC*} \leq \Pi^{CB*}$*); while* $\delta > 1/2$ *he would not change the channel selling strategy (i.e.,* $\Pi^{CC*} > \Pi^{CB*}$*).*

*(2) Under preannounced pricing strategy, he always has an incentive to change his selling strategy to an offline channel in the second period (i.e.,* $\pi^{CC*} < \pi^{CB*}$*).*

Proposition 1 shows that the dual-channel firm has different degrees of motivation to change his channel operations strategy at the beginning of the second period under different pricing strategies when he sells products through the online channel in period 1. Particularly, when the firm adopts a preannounced pricing strategy, he has full willingness to change his channel selling strategy. However, adopting a dynamic pricing strategy will reduce half of the motivation of the firm to use a dynamic channel strategy compared to the preannounced pricing strategy. To be more specific, when consumers' value discount on the second-period

purchasing product is sufficiently low, the firm would like to sell products through an online channel in period 1 while an offline channel in period 2. Conversely, he prefers to sell its products with an online channel over two periods when the value discount of strategic consumers on products is relatively high. Therefore, it can be concluded that the dynamic pricing strategy would reduce the advantage of Channel CB in comparison to the preannounced pricing strategy.

### *4.2. Selling products through offline channel first*

#### *4.2.1. Model BB (No channel switching)*

Under Channel BB, the firm sells its products always through the offline channel in both periods. In this setting, the firm adopting a dynamic pricing strategy first sets the first-period price $p_1^{BB}$ and then decides the second-period price $p_2^{BB}$ over different periods. Similarly, we employ a notation $\Pi_2^{BB}$ to represent the firm's second-period profit, thereby leading to the following firm's second-period pricing problem.

$$\begin{cases} \max\limits_{p_2^{BB}} \Pi_2^{BB} = p_2^{BB} d_{s2}^{BB}(p_2^{BB}|p_1^{BB}) \\ \quad s.t.\ p_2^{BB} < p_1^{BB} \end{cases} \tag{15}$$

In period 1, the firm determines the price $p_1^{BB}$ to maximize its total profit $\Pi^{BB}$ over two periods. The firm's first-period pricing problem is given by:

$$\begin{cases} \max\limits_{p_1^{BB}} \Pi^{BB} = p_1^{BB} d_{m1}^{BB} + p_1^{BB} d_{s1}^{BB} + \Pi_2^{BB*}(p_2^{BB*}|p_1^{BB}) \\ \quad s.t. p_2^{BB} < p_1^{BB} < 1 - \delta + \delta p_2^{BB} \end{cases} \tag{16}$$

where the first (second) term denotes the sale revenue from myopic (strategic) consumers in period 1 and $\Pi_2^{BB*}$ is the firm's equilibrium profit in the second period.

Under preannounced pricing strategy, the dual-channel firm announces the first- and second- period prices in advance. In this situation, the firm's optimal problem over two periods can be expressed as follows.

$$\begin{cases} \max\limits_{p_1^B, p_2^B} \pi^{BB} = p_1^{BB} d_{m1}^{BB} + p_1^{BB} d_{s1}^{BB} + p_2^{BB} d_{s2}^{BB} \\ \quad s.t.\ \ p_2^{BB} < p_1^{BB} < 1 - \delta + \delta p_2^{BB} \end{cases} \tag{17}$$

Similarly, solving the optimization problems of Eq. (15)-Eq. (17) yields the following results shown in Lemma 3.

**Lemma 3.** *Under Model BB, the equilibrium results under different pricing strategies are listed in Table 4.*

**Table 4.** The equilibrium solutions under Model BB.

| | Strategy D | Strategy P |
|---|---|---|
| $p_1^{BB*}$ | $\frac{2(1-\delta\theta)}{4-2\delta\theta(2-\rho)-\theta\rho}$ | $\frac{2}{4-\rho(1-\delta)}$ |
| $p_2^{BB*}$ | $\frac{1-\delta}{4-2\delta(2-\rho)-\rho}$ | $\frac{1+\delta}{4-\rho(1-\delta)}$ |
| $d_{m1}^{BB*}$ | $\frac{2-2\delta(1-\rho)-\rho}{4-2\delta(2-\rho)-\rho}$ | $\frac{2-\rho(1-\delta)}{4-\rho(1-\delta)}$ |
| $d_{s1}^{BB*}$ | $\frac{2-\rho-\delta(3-2\rho)}{4-2\delta(2-\rho)-\rho}$ | $\frac{2-\delta(1-\rho)-\rho}{4-\rho(1-\delta)}$ |
| $d_{s2}^{BB*}$ | $\frac{1}{4-2\delta(2-\rho)-\rho}$ | $\frac{1}{4-\rho(1-\delta)}$ |
| $\Pi^{BB*}$ | $\frac{1-\delta}{4-2\delta(2-\rho)-\rho}$ | $\frac{1}{4-(1-\delta)\rho}$ |

*4.2.2. Model BC (Channel switching)*

Compared to Model CB, the firm sells products first through the offline channel and then through the online channel under Channel BC. In what follows, we first consider the dual-channel firm's dynamic pricing strategy. In this setting, the firm first sets its sale price $p_1^{BC}$ at the beginning of period 1 and then decides the second-period price $p_2^{BC}$ at the start of period 2. The firm's second-period profit is denoted by $\Pi_2^{BC}$. So, the firm's second-period pricing problem can be expressed as below.

$$\begin{cases} \max\limits_{p_2^{BC}} \Pi_2^{BC} = p_2^{BC} d_{s2}^{BC}(p_2^{BC}|p_1^{BC}) \\ \quad s.t. p_2^{BC} < \theta p_1^{BC} \end{cases} \tag{18}$$

Come back to period 1, the firm determines $p_1^{BC}$ to maximize its total profit $\Pi^{BC}$ over two periods. The firm's first-period pricing problem is:

$$\begin{cases} \max\limits_{p_1^{BC}} \Pi^{BC} = p_1^{BC} d_{m1}^{BC} + p_1^{BC} d_{s1}^{BC} + \Pi_2^{BC*}(p_2^{BC*}|p_1^{BC}) \\ \quad s.t.\ p_2^{BC}/\theta < p_1^{BC} < 1 - \delta\theta + \delta p_2^{BC} \end{cases} \tag{19}$$

where the first (second) term denotes the sale revenue from myopic (strategic) consumers in period 1 and $\Pi_2^{BC*}$ is the firm's equilibrium profit in period 2.

Under Strategy P, the firm announces all prices at the start of the first period. Similarly, we can obtain the firm's optimal problem in this setting can be given by:

$$\begin{cases} \max\limits_{p_1^{BC}, p_2^{BC}} \pi^{BC} = p_1^{BC} d_{m1}^{BC} + p_1^{BC} d_{s1}^{BC} + p_2^{BC} d_{s2}^{BC} \\ \quad s.t.\ p_2^{BC}/\theta < p_1^{BC} < 1 - \delta\theta + \delta p_2^{BC} \end{cases} \tag{20}$$

Similarly, solving the optimization problems of Eq. (18)-Eq. (20) yields the following Lemma 4.

**Lemma 4.** *Under Model BC, the equilibrium outcomes under different pricing strategies are given in Table 5.*

**Table 5.** The equilibrium solutions under Model BC.

| | Strategy D | Strategy P |
|---|---|---|
| $p_1^{BC*}$ | $\frac{2(1-\delta\theta)}{4-2\delta\theta(2-\rho)-\theta\rho}$ | $\frac{2(1-\delta\theta)}{4-2\delta\theta(2-\rho)-\theta\rho(1+\delta^2)}$ |
| $p_2^{BC*}$ | $\frac{\theta(1-\delta\theta)}{4-2\delta\theta(2-\rho)-\theta\rho}$ | $\frac{\theta(1+\delta)(1-\delta\theta)}{4-2\delta\theta(2-\rho)-\theta\rho(1+\delta^2)}$ |
| $d_{m1}^{BC*}$ | $\frac{2-2\delta\theta-\theta\rho+2\delta\theta\rho}{4-2\delta\theta(2-\rho)-\theta\rho}$ | $\frac{2-2\delta\theta(1-\rho)-\theta\rho(1+\delta^2)}{4-2\delta\theta(2-\rho)-\theta\rho(1+\delta^2)}$ |
| $d_{s1}^{BC*}$ | $\frac{2-\theta\rho-\delta\theta(3-2\rho)}{4-2\delta\theta(2-\rho)-\theta\rho}$ | $\frac{2-\delta\theta(3-2\rho)+\delta^2\theta(1-\rho)-\theta\rho}{4-2\delta\theta(2-\rho)-\theta\rho(1+\delta^2)}$ |
| $d_{s2}^{BC*}$ | $\frac{1}{4-2\delta\theta(2-\rho)-\theta\rho}$ | $\frac{1-\delta}{4-2\delta\theta(2-\rho)-\theta\rho(1+\delta^2)}$ |
| $\Pi^{BC*}/\pi^{BC*}$ | $\frac{1-\delta\theta}{4-2\delta\theta(2-\rho)-\theta\rho}$ | $\frac{1-\delta\theta}{4-2\delta\theta(2-\rho)-\theta\rho(1+\delta^2)}$ |

Based on Lemmas 3 and 4, we can obtain Proposition 2 by comparing the firm's profits under Models BC and BB in terms of different pricing strategies, which discoveries the channel switching motivation of the dual-channel firm.

**Proposition 2.** *When the firm firstly uses the offline channel to sell products,*

*(1) Under dynamic pricing strategy: if* $\delta \le 1/2$*, he has no willingness to change his selling strategy (i.e.,* $\Pi^{BB*} \ge \Pi^{BC*}$*). While* $\delta > 1/2$*, he would like to change his channel strategy (i.e.,* $\Pi^{BB*} < \Pi^{BC*}$*).*

(2) *Under preannounced pricing strategy, he would never change his selling strategy to an online channel in the second period (i.e.,* $\pi^{BB*} > \pi^{BC*}$*).*

From Proposition 2, it can be found that when the dual-channel firm first utilizes the offline channel to sell products, he has an opposite channel preference in contrast to Proposition 1. Specifically, when the strategic consumers' value discount is relatively low, he prefers to sell his products through the offline channel in both periods. However, it is more advisable for the firm to adopt Channel BC under a higher consumers' value discount. Additionally, we can find from Proposition 2(2) that the firm has also an opposite channel preference under preannounced pricing strategy compared to Proposition 1(2). Put it differently, the firm would never change his channel strategy when he sells products by first using an offline channel under Strategy P. To sum up, it shows that Strategy D can keep a certain advantage of the dynamic channel selling strategy compared with Strategy P when the firm first sells products through an offline channel.

### 4.3. *Firm's optimal pricing strategy*

This subsection aims to explore how different pricing strategies affect the dual-channel firm's profitability in the presence of strategic customers. Comparing the profits between dynamic and preannounced pricing strategies under the same channel structure yields the following result. We also employ numerical examples (see Figs. 3 and 4) to visualize the relevant findings.

**Proposition 3.** *In the presence of strategic consumers, the preannounced pricing strategy outperforms the dynamic pricing strategy under four channel structures (i.e.,* $\pi^{l*} > \Pi^{l*}$*).*

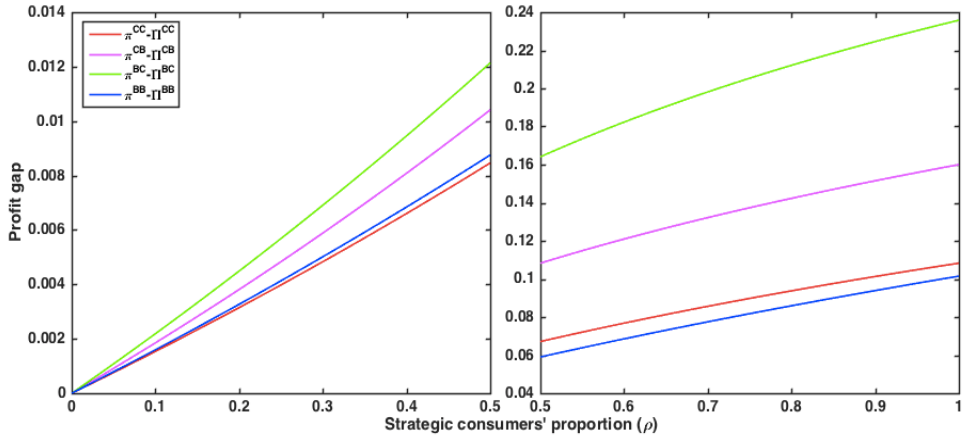



**Fig. 3.** The effects of $\rho$ on profit gaps based on $\theta = 0.9$ and $\delta = 0.4$ (0.8).

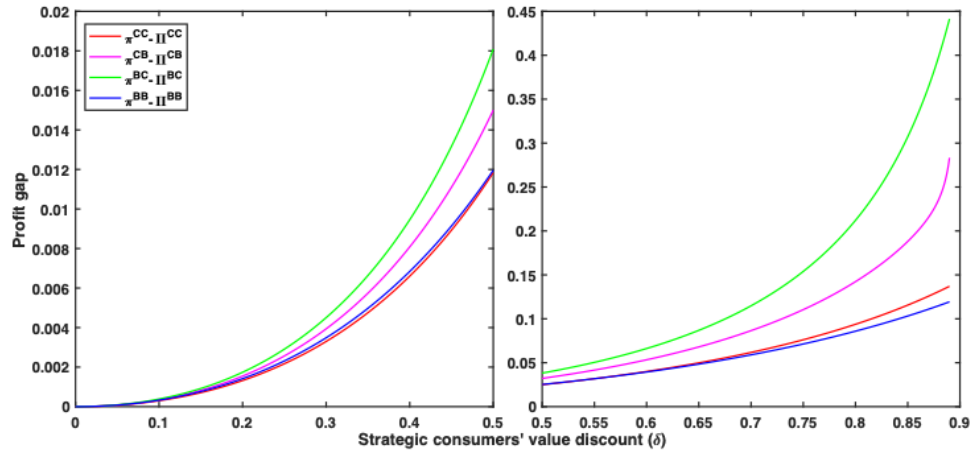



**Fig. 4.** The effects of $\delta$ on profit gaps based on $\theta = 0.9$ and $\rho = 0.4$ (0.8).

Proposition 3 demonstrates that when the dual-channel firm sells his products over two periods, it is more advisable for him to apply a preannounced pricing strategy no matter what kind of channel structure is applied, which has been proved to be a useful tool to fight against strategic consumers. The reason behind this may be that when strategic consumers can not know the second-period price at the beginning of the first period. Due to more uncertainty,

strategic consumers would more like to wait to buy until the second-period price is announced, thereby resulting in more value loss of products. It implies that firms should encourage strategic consumers to buy as early as possible. When a firm announces the second-period price in advance, the strategic consumers can make more accurate purchase decisions. This would reduce the unnecessary waiting of some strategic consumers, thus taking full use of the products by consuming the products early. Therefore, it could be suggested that dual-channel firms should adopt a preannounced pricing strategy when the market includes more strategic consumers. Lastly, Figs. 3 and 4 illustrate that Channel BC could strengthen the advantages of a static pricing strategy mostly as the green lines can get the highest level compared to other channel structures.

From Figs. 3 and 4, we can further obtain the effects of some key system factors regarding strategic consumers on the firm's pricing decisions as shown in Corollary 1.

**Corollary 1.** *The advantage of preannounced pricing strategy is getting more significant as the strategic consumers' proportion ($\rho$) and strategic consumers' value discount ($\delta$) increase.*

It is clear to say that using the preannounced pricing strategy is more beneficial to the firm if there are more strategic consumers and/or they have more patience to wait for a lower price. Moreover, when both $\rho$ and $\delta$ are relatively high, the influence intensity of strategic consumers' proportion and value discount on the firm's pricing decisions obeys the following rules: Channel BC is the most obvious, followed by Channel CB and then Channel CC; they have the lowest effects when the firm adopts Channel BB. This implies that adopting a dynamic channel selling strategy can strengthen the advantage of preannounced pricing strategy, especially when the firm sells products through an offline channel in period 1 and then through an online channel in period 2. Note that when there are fewer strategic consumers and/or the consumers are less strategic (i.e., lower $\rho$ and $\delta$), Channel BB is performing better than Channel CC. It suggests that dual-channel firms should adopt the offline channel over two periods if there are more myopic consumers. However, the dynamic channel selling strategies always outperform the static channel selling strategies. Additionally, we can observe that the growth rate of the effect of strategic consumers' proportion on firm's pricing strategy choice is getting weaker as it is increasing. By contrast, that of strategic consumers' value discount is becoming more significant when it is getting stronger. In other words, the role of $\delta$ is more pronounced than that of $\rho$.

### *4.4. Firm's optimal channel strategy*

In this subsection, we aim at exploring how different channel strategies affect the dual-channel firm's profitability. According to Proposition 3, we have known that the dynamic pricing strategy would never be the optimal option. Additionally, Propositions 1 and 2 have indicated that Channels CC and BC are always inferior to Channels CB and BB, respectively. Therefore, we next just need to compare the firm's profits under the latter two channels to identify the optimal channel strategy for the dual-channel firm.

**Proposition 4.** *There exists a key threshold of* $\theta$ *denoted by* $\overline{\theta}_1 = 2\delta(2-\rho) + \rho(1+\delta^2)/[4-(1-\delta)\rho]$*:*

*(1) When* $max(0, \overline{\theta}_0) < \theta \leq min\,(\overline{\theta}_1, 1)$*, channel CB is the firm's optimal channel strategy;*

*(2) When* $max(\overline{\theta}_0, \overline{\theta}_1) < \theta \leq 1$*, channel BB is the firm's optimal channel strategy.*

Fig. 5 is drawn to illustrate the dual-channel firm's channel strategy choices. Proposition 4 demonstrates that when consumers have a larger channel preference gap between online and offline channels (i.e., lower $\theta$), the firm would like to adopt a dynamic channel selling strategy (i.e., Channel CB) under the preannounced pricing strategy. Otherwise, he prefers to apply a static channel selling strategy (i.e., Channel BB). The reason behind this might be that when the online channel preference is relatively low, the difference that consumers buying from the online and offline channels is relatively high so that the firm can use the online channel to encourage consumers with higher willingness-to-pay to buy in period 1, thereby reducing the use value loss of products. However, when factor $\theta$ is sufficiently high the consumers would have little motivation to distinguish two channels and the strategic consumers still pay more attention to the prices. This implies that enhancing channel differences can reduce the strategic consumers' attention to the price difference so that firms can adopt this strategy to mitigate strategic consumer behavior. For example, the firms can improve his offline channel service level to enhance the differentiation between two channels.

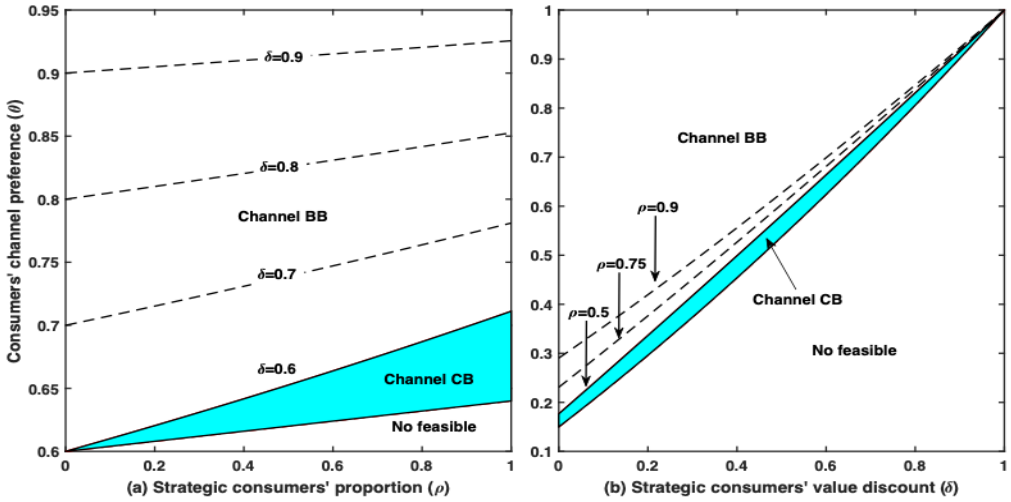



**Fig. 5.** The optimal channel strategy of the dual-channel firm based on $\delta = 0.6$ for (a) or $\rho = 0.6$ for (b).

According to Proposition 4, we can get the effects of strategic consumers' proportion and value discount on the dual-channel firm's optimal channel decisions as shown as below.

**Corollary 2.** *The dual-channel firm has more incentive to adopt a dynamic channel strategy if there are more strategic consumers and/or the consumers become more strategic (i.e.,* $\partial\overline{\theta}_1/\partial\rho > 0$ *and* $\partial\overline{\theta}_1/\partial\delta > 0$*).*

Corollary 2 shows that when there are more strategic consumers and/or they become more strategic, the advantage of the dynamic channel selling strategy is more significant. It implies that Channel CB is more suitable to be used as a strategic tool for the dual-channel firm to deal with strategic consumers. From Fig. 5, we can further find that the impacts of strategic consumers' value discount on the firm's channel decisions are more apparent than the strategic consumers' proportion relative to myopic consumers. It further indicates that the dynamic channel selling strategy is more appropriate to fight against the strategic consumers when their value discount perception on the products purchased in the second period is getting higher.

## 5. Numerical example and sensitivity analysis

This subsection aims at exploring the effects of some critical factors on the firm's optimal profits and consumer surplus numerically.

### *5.1. Effects of key factors on profits*

We here seek how factors $\rho$, $\delta$, and $\theta$ affect the dual-channel firm's profits under different models. By taking the derivatives of the firm's profits $\Pi^{j*}$ and $\pi^{j*}$ with respect to

$\rho$, $\delta$, and $\theta$, respectively (see Appendix), we summarize the results in Table 6 and the numerical examples are performed to facilitate our statements (see Figs. 6-8).

**Table 6.** Sensitivity analysis under different channel structures.

| Factors | Scenario | $\Pi^{CC}$ | $\pi^{CC}$ | $\Pi^{CB}$ | $\pi^{CB}$ | $\Pi^{BC}$ | $\pi^{BC}$ | $\Pi^{BB}$ | $\pi^{BB}$ |
|---|---|---|---|---|---|---|---|---|---|
| $\boldsymbol{\rho}$ | $\delta < 0.5$ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| | $\delta > 0.5$ | ↓ | | ↓ | | ↓ | | ↓ | |
| $\boldsymbol{\delta}$ | $\theta < 0.5$ | ↓ | ↓ | ↑ | ↑ | ↓ | ↓ | ↓ | ↓ |
| | $\theta > 0.5$ | | | ↓ | ↓ then ↑ | | | | |
| $\boldsymbol{\theta}$ | $\delta < 0.5$ | ↑ | ↑ | ↓ then ↑ | ↓ then ↑ | ↑ | ↑ | – | – |
| | $\delta > 0.5$ | | | ↑ | | ↓ | | | |

From Table 6, when the firm adopts a preannounced pricing strategy, his profits under four channel structures increase in strategic consumers' proportion $\rho$. Differently, when the firm uses the dynamic pricing strategy, his profits increase in $\rho$ if the strategic consumers' value discount $\delta$ is relatively low. However, they are decreasing with the raise of $\rho$ when factor $\delta$ is relatively high. Furthermore, it could be found that the profits of the firm under preannounced pricing strategy are always higher than that under a dynamic strategy regardless of the values of $\delta$ and $\rho$.

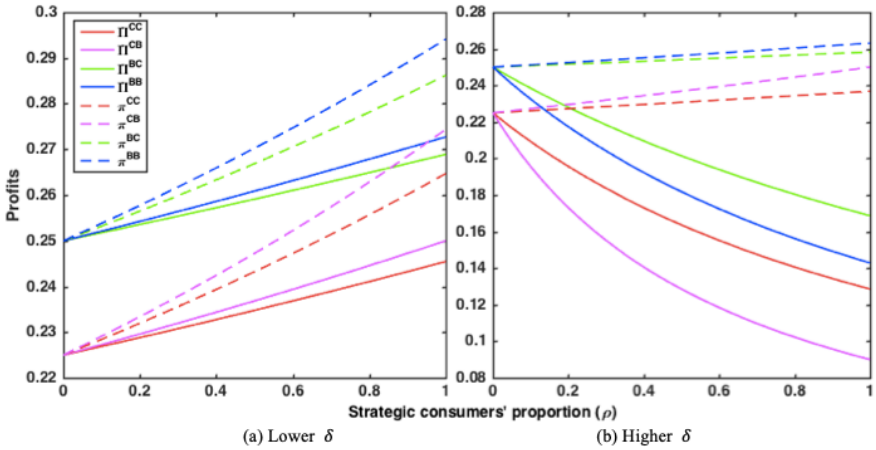



**Fig. 6.** Effects of $\rho$ on the firm's profits based on $\theta = 0.9$ and $\delta = 0.4$ (0.8).

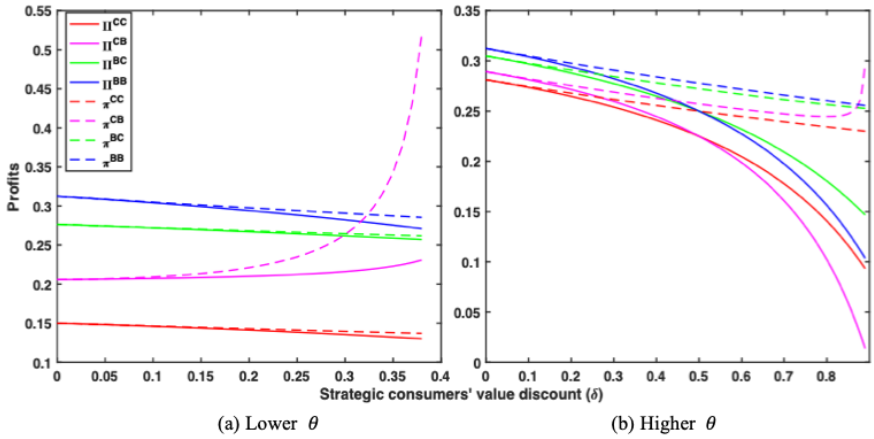
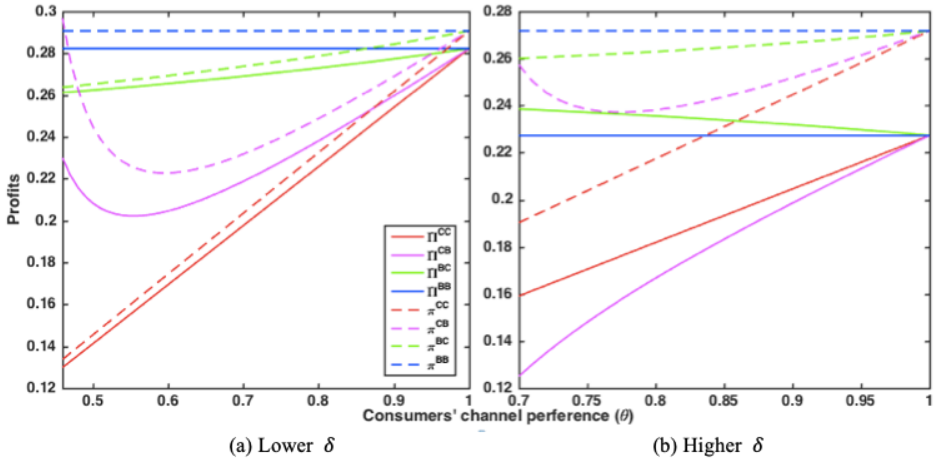



**Fig. 7.** Effects of $\delta$ on the firm's profits $\theta = 0.48\ (0.9)$ and $\rho = 0.8$.

According to Table 6 and Fig. 7, the firm's profits in most situations except for Channel CB are decreasing as the consumers' value discount is increasing, which means that the strategic consumer behavior hurts the firm in most situations. Notably, when the firm adopts Channel CB, it could help him reduce the negative effect of $\delta$ to some extent. Specifically, when $\delta$ is relatively low, a higher consumer's value discount would benefit the firm. However, when $\delta$ is relatively high, this advantage disappears. The reason might be that as we discussed in Proposition 1, the dynamic channel selling strategy can be used as an advanced selling tool to against strategic consumers. Therefore, when the consumers' value discount is relatively low, the advantage of the dynamic channel selling strategy is more evident than the negative effect of consumers' strategic behavior. Conversely, when the consumers' value discount is sufficiently high, the advantage of Strategy D is getting lower than the negative effect of strategic consumer behavior. It is also worth noting that when the firm adopts Channel CB under preannounced pricing strategy, the firm's profit may first decrease then increase. The reason behind this is that Strategy P is also beneficial for the firm to counteract strategic consumers.

It could be observed from Fig. 8 that the firm's profits under Channel BB are unaffected by the consumers' online channel preference. The reason is very intuitive because there is no channel difference. Furthermore, most profits would increase with the rise of factor $\theta$ when both it and the consumers' value discount are sufficiently high (see the right region of Fig. 8) except for the profit under Channel BC under the dynamic pricing strategy. It can also find a special case where the profits under Model CB first decrease and then increase with respect to $\theta$. This trend under dynamic pricing strategy will disappear when $\delta$ is relatively high but that under preannounced pricing strategy still holds. This could be explained by when $\delta$ is

relatively low, the advantage of Channel CB is more obvious so that a lower $\theta$ is better for the firm. On the contrary, a higher $\theta$ would reduce the advantage of Channel CB, thereby leading to some profit loss. Nevertheless, when factor $\delta$ is relatively high, a higher online channel preference means that the consumers more recognize the product value of the company, thus resulting in higher profits.



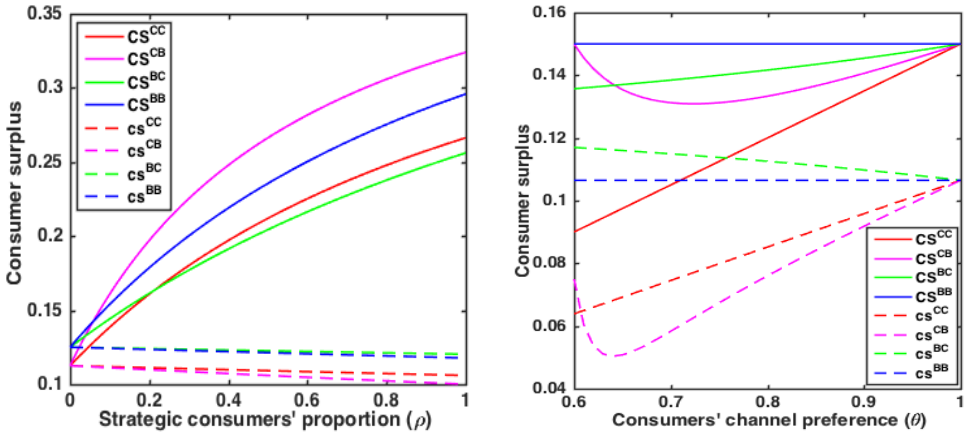

(a) Lower $\delta$ (b) Higher $\delta$

**Fig. 8.** Effects of $\theta$ on the firm's profits based on $\delta = 0.3\ (0.6)$ and $\rho = 0.8$.

### 5.2. *Effects of key factors on consumer surplus*

Due to the complexity of consumer surpluses, we present numerical examples to observe the influences of strategic consumers' proportion and value discount, as well as online channel preference.

From Fig. 9(a), we can find that the consumer surpluses are increasing under the dynamic pricing strategy but decreasing under the preannounced pricing strategy as the strategic consumers' proportion increases, which is the opposite of that on the firm's profits when strategic consumers' value discount is relatively high. This implies that the firm adopting a preannounced pricing strategy can enhance his own profit by extracting more consumer surpluses. Fig. 9(b) demonstrates that the impacts of online channel preference on surpluses are similar to that on the firm's profits. Both imply that a higher online channel preference is better for the firm and consumers in most situations.




(a) (b)

**Fig. 9.** Effects of $\rho$ and $\theta$ on consumer surplus based on $\theta = 0.9$ and $\delta = 0.8$ for (a) and $\delta = 0.5$ and $\rho = 0.8$ for (b).

Fig. 10 indicates that the consumer surpluses almost are increasing as the strategic consumers' value discount increases except for Channel CB under preannounced pricing strategy. Specifically, it first increases and then decreases along with $\delta$, which is the opposite of that on the firm's profits in certain scenarios. This implies that when the firm adopts a channel strategy CB, higher strategic consumer behavior may yield greater revenue for him. To sum up, the effects of factors $\rho$ and $\delta$ on the firm's profits are opposite to that on consumer surpluses, while the effects of factor $\theta$ on the firm's profits are very similar to that on consumer surpluses.

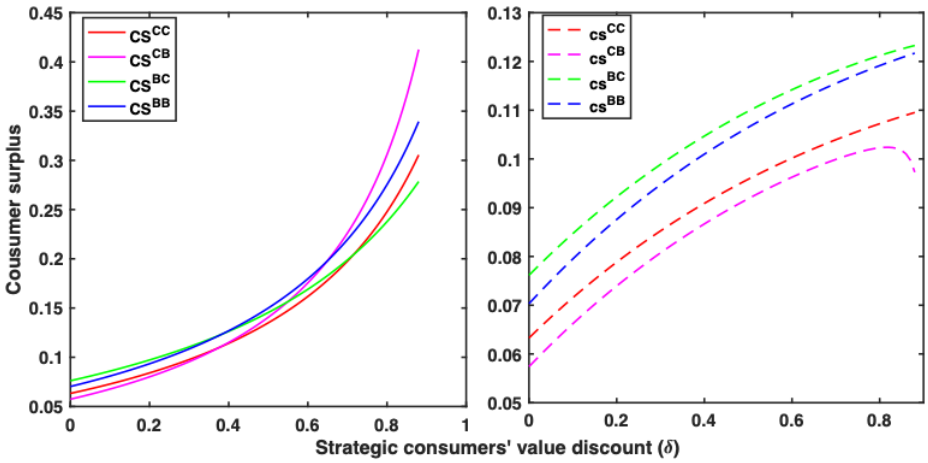



**Fig. 10.** Effects of $\delta$ on consumer surplus based on $\theta = 0.9$ and $\rho = 0.8$.

## 6. Discussion on channel switching cost

In the basic models, we assume that there is no cost when the firm changes his selling strategy from an online (offline) channel to an offline (online) one. In this section, we will relax this assumption to investigate how the possible channel switching cost affects the firms' optimal channel strategy choices. To focus on Channels CB and BB, we further consider that

when the dual-channel firm adopts Channel CB, he will occur a lump sum cost denoted by $f$, which can be referred to as channel switching cost. However, it is reasonable that there is no other cost when he applies Channel BB. We hereafter mainly test the robustness when the firm uses a preannounced pricing strategy. Consequently, we can obtain the following results.

**Proposition 5.** *Considering the channel switching cost, there exists a key threshold of* $f$*:*
*(1) When* $0 < \theta \le \overline{\theta}_1$ *and* $f \le \overline{f}_1$*, channel CB is the firms' optimal channel strategy;*
*(2) When* $0 < \theta \le \overline{\theta}_1$ *but* $f > \overline{f}_1$*, channel BB is always the firms' optimal channel strategy;*
*(3) When* $\overline{\theta}_1 < \theta \le 1$*, channel BB is the firms' optimal channel strategy;*

*where* $\overline{f}_1 = \frac{(1-\theta)(\rho+\delta^2\rho-\theta(4-\rho)+\delta(4-(2+\theta)\rho))}{(4-(1-\delta)\rho)(4\theta-2\delta(2-\rho)-\rho-\delta^2\rho)}$ *and* $\overline{\theta}_1 = \frac{2\delta(2-\rho)-\rho(1+\delta^2)}{4-(1-\delta)\rho}$.

Proposition 5 shows that the channel switching cost would decrease the opportunity for the firm to utilize a dynamic channel strategy CB. When the channel switching cost is sufficiently high, the firm would never adopt the dynamic channel selling strategy. On the contrary, the previous research results still hold. This is very straightforward because the channel switching cost would reduce the advantage of the dynamic channel selling strategy to some extent. We further investigate how the key system factors affect the threshold of $f$ by taking the first-order of $\theta$. The results are listed in Corollary 3.

**Corollary 3.** *When* $2\theta < \delta \le 1$ *or* $\delta < 2\theta$ *&* $\rho > 4(\delta-\theta)^2/(1-\delta)^2(2\theta-\delta)$*, the upper bound* $\overline{f}_1$ *increases in online channel preference; when* $\delta < 2\theta$ *and* $\rho < 4(\delta-\theta)^2/(1-\delta)^2(2\theta-\delta)$*, the upper bound* $\overline{f}_1$ *decreases in online channel preference.*

Corollary 3 uncovers the effects of online channel preference on the upper bound of channel switching cost. When consumers are very strategic, the upper bound $\overline{f}_1$ is increasing along with online channel preference regardless of strategic consumers' proportion. It means that if consumers are more likely to buy products from the online channel, the firm has more opportunities to implement a dynamic channel selling strategy. By contrast, the strategic consumers' proportion makes sense when consumers are less strategic. In this setting, when the strategic consumers' proportion is relatively high, the former result still holds. Counter-intuitively, the upper bound $\overline{f}_1$ is decreasing with the rise of the online channel preference when the strategic consumers' proportion is relatively low. In other words, the firm would have less opportunity to use a dynamic channel selling strategy. The rationale may be that when the strategic consumer's amount in the market is relatively small, there is less

incentive for the firm to consider the strategic consumers so that he would like to keep channel consistent over two periods to reduce the operational cost.

## 7. Conclusions and managerial implications

### *7.1. Conclusions*

This paper investigates a dual-channel firm's joint pricing and channel decisions over two periods by considering strategic consumers when there are four channel components available viz., channels CC, CB, BC and BB. To identify the firm's optimal channel and pricing strategies, we establish four game-theoretical models. Under each model, we derive the demands of different consumer types and develop the firm's optimization problems under the dynamic and preannounced pricing strategies, respectively. Based on the equilibria, we identify the firm's optimal channel and pricing strategies under specific conditions. Furthermore, we numerically examine the influences of some key factors on the firm's profitability and consumer surplus. The main research results show that the preannounced pricing strategy is always performing better than the dynamic pricing strategy and the dual-channel firm would like to first sell products through the online channel and then through the offline channel under the preannounced pricing strategy when the gap between the online and offline channels is relatively high. The extension indicates that channel switching cost would reduce the chance that Channel CB is better for the firm but the main results still hold qualitatively.

### *7.2. Managerial insights*

With the maturity and popularity of e-commerce, more and more firms have established the online and offline channels and the product managers have attempted to sell their products through separate channels over different periods. We demonstrate that when a dual-channel firm utilizes an online channel to sell a specific type of product in the first period, he had better change his previous channel into an offline channel in the next period under the preannounced pricing strategy. Under the dynamic pricing strategy, he also should change his channel strategy if the strategic consumers' value discount is relatively low; otherwise, he should keep using the online channel in both periods. These insights would change to the opposite when the dual-channel firm firstly employs an offline channel to sell items. Specifically, the firm should always utilize the offline channel in both periods under the preannounced pricing strategy. When the firm adopts a dynamic pricing strategy, he should change his channel strategy in the second period if the strategic consumers' value discount is

relatively high; otherwise, he had better adopt the same channel strategy over two periods. Moreover, it suggests that dual-channel firms should announce all prices in the first period to lure people to buy early if the market exists more strategic consumers. Most importantly, we confirm that a dynamic channel selling strategy along with a preannounced pricing strategy may benefit the firms who have online and offline channels to mitigate the strategic consumer behavior. Particularly, when the difference between two channels is relatively high, the dual-channel firm had better sell products first through the online channel and then through the offline channel (i.e., Channel CB). Conversely, they should always use an offline channel to sell products. Therefore, it suggests that dual-channel firms could enhance the channel differentiation through providing different services to counter strategic consumers by using Channel CB.

### *7.3. Future research*

Certainly, this research has some challenges that need to be further studied in the future. The current work considers a monopolist firm without any downstream distributor. In practice, companies may sell products through offline retailers. It would be interesting and challenged to extend this research framework to a supply chain and study the influences of vertical cooperation on the firms' channel strategy choices and pricing decisions. Moreover, this study assumes that the firm doesn't introduce any new product in period two. However, some companies may announce new competitive products in the second period. Hence, another complex situation is to consider the firm's new generation product competition. Finally, inventory management would be also used as a tool to alleviate strategic consumer behavior. So, it would be meaningful and challenging to explore the joint value of firm's possible inventory strategies (e.g., hunger marketing) and channel strategies over different periods in the future.

## Declarations of interest

None.

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# Appendix

**Proof of Lemma 1**

Under the dynamic pricing strategy, the firm first sets $p_2^{CC}$ to maximize the second-period profit. Taking the first- and second-order derivatives of $\Pi_2^{CC}$ with respect to $p_2^{CC}$ yields $d^2\Pi_2^{CC}/d(p_2^{CC})^2 = -2\rho/\theta(1-\delta) < 0$, which means the $\Pi_2^{CC}$ is concave in $p_2^{CC}$. Hence, we can obtain the optimal responsive second-period price $p_2^{CC*} = p_1^{CC}/2$. We plug this optimal reaction into Eq. (4) and take the first- and second-order derivatives of $\Pi^{CC}$ with respect to $p_1^{CC}$ to obtain $d^2\Pi^{CC}/d(p_1^{CC})^2 = [2\delta(2-\rho)+\rho-4]/2(1-\delta)\theta < 0$. According to the first-order condition, we can get the optimal first-second price $p_1^{CC*}$ and substitute $p_1^{CC*}$ into the optimal responsive second-period price result in the $p_2^{CC*}$.

Under the preannounced pricing strategy, taking the first- and second-order derivatives of $\pi^{CC}$ with respect to $p_2^{CC}$ and $p_2^{CC}$ yields the following Hessian matrix $H^{CC} = \begin{bmatrix} \frac{2[1-\delta(1-\rho)]}{-(1-\delta)\theta} & \frac{(1+\delta)\rho}{(1-\delta)\theta} \\ \frac{(1+\delta)\rho}{(1-\delta)\theta} & \frac{-2\rho}{(1-\delta)\theta} \end{bmatrix}$. It is clear that $\frac{\partial^2\pi^{CC}}{\partial(p_1^{CC})^2} = \frac{2[1-\delta(1-\rho)]}{-(1-\delta)\theta} < 0$ and $|H^{CC}| = \frac{\rho(4-\rho+\delta\rho)}{(1-\delta)\theta^2} > 0$. Thus, the first-order conditions can give the optimal price.

Because the solution processes of remaining lemmas are similar to this case, next we just provide the conditions that ensure the optimal solutions of problems exist.

**Proof of Lemma 2**

Under Strategy D, it is easy to find that $\frac{d^2\Pi_2^{CB}}{d(p_2^{CB})^2} = \frac{2\theta\rho}{\delta-\theta} < 0$ and $\frac{d^2\Pi^{CB}}{d(p_1^{CB})^2} = \frac{4\theta-2\delta(2-\rho)-\rho}{-2\theta(\theta-\delta)} < 0$. We assume that $\theta > \overline{\theta}_0 = [4\delta+\rho-\delta\rho(2-\delta)]/4$, so $d^2\Pi^{CB}/d(p_1^{CB})^2 < 0$. Under Strategy P, we can obtain $\frac{\partial^2\pi^{CB}}{\partial(p_1^{CB})^2} = \frac{2(\theta-\delta(1-\rho))}{-\theta(\theta-\delta)} < 0$ and $|H^{CB}| = \frac{\rho(4\theta-2\delta(2-\rho)-\rho-\delta^2\rho)}{(\delta-\theta)^2} > 0$.

**Proof of Proposition 1**

Under Strategy D or P, comparisons of profits in channel CC and CB yields the following equations:

$$\Pi^{CC*} - \Pi^{CB*} = \frac{(2\delta-1)(1-\theta)\theta\rho}{[4-2\delta(2-\rho)-\rho][4\theta-2\delta(2-\rho)-\rho]} \tag{A.1}$$

$$\pi^{CC*} - \pi^{CB*} = \frac{-(1-\delta)(1-\theta)\theta\rho}{(4-(1-\delta)\rho)(4\theta-2\delta(2-\rho)-\rho-\delta^2\rho)} < 0 \tag{A.2}$$

From Eq. (A.1), we can obtain that when $\delta \leq 1/2$, then $\Pi^{CC*} \leq \Pi^{CB*}$. Otherwise, we can get $\Pi^{CC*} > \Pi^{CB*}$.

**Proof of Lemma 3**

Under Strategy D, it is easy to find that $\frac{d^2\Pi_2^{BB}}{d(p_2^{BB})^2} = \frac{-2\rho}{1-\delta} < 0$ and $\frac{d^2\Pi^{BB}}{d(p_1^{BB})^2} = \frac{4-2\delta(2-\rho)-\rho}{-2(1-\delta)} < 0$.

Under Strategy P, we can obtain $\frac{\partial^2\pi^{BB}}{\partial(p_1^{BB})^2} = \frac{2(1-\delta(1-\rho))}{-(1-\delta)} < 0$ and $|H^{BB}| = \frac{\rho(4-\rho+\delta\rho)}{1-\delta} > 0$.

**Proof of Lemma 4**

Under Strategy D, it is easy to find that $\frac{d^2\Pi_2^{BC}}{d(p_2^{BC})^2} = \frac{-2\rho}{\theta(1-\delta\theta)} < 0$ and $\frac{d^2\Pi^{BC}}{d(p_1^{BC})^2} = \frac{4-2\delta\theta(2-\rho)-\theta\rho}{-2+2\delta\theta} < 0$. Under Strategy P, we can obtain $\frac{\partial^2\pi^{BC}}{\partial(p_1^{BC})^2} = \frac{2(1-\delta\theta(1-\rho))}{-1+\delta\theta} < 0$ and $|H^{BC}| = \frac{\rho(4-2\delta\theta(2-\rho)-\theta\rho-\delta^2\theta\rho)}{\theta(1-\delta\theta)^2} > 0$.

**Proof of Proposition 2**

Under Strategy D or P, comparisons of profits in channel BB and BC yield the following equations:

$$\Pi^{BB*} - \Pi^{BC*} = \frac{(1-\theta)(1-2\delta)\rho}{[4-2\delta(2-\rho)-\rho][4-2\delta\theta(2-\rho)-\theta\rho]} \tag{A.3}$$

$$\pi^{BB*} - \pi^{BC*} = \frac{(1-\delta)(1-\theta)\rho}{(4-(1-\delta)\rho)(4-2\delta\theta(2-\rho)-\theta\rho-\delta^2\theta\rho)} > 0 \tag{A.4}$$

From Eq. (A.3), we can obtain that when $\delta \leq 0.5$, then $\Pi^{BB*} \geq \Pi^{BC*}$. Otherwise, we can get $\Pi^{BB*} < \Pi^{BC*}$.

**Proof of Proposition 3**

Under four channel structures, comparing profits under the dynamic and preannounced pricing strategies, we can obtain the following equations:

$$\pi^{CC*} - \Pi^{CC*} = \frac{\delta^2\theta\rho}{(4+2\delta(-2+\rho)-\rho)(4+(-1+\delta)\rho)} > 0 \tag{A.5}$$

$$\pi^{CB*} - \Pi^{CB*} = \frac{\delta^2(\delta-\theta)\theta\rho}{(4\theta+2\delta(-2+\rho)-\rho)(-4\theta-2\delta(-2+\rho)+\rho+\delta^2\rho)} > 0 \tag{A.6}$$

$$\pi^{BC*} - \Pi^{BC*} = \frac{\delta^2\theta(-1+\delta\theta)\rho}{(4+2\delta\theta(-2+\rho)-\theta\rho)(-4-2\delta\theta(-2+\rho)+\theta\rho+\delta^2\theta\rho)} > 0 \tag{A.7}$$

$$\pi^{BB*} - \Pi^{BB*} = \frac{\delta^2\rho}{(4-2\delta(2-\rho)-\rho)(4-(1-\delta)\rho)} > 0 \tag{A.8}$$

**Corollary 1** can be obtained by observed from Figs. 3 and 4.

**Proof of Proposition 4**

Under the preannounced pricing strategy, we can get the following result by comparing the profits in channel CB and BB.

$$\pi^{CB*} - \pi^{BB*} = \frac{(1-\theta)(\rho+\delta^2\rho+\delta(4-(2+\theta)\rho)-\theta(4-\rho))}{(4-(1-\delta)\rho)(4\theta-2\delta(2-\rho)-\rho-\delta^2\rho)} \tag{A.9}$$

We set $f(\theta) = \rho + \delta^2\rho + \delta(4-(2+\theta)\rho) - \theta(4-\rho)$. Solving the equation $f(\theta) = 0$, we can have $\overline{\theta}_1 = \frac{2\delta(2-\rho)+\rho(1+\delta^2)}{4-(1-\delta)\rho}$. When $\theta \leq \overline{\theta}_1$, we derive $\pi^{CB*} \geq \pi^{BB*}$. On the contrary, we have $\pi^{CB*} < \pi^{BB*}$ if $\theta > \overline{\theta}_1$.

**Proof of Corollary 2**

Taking the first-order derivative of $\overline{\theta}_1$ with respect to $\rho$ and $\delta$, we have $\partial\overline{\theta}_1/\partial\rho =$

$\frac{4(1-\delta)}{(4-(1-\delta)\rho)^2} > 0$ and $\frac{\partial \overline{\theta}_1}{\partial \delta} = \frac{16-4(3-2\delta)\rho+(1-\delta)^2\rho^2}{(4-(1-\delta)\rho)^2} > 0$.

**Proof of Sensitivity Analysis**

$\frac{\partial \Pi^{CC*}}{\partial \rho} = \frac{(1-2\delta)(\theta-\delta\theta)}{(4-2\delta(2-\rho)-\rho)^2}$; $\frac{\partial \Pi^{CC*}}{\partial \delta} = \frac{-\theta\rho}{(4-2\delta(2-\rho)-\rho)^2}$; $\frac{\partial \Pi^{CC*}}{\partial \theta} = \frac{1-\delta}{4-2\delta(2-\rho)-\rho}$; $\frac{\partial \pi^{CC*}}{\partial \rho} = \frac{(1-\delta)\theta}{(4-(1-\delta)\rho)^2}$;

$\frac{\partial \pi^{CC*}}{\partial \delta} = \frac{-\theta\rho}{(4-(1-\delta)\rho)^2}$; $\frac{\partial \pi^{CC*}}{\partial \theta} = \frac{1}{4-(1-\delta)\rho}$; $\frac{\partial \Pi^{CB*}}{\partial \rho} = \frac{(1-2\delta)(\theta-\delta)\theta}{(4\theta-2\delta(2-\rho)-\rho)^2}$; $\frac{\partial \Pi^{CB*}}{\partial \delta} = \frac{(1-2\theta)\theta\rho}{(4\theta-2\delta(2-\rho)-\rho)^2}$;

$\frac{\partial \Pi^{CB*}}{\partial \theta} = \frac{2\theta(2\theta-\rho)+2\delta^2(2-\rho)-\delta(4\theta(2-\rho)-\rho)}{(4\theta-2\delta(2-\rho)-\rho)^2}$; $\frac{\partial \pi^{CB*}}{\partial \rho} = \frac{(1-\delta)^2(\theta-\delta)\theta}{(4\theta-2\delta(2-\rho)-\rho-\delta^2\rho)^2}$; $\frac{\partial \pi^{CB*}}{\partial \delta} =$

$\frac{(1-\delta)(1+\delta-2\theta)\theta\rho}{(4\theta-2\delta(2-\rho)-\rho-\delta^2\rho)^2}$; $\frac{\partial \pi^{CB*}}{\partial \theta} = \frac{2\theta(2\theta-\rho)+\delta^3\rho-\delta(4\theta(2-\rho)-\rho)+2\delta^2(2-\rho-\theta\rho)}{(4\theta-2\delta(2-\rho)-\rho-\delta^2\rho)^2}$; $\frac{\partial \Pi^{BC*}}{\partial \rho} =$

$\frac{(1-2\delta)\theta(1-\delta\theta)}{(4-2\delta\theta(2-\rho)-\theta\rho)^2}$; $\frac{\partial \Pi^{BC*}}{\partial \delta} = \frac{-(2-\theta)\theta\rho}{(4-2\delta\theta(2-\rho)-\theta\rho)^2}$; $\frac{\partial \Pi^{BC*}}{\partial \theta} = \frac{\rho(1-2\delta)}{(4-2\delta\theta(2-\rho)-\theta\rho)^2}$; $\frac{\partial \pi^{BC*}}{\partial \rho} =$

$\frac{(1-\delta)^2\theta(1-\delta\theta)}{(4-2\delta\theta(2-\rho)-\theta\rho-\delta^2\theta\rho)^2}$; $\frac{\partial \pi^{BC*}}{\partial \delta} = \frac{-(1-\delta)\theta(2-\theta-\delta\theta)\rho}{(4-2\delta\theta(2-\rho)-\theta\rho-\delta^2\theta\rho)^2}$; $\frac{\partial \pi^{BC*}}{\partial \theta} = \frac{(1-\delta)^2\rho}{(4-2\delta\theta(2-\rho)-\theta\rho-\delta^2\theta\rho)^2}$;

$\frac{\partial \Pi^{BB*}}{\partial \rho} = \frac{(1-\delta)(1-2\delta)}{(4-2\delta(2-\rho)-\rho)^2}$; $\frac{\partial \Pi^{BB*}}{\partial \delta} = \frac{-\rho}{(4-2\delta(2-\rho)-\rho)^2}$; $\frac{\partial \Pi^{BB*}}{\partial \theta} = 0$; $\frac{\partial \pi^{BB*}}{\partial \rho} = \frac{1-\delta}{(4-(1-\delta)\rho)^2}$; $\frac{\partial \pi^{BB*}}{\partial \delta} =$

$\frac{-\rho}{(4-(1-\delta)\rho)^2}$; $\frac{\partial \pi^{BB*}}{\partial \theta} = 0$;

By distinguishing the signs of the above expressions, we can obtain Table 6.

**Proof of Proposition 5**

Under the preannounced pricing strategy, we can obtain the following result by comparing the profits in channel CB and BB when considering the channel switching cost.

$$\pi^{CB*} - \pi^{BB*} = \frac{(1-\theta)\left(\rho+\delta^2\rho+\delta(4-(2+\theta)\rho)-\theta(4-\rho)\right)}{(4-(1-\delta)\rho)(4\theta-2\delta(2-\rho)-\rho-\delta^2\rho)} - f \tag{A.10}$$

We define $\overline{f}_1 = \frac{(1-\theta)(\rho+\delta^2\rho-\theta(4-\rho)+\delta(4-(2+\theta)\rho))}{(4-(1-\delta)\rho)(4\theta-2\delta(2-\rho)-\rho-\delta^2\rho)}$, so it is easy to obtain Proposition 5.

**Proof of Corollary 3**

Taking the first-order derivative of $\overline{f}_1$ with respect to $\theta$, we can obtain the following result.

$\frac{\partial \overline{f}_1}{\partial \theta} = \frac{2\theta(2\theta-\rho)+\delta^3\rho-\delta(4\theta(2-\rho)-\rho)+2\delta^2(2-\rho-\theta\rho)}{(4\theta-2\delta(2-\rho)-\rho-\delta^2\rho)^2}$ . We define $f(\rho) = 2\theta(2\theta-\rho)+\delta^3\rho-\delta(4\theta(2-\rho)-\rho)+2\delta^2(2-\rho-\theta\rho)$. Solving the equation $f(\rho)=0$, we have $\rho = \frac{4(\delta-\theta)^2}{(1-\delta)^2(2\theta-\delta)}$. Hence, it is easy to discuss the sign of $\frac{\partial \overline{f}_1}{\partial \theta}$ so that we obtain Corollary 3**.**