Int. J. Production Economics 280 (2025) 109479

Contents lists available at ScienceDirect

International Journal of Production Economics

journal homepage: www.elsevier.com/locate/ijpe

Dual pricing with purchase hassle

Xuelan Zhang [a], Jun Lin [a,*], Yifu Li [b]

[a] School of Management, Xi'an Jiaotong University, Xi'an, 710049, China
[b] International Institute of Finance, School of Management, University of Science and Technology of China, Hefei, 230026, China

ARTICLE INFO

Keywords:
Dual pricing
Hassle cost
Price discrimination
Consumer self-selection

ABSTRACT

Previous research indicates that hassle cost reduces consumers' utility and hurts sellers' profits. However, counterintuitively, some sellers, particularly those who sell online, purposefully increase the hassle cost of purchasing their products. Our work examines how sellers effectively apply dual pricing with purchase hassle to increase their profit and how it affects consumers' purchasing decisions and utility. Different from previous studies, we take into account both the heterogeneities of consumers' product valuations and hassle costs. We find that when consumers' hassle costs are independent of their product valuations, decrease or concavely increase in the product valuations, dual pricing with purchase hassle reduces sellers' profits. When consumers' hassle costs are convex increasing in their product valuations and the relative increasing rate is high, sellers can obtain additional profit through dual pricing. Moreover, under dual pricing, consumers' utility is non-monotonic in their product valuations. Finally, we extend our model to the case where the former full price is kept while switching to dual pricing, the case with network effects, the case where the cost to sellers of offering dual pricing is higher than single pricing, as well as the implications on consumer surplus. In these cases, our findings remain applicable.

1. Introduction

Recently, many sellers offer consumers the opportunity to choose whether to purchase a product at the full price or the discounted price with hassle. For example, Didi, the largest online car-hailing platform in China, gives consumers two choices when they hail a car on the app, hailing at the full price or at the discounted price, as shown in Fig. 1. Consumers can tap the task button to obtain a coupon before taking a trip (Fig. 1(b)). While the coupon information is shown conspicuously on the homepage (Fig. 1(a)), it takes time for consumers to get and use the coupon. The platform can adjust the purchase hassle by adjusting the effort needed to obtain and use the coupon. Consumers who take the hassle can get the vouchers and order the transportation service at a discounted price, while others who do not take the hassle will buy at the full price.

Many e-commerce sites adopt similar strategies. In coupon search websites, such as coupon zone of Amazon*, Ma Reduc and so on, consumers have to log into a specific website to obtain the coupons or the discount code if they want to purchase at a discounted price. Otherwise, they can only purchase at full price with few hassle costs. Rakuten, the largest cashback website in the United States, offers rebates to consumers. To qualify for these rebates, users must log into their Rakuten account before making a purchase; otherwise, they will not be eligible for cashback. Another example is e-commerce live streaming in Taobao, which usually offers coupons or discounted prices for audiences exclusively. Consumers can purchase the product at a discounted price, but they need to fulfill certain requirements during the live streaming, such as entering specific words requested by the sellers, watching the live streaming for more than 1 minute, and making the purchase through an exclusive link. This introduces more hassle than just click and buy, and sellers have the ability to change this hassle by adjusting the requirements or stepts. Alternatively, consumers can choose to purchase directly from the official website at a higher price but with less hassle.

The aforementioned examples are notable in that the same seller provides two prices for the same goods at the same time. If the consumer wants to buy the product at the discounted price, she has to experience an additional hassle, which is intentionally introduced by the seller. For example, Didi, as mentioned earlier, offers different prices to consumers depending on whether they are willing to complete the task. Pinduoduo, an integrated e-commerce platform in China, provides discounts only to

* Corresponding author.
E-mail addresses: zxuelan@stu.xjtu.edu.cn (X. Zhang), ljun@xjtu.edu.cn (J. Lin), yifuli@ustc.edu.cn (Y. Li).

* The Address of Amazon's Coupon Zone: http://www.amazon.com/coupons.

https://doi.org/10.1016/j.ijpe.2024.109479
Received 28 May 2024; Received in revised form 18 November 2024; Accepted 20 November 2024
Available online 22 November 2024

consumers who share the link with several friends. Many merchants publish discount codes on major discount websites, such as Shopify and Ma Reduc, offering discounts only to consumers who enter the code during checkout. We call this strategy the dual pricing strategy with purchase hassle. For simplicity, we refer to the strategy as the dual pricing strategy in the absence of ambiguity. Another feature in these examples is that every consumer can buy the product at the discounted price if she takes on the hassle. The hassle includes searching for coupons or discount codes (i.e., Amazon's Coupon Zone, Ma Reduc), sharing links with friends (i.e., Pinduoduo), logging into the cashback website before making a purchase (i.e., Rakuten), and so on. Naturally, there are certain consumers who are unwilling to take on the hassle and purchase at the full price. In this way, the additional hassle required to obtain discounts encourages consumers to select different purchase prices, thereby acting as a tool for price discrimination and assisting sellers in distinguishing between consumers.

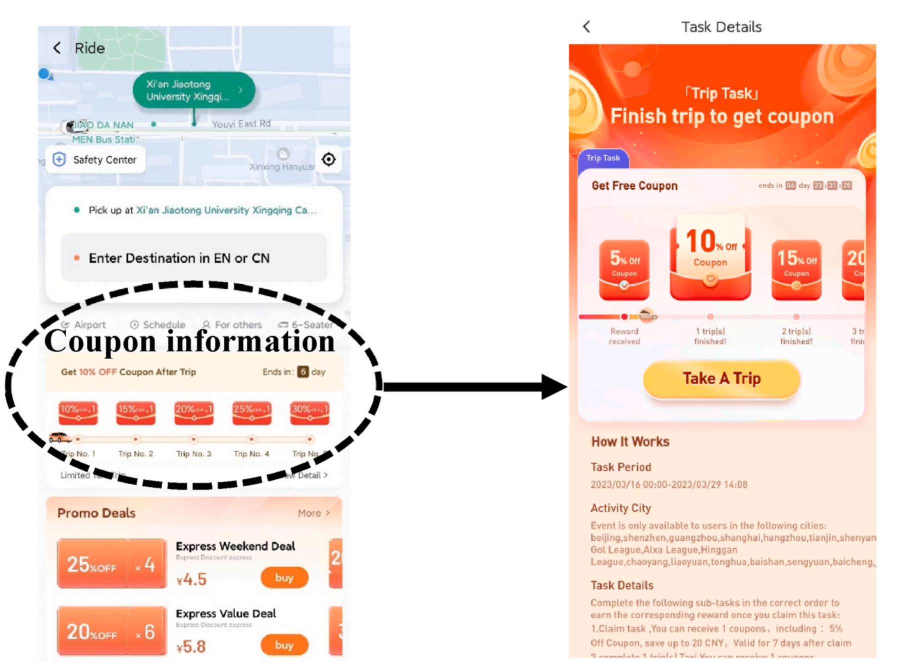
Dual pricing differs from traditional price discrimination on ethical concerns. In traditional price discrimination, sellers determine which consumers receive discounts and which must pay the full price (Anderson and Dana, 2009). This is viewed as unfair (Cohen et al., 2022). In contrast, dual pricing with purchase hassle gives consumers the right to choose between the discounted or full prices based on their perceived hassle. In this way, the hassle acts as the tool for price discrimination, which leads consumers with different hassle sensitivity to purchase at different prices. Additionally, this difference can alleviate consumer dissatisfaction to some extent.

Hassle costs are common in shopping and are typically regarded as obstacles for consumers to buy products because they temper consumer utility (Anderson and Song, 2004; Dukes and Zhu, 2019; Wang and Hu, 2020). Therefore, sellers usually try their best to reduce consumers' hassle costs to incentive procurement. Many studies also view hassle costs as exogeneous and investigate how to reduce hassle costs in the purchase process (Gao and Su, 2017; Wang and Hu, 2020). Counterintuitively, when applying the dual pricing strategy, the sellers do the opposite; that is, they intentionally increase the purchase hassle costs of the consumers who buy at a discounted price. Furthermore, advances in electronic information technology and changes in shopping methods have made dual pricing with purchase hassle viable. For instance, sellers can create tasks associated with discount vouchers, identify the consumers who have completed these tasks, and issue vouchers exclusively to them. However, these situations-where hassle costs are intentionally designed and used as a tool for price discrimination, as illustrated in the aforementioned examples-are seldom discussed in the literature. To fill this gap, we investigate the dual pricing strategy with purchase hassle. We aim to answer the following research questions:

1. Under what circumstances the dual pricing strategy with purchase hassle is more profitable than the single pricing strategy?
2. How should sellers set the dual prices and the purchase hassle?
3. How does this dual pricing strategy affect consumer utility?

To answer these questions, we developed an analytical model in which hassle cost is described with hassle level and hassle sensitivity. The hassle level is designed by the seller. For example, Didi can alter the hassle level by changing the settings of the task button. In the case mentioned above (as illustrated in Fig. 1), the ease of obtaining a discount coupon by simply clicking a button made the discount more appealing, thereby attracting a large number of consumers to use the service at a discounted price. Didi has also offered a button-click option to join an exclusive community in WeChat to obtain a voucher. This approach has a higher hassle level and reduces the attractiveness of discount, but it also limits the number of customers who can purchase at the discounted price. Hassle sensitivity reflects consumers' acceptance level on taking the hassle to purchase at the discounted price. We assume that consumers are heterogenous in their hassle sensitivity. The hassle sensitivity can be either product-valuation-independent (PVI) or product-valuation-dependent (PVD). We analyze the optimal prices and hassle level and compare the expected maximum profits and social welfare under the single and dual pricing strategies with both the PVI and PVD hassle sensitivities.

We summarize the main results below. First, if consumers' hassle sensitivity is PVI, we find that the dual pricing strategy is less profitable than the single pricing strategy. The reason is that the seller cannot screen the consumers with different product valuations because of the



(a) The Homepage on Didi (b) The Details of the Coupons

Fig. 1. An example of the dual pricing strategy in Didi.

independence between consumers' hassle cost sensitivity and product valuation in this case. Thus, the dual pricing strategy cannot improve the total demand by the price discrimination effect. Second, if consumers' hassle sensitivity is PVD, we find that when consumers' hassle sensitivity function (HSF) is convex increasing in product valuation, sellers can increase their profits by using dual pricing as long as the relative increasing rate of hassle sensitivity is high enough. In this case, the difference in consumers' hassle sensitivities makes them purchase the product at different prices. The price discrimination effect dominates when the relative increasing rate of hassle sensitivity is high. However, when HSF is decreasing or concave increasing in product valuation, the price discrimination effect is weakened, and thus, the single pricing strategy is more profitable.

Furthermore, we study the case where the seller maintains the full price when he switches to the dual pricing strategy from the single pricing strategy. We find that the conditions mentioned above under which the dual pricing strategy is more profitable are still valid. Besides, since the dual pricing strategy is often adopted by e-commerce platforms, where network effects play an important role in consumers' purchasing decisions, we consider network effects. We find that the conditions under which the dual pricing strategy is more profitable have robustness with or without network effects. Moreover, we extend our model into the case that the cost to sellers of offering dual pricing is higher than single pricing, and our findings remain applicable. Finally, we use the quadratic hassle cost function to validate computations and further investigate consumer surplus, and we find the dual pricing strategy may improve social welfare.

The rest of our paper is organized as follows. Section 2 reviews the related literature. Section 3 presents the model setup. We analyze the optimal pricing strategies with the PVI and PVD hassle sensitivities in Sections 4 and 5, respectively. In Section 6, we extend our model to investigate the full-price-maintained scenario, the influence of network effects, the case where the cost to sellers of offering dual pricing is higher than single pricing, and consumer surplus of the two pricing strategies. Section 7 concludes our work, and dirve managerial insights and future work. All proofs are shown in Appendix.

2. Related literature

There are two streams of literature relevant to our research. The first stream is on hassle costs. The other is on coupon design under a dual pricing strategy or third-degree price discrimination.

Hassle costs are the time and effort that consumers spend in the transaction process. According to previous studies, consumers incur hassle costs mainly in the process of purchasing products or returning products. In the purchase procedure, consumers' hassle costs are usually travel costs or time costs (Li et al., 2019; Kong et al., 2020; Niu et al., 2021). For example, when shopping in offline stores, consumers incur travel costs (Gao and Su, 2017; Yang et al., 2022; Cui et al., 2023). When shopping online, consumers incur pre-purchase information-searching costs and time costs because of waiting for shipment (Ertekin et al., 2022; Wu et al., 2024; Xin et al., 2024). In the return process, hassle costs are related to return modes, such as shipping fees and return-handling fees (Hess et al., 1996; Mandal et al., 2021; Zhang et al., 2022). The hassle costs mentioned above are considered exogenous and inherent, making it difficult for sellers to take the initiative to change or eliminate them.

Some works that view hassle costs to be endogenous. Sellers can change purchase or return policies, such as service level (Lambrecht and Tucker, 2012; Bo et al., 2024), modes of payment (Dukes and Zhu, 2019), return channels (Nageswaran et al., 2020), and rebate policy (Lu and Moorthy, 2007), to impact consumers' hassle costs and thus influence consumers' behaviors (Wang, 2004). Previous studies have analyzed the coordination of endogenous hassle costs and sellers' service contracts (Lambrecht and Tucker, 2012), group buying strategies (Hu et al., 2021), channel distribution strategies (Chintagunta et al., 2012), return policies (Nie et al., 2024; Xiong and Liu, 2023), and so on. Our paper contributes to the literature on endogeneous hassle cost by considering the coordination of endogenous hassle costs and the pricing strategy. That is, sellers can adjust the hassle levels of coupon acquisition and thus influence customers' hassle costs. For example, Pinduoduo offers a discount to consumers who share a link with a specified number of friends. The hassle level of obtaining the Pinduoduo discount depends on the number of friends required to share the link. Pinduoduo may adjust the hassle level by changing the number of required shares. We investigate how the endogeneous hassle cost can act as an instrument for price discrimination.

In addition to endogeneity, we also consider the heterogeneity of hassle costs. Consumers' heterogeneous hassle costs, such as traveling costs, return costs, and searching costs, can affect sellers' strategies (Herbon, 2017; Morozov et al., 2021; Huang et al., 2024). Herbon (2017) investigates the impact of asymmetric information regarding consumers' heterogeneous hassle costs(i.e., traveling cost) on the competition in duopoly markets. Huang et al. (2024) investigate the impact of consumers' heterogeneous hassle costs (i.e., live-streaming watching costs) on retailers' channel strategies. According to the relationship between consumers' hassle costs and their product valuations, there are two views on the heterogeneity of hassle costs. Some studies hold the view that consumers' hassle costs are independent of their product valuations (PVI) (Anderson, 1988). The Hotelling model is representative, as it holds that hassle costs are affected by geographic locations or distance (Hotelling, 1929; D'Aspremont et al., 1979). In this way, hassle costs are related to the length of time, which is independent of the product valuations There is a growing body of literature that suggests that consumers' hassle costs are related to their product valuations (PVD) (Blattberg et al., 1978; Anderson and Song, 2004; Hsiao and Chen, 2012). For example, consumers who place a high value on a product often prefer immediate purchase over investing time and effort in redeeming a discount offer. However, the consumers who place a low value on a product usually would invest time and effort in redeeming a discount offer. Some scholars also argue that consumers who perceive a higher value in the same product or service are often more affluent. Their higher time value means that the cost of spending time or effort is relatively greater for them (Narasimhan, 1984; Gerstner and Hess, 1991; Zhang et al., 2020). That is, consumers who value a product highly have greater hassle costs. In this paper, we consider both PVI and PVD hassle costs to study dual pricing with purchase hassle. Besides, we use a continuous distribution to describe PVD hassle costs, instead of using a two-point distribution as in the previous literature (Lu and Moorthy, 2007; Hsiao and Chen, 2012). This allows us to further investigate the impact of different positive correlations (concave increasing, convex increasing) between consumers' product valuation and their hassle cost on sellers' pricing strategies.

Our work is also related to the literature on coupon design in third-degree price discrimination. Coupons are divided into nontargeted and targeted coupons depending on whether all consumers can use them (Su et al., 2014). Nontargeted coupons are available to all consumers (Shaffer and Zhang, 1995; Chen et al., 2001). In terms of nontargeted coupons, relevant research pays attention to coupon face value (Anderson and Song, 2004), coupon duration (Krishna and Zhang, 1999; Tian and Feinberg, 2020), and coupon profitability (Neslin and Shoemaker, 1983). The dual pricing strategy with purchase hassle is different from nontargeted coupon design. If nontargeted coupons are issued, sellers influence consumer purchasing decisions through changing the face value of the coupon, which is the prices of the product. In contrast, under the dual pricing, sellers have the ability to influence consumer purchasing decisions not only through changing prices but also by adjusting their hassle costs.

Targeted coupons are available only to consumers with certain characteristics, such as new consumers, repurchased consumers, and students (Wan et al., 2021; Gabel and Guhl, 2022). In terms of targeted coupons, in addition to pricing decisions, related research has also studied which kinds of consumers to target (Choudhary and Shivendu, 2017; Despotakis and Yu, 2022) and how to attract targeted consumers (Reimers and Xie, 2018; Shin and Yu, 2021). The dual pricing strategy with purchase hassle is also different from targeted coupon design. Targeted coupons are issued only to consumers who have certain attributes. These consumers can buy the product at a discounted price. In contrast, under dual pricing with purchase hassle, every consumer can purchase at a discounted price by taking on the hassle costs. That is, consumers choose whether to purchase the product at the discounted price or the full price based on their hassle costs. We contribute to coupon design literature by considering the hassle costs as the tool for price discrimination, which is used by many sellers in reality. Moreover, we consider consumer's autonomy and choices based on their heterogeneious hassle costs.

3. Model setup

We consider a pricing problem with a monopolist (he) selling one product (or service) to the consumers in the market. We normalize the size of the market to one and assume that each consumer (she) has a valuation v of the product, which is uniformly distributed in [0,1] (Chiang et al., 2003; McWilliams, 2012; Lu et al., 2019); that is, $v \sim U[0, 1]$. Each consumer purchases at most one-unit product.

The seller has two alternative pricing strategies—the single pricing strategy and the dual pricing strategy with purchase hassle. When the seller adopts the single pricing strategy, he offers the product at a single price p_s to all consumers. Note that under the single pricing strategy, the discount is not considered an option (the proof is in appendix). When the dual pricing strategy is adopted, the seller offers the product at full price p_f and discounted price p_d to the consumers simultaneously, where $p_d < p_f$. The seller asks consumers to pay a certain hassle cost if they want to purchase the product at the discounted price. Consumers do not need to pay the hassle cost when purchasing at the full price.

3.1. Consumers' hassle cost

The hassle cost (h) reflects the time and effort spent by the consumers if they want to buy at the discounted price (Lu and Moorthy, 2007). Consumers' hassle cost is critically related to the purchase hassle designed by the seller. The seller can adjust the hassle cost that consumers have to pay by changing the efforts to be exerted to obtain the price discount (Choudhary and Shivendu, 2017; Liu, 2023), which we call hassle level in this paper. The seller needs to set an appropriate hassle level to encourage consumers to choose different prices to purchase, thereby better leveraging the advantages of the dual pricing strategy: If the hassle level is excessively high, consumers face substantial hassle costs and are more likely to purchase at full price, thereby reducing the effectiveness of price discrimination; Conversely, if the hassle level is minimal, most consumers will buy at a discount, again undermining the effectiveness of price discrimination.

Moreover, consumers have different evaluations to the purchase hassle (Gerstner and Hess, 1995; Krishna and Zhang, 1999; Anderson and Song, 2004; Hsiao and Chen, 2012). Existing literature identifies consumers' information-searching capabilities (Wang and Sahin, 2018), opportunity cost of time (Iyer, 1998; Banks and Moorthy, 1999), and elasticity to price discounts (Pindyck and Rubinfeld, 2005) can result in their different evaluations to purchase hassle. Following Dukes and Zhu (2019), we use hassle sensitivity to describe this different evaluation. Consumers who are less sensitive to the hassle will purchase at the discounted price, but the others will purchase at the full price.

Thus, we assume the consumer's hassle cost is $h = xt$, where x is the consumer's hassle sensitivity, and t is the hassle level. We consider the cases with PVI and PVD hassle sensitivities in Sections 4 and 5, respectively. Since the PVD case is more common in practice, we treat the PVI case as the benchmark.

3.2. Consumer purchasing decision

Consumers make their purchasing decisions to maximize their utilities. If a consumer buys the product at the full price, she does not need to pay the hassle cost, and thus her utility is $u_f = v - p_f$. If a consumer buys the product at the discounted price, she needs to pay a hassle cost xt, and thus her utility is $u_d = v - xt - p_d$. We assume the consumer's utility is zero if she does not purchase the product.

When the seller applies the single pricing strategy, he offers the product at a single price p_s to all consumers. Note that under the single pricing strategy, the discount is not considered as an option (the proof is in appendix). When the seller applies the dual pricing strategy, the seller sells the product at the full price and the discounted price simultaneously. Thus, consumers have three options: buying the product at the discounted price p_d, buying the product at the full price p_f, or not buying the product. Thus, consumers will buy the product at the discounted price if $u_d > max\{0, u_f\}$ and at the full price if $u_f > max\{0, u_d\}$.

3.3. Pricing and purchase hassle design

When selling the product, the seller needs to pay certain costs. We assume that the marginal cost of selling each unit product is $c \geq 0$. We then formulate the seller's profit maximization problem under the single and dual pricing strategies as follows.

(i) Single Pricing Strategy

When the seller applies the single pricing strategy, he sells only at the single price p_s. Let $D_s(p_s)$ denote the expected demand for the product. According to the utility function $u_s = v - p_s$, the consumers with product valuations $v > p_s$ will buy the product. Recalling that the product valuation is uniformly distributed in $[0, 1]$, the expected demand under the single pricing strategy is: $D_s(p_s) = 1 - p_s$. The cost of offering single pricing strategy for the seller is C_1, which we normalize to zero without loss of generality. The seller optimizes his expected profit by adjusting p_s. Thus, the seller's single pricing decision problem is given by:

$$\begin{aligned} &\max_{p_s} \pi_s = (p_s - c)D_s(p_s) \\ &\text{Subject to } D_s(p_s) > 0, \end{aligned} \tag{1}$$

where $D_s(p_s) = 1 - p_s$.

(ii) Dual Pricing Strategy

Under the dual pricing strategy, the seller optimizes his expected profit by adjusting the full price p_f, the discounted price p_d and the hassle level t. According to the utility functions $u_f = v - p_f$ and $u_d = v - xt - p_d$, the consumers with product valuation $v > p_f$ and hassle sensitivity $x > \frac{p_f - p_d}{t}$ have the utility $u_f > max\{0, u_d\}$, and they will buy the product at the full price. Let $D_f\left(p_f, p_d, t\right)$ denote the expected demand for the product sold at the full price. The consumers with product valuation $v > p_d + xt$ and hassle sensitivity $x \leq \frac{p_f - p_d}{t}$ have the utility $u_d > max\{0, u_f\}$, and they will buy the product at the discounted price. Let $D_d\left(p_f, p_d, t\right)$ denote the expected demand for the product sold at the discounted price. The cost of offering dual pricing strategy for the seller is C_2 ($C_2 \geq 0$). Then, the seller's dual pricing decision problem can be formulated as:

$$\begin{aligned} &\max_{p_f, p_d, t} \pi_d = \left(p_f - c\right)D_f\left(p_f, p_d, t\right) + (p_d - c)D_d\left(p_f, p_d, t\right) - C_2 \\ &\qquad \text{Subject to } D_f\left(p_f, p_d, t\right) > 0, \\ &\qquad D_d\left(p_f, p_d, t\right) > 0, \\ &\qquad t > 0. \end{aligned} \tag{2}$$

For simplicity, we suppose $C_2 = 0$ in the main model. We discuss the case $C_2 > 0$ in Section 6.3.

4. Benchmark: Pricing strategies with PVI hassle sensitivity

In this section, we consider a benchmark case where a consumer's hassle sensitivity is independent of her product valuation. We assume that the hassle sensitivity x is positive, finite, and randomly distributed in the range $0 \le x \le \overline{x}$, and $F(x)$ and $f(x)$ are the cumulative distribution function (CDF) and probability density function (PDF) of x, respectively. We discuss the optimal prices and compare the two pricing strategies.

(i) Single Pricing Strategy

When applying the single pricing strategy, the seller sells the product only at the full price p_s. the seller's profit optimization problems is the same as defined in (1).

(ii) Dual Pricing Strategy

The demand under the dual pricing strategy depends on both the product valuation and hassle cost. According to the analysis in Section 3.3, consumers will buy the product at the full price if $v > p_f$ and $x > \frac{p_f - p_d}{t}$ (see Region 1 in Fig. 2), while consumers will buy the product at the discounted price if $v > p_d + xt$ and $x \le \frac{p_f - p_d}{t}$ (see Region 2 in Fig. 2). Recalling that the product valuation is uniformly distributed in $[0, 1]$, and the PDF of x is $f(x)$, since a consumer's hassle sensitivity (x) is independent of her product valuation (v), the demands for the product at the full price $D_f\left(p_f, p_d, t\right)$ and the discounted price $D_d\left(p_f, p_d, t\right)$ are given by:

$$D_f\left(p_f, p_d, t\right) = \int_{p_f}^{1} \int_{\frac{p_f - p_d}{t}}^{\overline{x}} 1 \bullet f(x) dx dv = \left(1 - p_f\right) \bullet \left(1 - F\left(\frac{p_f - p_d}{t}\right)\right), \tag{3}$$

$$D_d\left(p_f, p_d, t\right) = \int_{p_d + xt}^{1} \int_{0}^{\frac{p_f - p_d}{t}} 1 \bullet f(x) dx dv = \left(1 - p_f\right) \bullet F\left(\frac{p_f - p_d}{t}\right) + t \times \int_{0}^{\frac{p_f - p_d}{t}} F(x) dx. \tag{4}$$

Then, the seller's dual pricing decision problem can be rewritten as:

$$\begin{aligned} \max_{p_f, p_d, t} \pi_d &= \left(p_f - c\right) \bullet D_f\left(p_f, p_d, t\right) + \left(p_d - c\right) \bullet D_d\left(p_f, p_d, t\right) \\ &= \left(p_f - c\right) \bullet \left(1 - p_f\right) \bullet \left(1 - F\left(\frac{p_f - p_d}{t}\right)\right) + \left(p_d - c\right) \bullet \left[\left(1 - p_f\right) \bullet F\left(\frac{p_f - p_d}{t}\right) + t \int_{0}^{\frac{p_f - p_d}{t}} F(x) dx\right]. \end{aligned} \tag{5}$$

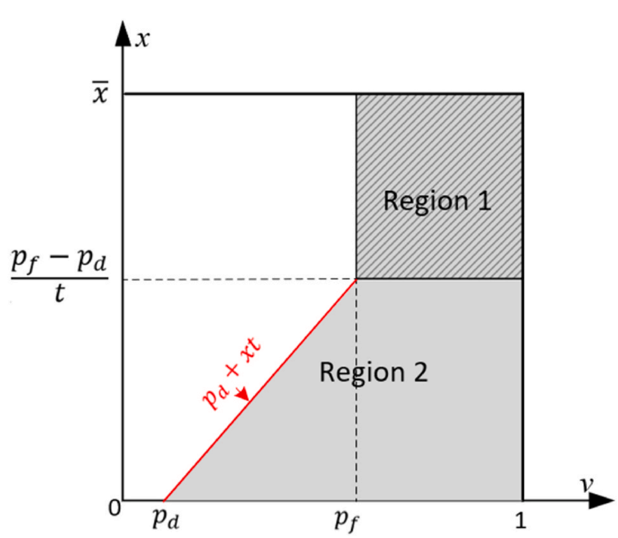


Fig. 2. Consumers' purchasing decisions under the dual pricing strategy.

By solving the single pricing and dual pricing decision problems, we obtain the following result.

Proposition 1. *If consumers' hassle costs are independent of their product valuations, the single pricing strategy always outperforms the dual pricing strategy in terms of the seller's profit. Specifically, the optimal single price is* $p_s^* = \frac{1+c}{2}$, *and seller's profit is* $\pi_s^* = \frac{(1-c)^2}{4}$.

We explain why the seller cannot improve his profit through the dual pricing strategy with *Fig. 3*. It is worth noting that the total demand under the dual pricing strategy may either exceed or be less than the demand under the single pricing strategy (as *Fig. 3* shows). The rationale is as follows: under the dual pricing strategy, the total demand includes consumers with $v > p_f$ and $x > \frac{p_f - p_d}{t}$, as well as those with $v > p_d + xt$ and $x \le \frac{p_f - p_d}{t}$ (in areas S_2, S_3, and S_5). If the seller adopts the single pricing strategy, the demand includes consumers with $v > p_s$ and $0 \le x \le \overline{x}$ (in areas S_1, S_2, S_3, and S_4). The relation between the consumers in the two areas depends on the distribution of x.

As shown in Fig. 3, we divide the consumers into those with high hassle sensitivities ($x > \frac{p_f - p_d}{t}$) and those with low hassle sensitivities ($x \le \frac{p_f - p_d}{t}$). Consumers with high hassle sensitivities have higher hassle

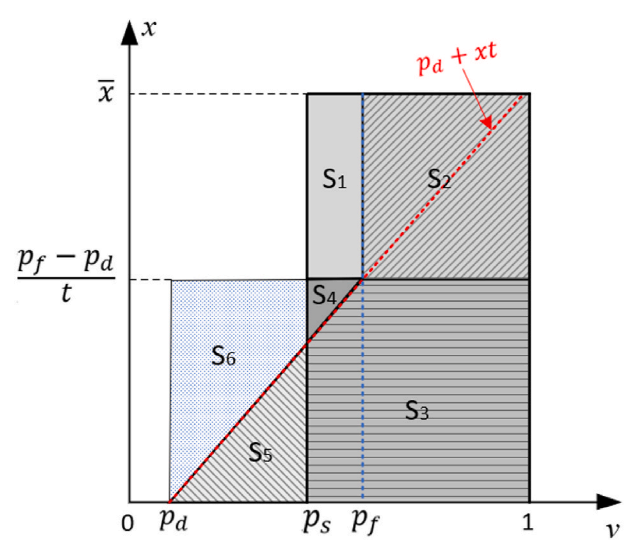


Fig. 3. Consumer purchasing decisions under the single and dual pricing strategies.
Notes. Consumers purchasing the product under the single and dual pricing strategies are in areas S_1, S_2, S_3, and S_4 and in areas S_2, S_3, and S_5, respectively.

costs. They will either buy the product at the full price or not buy the product; that is, only the full price works for them. Because consumers' hassle sensitivities and their product valuations are independent, the distribution of product valuations for consumers with high hassle sensitivities is the same as the distribution for all consumers. Thus, when only the single full price works, the optimal single price provides the highest profit for the seller from consumers with high hassle sensitivity. Therefore, the seller's expected profit from consumers with high hassle sensitivity under the dual pricing strategy cannot be higher than that under the single pricing strategy.

Consumers with low hassle sensitivities have lower hassle costs. They will either buy the product at the discounted price or not buy the product. As shown in Fig. 3, under the dual pricing strategy, consumers in areas S_3 and S_5 will take the purchase hassle and buy the product at the discounted price. When the single price equals the discounted price, the consumers who purchase the product increase to areas S_3, S_4, S_5, and S_6. Therefore, the seller's expected profit from consumers with low hassle sensitivity under the dual pricing strategy is lower than that under the single pricing strategy.

In summary, when hassle sensitivity is PVI, the dual pricing strategy with purchase hassle is less profitable than the single pricing strategy.

5. Pricing strategies with PVD hassle sensitivity

In this section, we consider the case with PVD hassle sensitivity. To capture the relationship between consumers' product valuations and their hassle sensitivity, we introduce the HSF as $x = g(v)$, where $g(v)$ is continuous and second-order differentiable, and $g(v) > 0$ for any $v\epsilon[0,1]$. Thus, a consumer's utility when she buys at the discounted price can be expressed as $u_d = v - g(v)t - p_d$. Since consumers have no hassle cost when they purchase at the full price, their utility is $u_f = v - p_f$.

According to Anderson and Song (2004) and Hsiao and Chen (2012), consumers' evaluations of hassle level usually correlate with their product valuations. Consumers who value the product more have higher hassle sensitivity because consumers with higher product valuations have a greater opportunity cost if they do not purchase the product immediately (see, e.g., Anderson and Song, 2004; Gerstner and Hess, 1991). They are more eager to get the product right away than to spend time and effort to receive the coupon. In addition, consumers with higher product valuation are suggested to be wealthier (Anderson and Song, 2004; Hsiao and Chen, 2012). They are less sensitive to the price, such that they are less interested in getting the price discount with extra hassle cost. In contrast, consumers with low product valuations are more sensitive to the product price, and they would be more interested in taking the hassle to obtain the opportunity to purchase at a lower price. Therefore, although the cases where $g'(v) \le 0$ and $g'(v) > 0$ are both examined in this paper, the main focus is on the latter case. Moreover, when $g'(v) > 0$, for analytical tractability, we assume that the HSF is either convex (Mandelbaum and Stolyar, 2004; Golrezaei et al., 2020; Fattahi et al., 2022) or concave (Malik et al., 2022).

We then discuss the seller's profit optimization problem under the single and dual pricing strategies with PVD hassle sensitivity.

(i) Single Pricing Strategy

Since the seller only sells at the full price with no hassle cost, the seller's profit optimization problems with PVD and PVI hassle sensitivities are the same as defined in (1).

(ii) Dual Pricing Strategy

Under the dual pricing strategy, consumers will buy the product at the discounted price if $v > p_d + xt$ and $x \le \frac{p_f - p_d}{t}$, while consumers will buy at the full price if $v > p_f$ and $x > \frac{p_f - p_d}{t}$. Otherwise, they will not purchase the product. Since $x = g(v)$, $x \le \frac{p_f - p_d}{t}$ is equivalent to $g(v) \le \frac{p_f - p_d}{t}$. To analyze consumers' purchasing decisions, we define three indifference points v_f, v_d, and v_0. For consumer with valuation v_f, the utility of buying at the full price and not buying is indifferent, i.e., $v_f = p_f$. For consumer with valuation v_d, the utility of buying at the discounted price and not buying is indifferent, i.e., $v_d = p_d + g(v_d)t$. For consumer with v_0, the utility of buying at the full and discounted price is indifferent. That is, $g(v_0) = \frac{p_f - p_d}{t}$, which is equivalent to $v_0 = g^{-1}\left(\frac{p_f - p_d}{t}\right)$ where $v = g^{-1}(x)$ is the adverse function of $x = g(v)$. Under the dual pricing strategy, the demands of full and discounted prices depend on the values of the indifference points, which are different between $g'(v) \le 0$ and $g'(v) > 0$.

(a) When $g'(v) \le 0$, consumers with product valuation $v \ge v_0$ satisfy the condition $g(v) \le \frac{p_f - p_d}{t}$, and consumers with product valuation $v < v_0$ satisfy the condition $g(v) > \frac{p_f - p_d}{t}$. Therefore, consumers with product valuation $v > max\{v_d, v_0\}$ will purchase at the discounted price, and consumers with product valuation $v_f < v \le v_0$ will purchase at the full price. Thus, the demand for the product at the full price and the discounted price are:

$$D_f\left(p_f, p_d, t\right) = v_0 - v_f = g^{-1}\left(\frac{p_f - p_d}{t}\right) - p_f, (6)$$

$$D_d\left(p_f, p_d, t\right) = 1 - max\{v_d, v_0\} = 1 - max\left\{p_d + g(v_d)t, g^{-1}\left(\frac{p_f - p_d}{t}\right)\right\}. \tag{6}$$

Then, the seller's dual pricing decision problem can be rewritten as:

$$\begin{aligned} \max_{p_f, p_d, t} \pi_d &= \left(p_f - c\right) D_f\left(p_f, p_d, t\right) + (p_d - c) D_d\left(p_f, p_d, t\right) \\ &= \left(p_f - c\right) \bullet \left(g^{-1}\left(\frac{p_f - p_d}{t}\right) - p_f\right) \\ &+ (p_d - c) \bullet \left(1 - max\left\{p_d + g(v_d)t, g^{-1}\left(\frac{p_f - p_d}{t}\right)\right\}\right). \end{aligned} \tag{7}$$

(b) When $g'(v) > 0$, consumers with product valuation $v > v_0$ satisfy the condition $g(v) > \frac{p_f - p_d}{t}$, and consumers with product valuation $v \le v_0$ satisfy the condition $g(v) \le \frac{p_f - p_d}{t}$. Therefore, consumers with product valuation $v_d < v \le v_0$ will purchase at the discounted price, and consumers with product valuation $v > max\{v_0, v_f\}$ will purchase at the full price. Thus, the demand for the product at the full price and the discounted price are:

$$D_f\left(p_f, p_d, t\right) = 1 - max\{v_f, v_0\} = 1 - max\left\{p_f, g^{-1}\left(\frac{p_f - p_d}{t}\right)\right\}, \tag{8}$$

$$D_d\left(p_f, p_d, t\right) = v_0 - v_d = g^{-1}\left(\frac{p_f - p_d}{t}\right) - p_d - g(v_d)t. \tag{9}$$

Then, the seller's dual pricing decision problem can be rewritten as:

$$\begin{aligned} \max_{p_f, p_d, t} \pi_d &= \left(p_f - c\right) D_f\left(p_f, p_d, t\right) + (p_d - c) D_d\left(p_f, p_d, t\right) \\ &= \left(p_f - c\right) \bullet \left(1 - max\left\{p_f, g^{-1}\left(\frac{p_f - p_d}{t}\right)\right\}\right) \\ &+ (p_d - c) \bullet \left(g^{-1}\left(\frac{p_f - p_d}{t}\right) - p_d - g(v_d)t\right). \end{aligned} \tag{10}$$

5.1. Optimal pricing strategies

Next, we discuss the optimal pricing strategies with PVD hassle sensitivity. The optimal single price and profit are the same with those with PVI hassle sensitivity. We present the optimal prices and expected profits under the dual pricing strategy in Lemma 1. Parameter α and β satisfy the conditions (B7) and (B8) in appendix B.

Lemma 1. *When consumers' hassle sensitivity depends on their product valuations, under the dual pricing strategy, the optimal prices, optimal hassle level, and the seller's expected maximum profit are* $p_f^* = \alpha, p_d^* = \beta - g(\beta) \bullet \frac{\alpha-\beta}{g(\alpha)-g(\beta)}, t^* = \frac{\alpha-\beta}{g(\alpha)-g(\beta)}$, *and* $\pi_d^* = (\alpha - \beta)\left[\beta - g(\beta) \bullet \frac{\alpha-\beta}{g(\alpha)-g(\beta)} - c\right] + (1-\alpha)(\alpha - c)$, *respectively.*

By analyzing the expected maximum profits under different pricing strategies, we find that the results are different among decreasing HSF (*where* $g'(v) \le 0$), concave increasing HSF (where $g'(v) > 0$ and $g''(v) \le 0$) and convex increasing HSF (where $g'(v) > 0$ and $g''(v) > 0$). We start by analyzing the case with decreasing or concave increasing HSF.

(i) Optimal pricing strategy with decreasing or concave increasing HSF

We examine the case with decreasing and concave increasing HSF in *Proposition 2*.

Proposition 2. *If the HSF is decreasing or concave increasing, the single pricing strategy is more profitable than the dual pricing strategy.*

The profitability of the dual pricing strategy compared to the single pricing strategy depends on the difference in consumers' hassle sensitivities, which depend on the HSF. When the HSF is decreasing, since consumers with low product valuations have higher hassle sensitivity, they have higher hassle costs when purchasing at the discounted price. The discounted price is therefore not attractive enough for them. The price discrimination effect under the dual pricing strategy diminishes. Thus, the dual pricing strategy is less profitable than the single pricing strategy. When the HSF is concave increasing, the difference in hassle sensitivity between consumers with high and low product valuations is quite small. As a result, the difference in their price preference is not significant, which weakens the price discrimination effect of the dual pricing strategy. In addition, the discounted price under the dual pricing strategy reduces the unit profit, which has a negative effect on the seller's expected profit. This negative effect outweighs the benefit from the price discrimination effect, making the dual pricing strategy less profitable than the single pricing strategy.

(ii) Optimal pricing strategy with convex increasing HSF

We then investigate the case with convex increasing HSF. To facilitate the analysis, we introduce a concept called the relative increasing rate of hassle sensitivity defined as:

$$H(v) = \frac{g'(v)}{g(v)}. \tag{11}$$

$H(v)$ reflects the relative change rate of consumer hassle sensitivity as product valuation grows. We present a sufficient condition under which the dual pricing strategy is more profitable than the single pricing strategy in *Proposition 3*.

Proposition 3. *When the HSF is convex increasing, the dual pricing strategy is more profitable than the single pricing strategy if there exists* $v \in \left(c, \frac{1+c}{2}\right]$ *such that* $H(v) > \frac{1}{v-c}$.

Proposition 3 gives a sufficient condition under which the dual pricing strategy is more profitable than the single pricing strategy when the HSF is convex increasing. We can discuss the rationale of Proposition 3 with Fig. 4. Under the optimal single pricing strategy, the seller charges consumers p_s^*. Thus, the consumers with product valuations $v > p_s^*$ will purchase the product and the product's demand under the single pricing strategy is $1 - p_s^*$ (i.e., $1 - v_0$ in Fig. 4). The seller achieves profit π_s^* shown by the area of region D1 in Fig. 4. When $H(v) > \frac{1}{v-c}$, if the seller can simultaneously offer a proper discounted price p_d with purchase hassle level t and a full price that equals the optimal single price under the single pricing strategy $p_f = p_s^*$. Then, consumers with product valuation $v_d < v \le v_0$ will buy the product at the discounted price, while the consumers with product valuation $v_0 < v \le 1$ will buy the product at the full price. Therefore, the total demand under the dual pricing strategy (represented as $1 - v_d$ in Fig. 4), is greater than the demand at the single pricing strategy (i.e., $1 - v_0$ in Fig. 4). Therefore, the seller's profit under the dual pricing strategy is the area of regions D1 and D2.

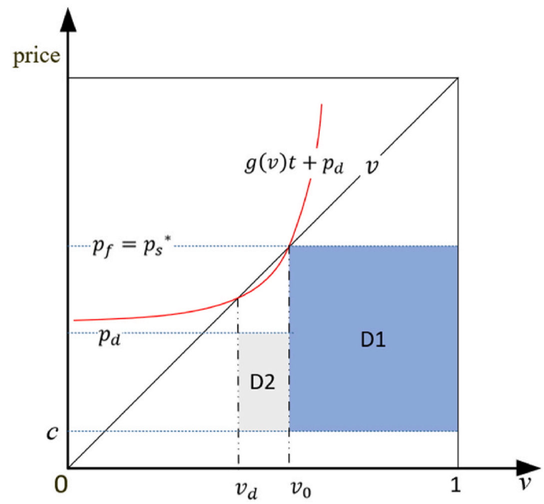


Fig. 4. Demands distribution and Seller's profit under the single and dual pricing strategies when $H(v) > \frac{1}{v-c}$.

In summary, if the conditions in Proposition 3 are satisfied, the difference in consumers' hassle sensitivity between consumers with high and low product valuations is large enough, resulting in a significant difference in their price preferences. Thus, under the dual pricing strategy, the price discrimination effect is stronger, which leads to a higher total demand. This results in the dual pricing strategy being more profitable than the single pricing strategy.

5.2. Optimal properties when the dual pricing outperforms the single pricing strategy

Next, we analyze the properties of prices and consumer utility when the dual pricing strategy outperforms the single pricing strategy in terms of the seller's profit.

Proposition 4. *When the dual pricing strategy is more profitable than the single pricing strategy, we have* $p_d^* < p_s^* \le p_f^*$.

Proposition 4 compares the optimal prices under the two pricing strategies if the dual pricing strategy outperforms the single pricing strategy. Under the dual pricing strategy, the seller offers the discounted price, which is lower than the optimal single price, to attract consumers with low product valuations. In addition, the full price under the dual pricing strategy is higher than the optimal single price, which attracts consumers with high product valuations. The price discrimination effect plays a critical role in the dual pricing strategy.

Proposition 5. *Under the dual pricing strategy, consumers' utility is non-monotonic in the product valuation. Specifically, under the optimal dual pricing strategy, the utility of consumers with product valuation* v_0 *is zero.*

Under the optimal dual pricing strategy, the seller sets the appropriate discounted price and full price to ensure that the consumers at the indifference point v_0 receive zero utility, such that both the consumers with high and low product valuations will purchase the product, and the seller can simultaneously achieve higher unit profits. Under price discrimination, intuitively, consumers' utility increases in their product valuation. Interestingly, under dual pricing with purchase hassle, consumers' utility initially increases but then decreases in their product valuation when they purchase at the discount price. The reasons are as follows. Since consumers' hassle cost is positively correlated with their product valuation, under the dual pricing strategy, consumers with low product valuation purchase the product at the discounted price. Consumers' utility depends on the difference between their product valuations and their hassle costs. At first, the hassle costs increase slowly, such that the increment in product valuations exceeds the increment in hassle costs. Thus, initially, consumers' utility increases in their product valuations. As the product valuation grows, the increment in hassle costs gradually accelerates. When the increment in hassle costs exceeds the increment in product valuations, consumers' utility decreases in product valuation. After the hassle cost exceeds the price difference, consumers will choose to purchase at the full price without hassle cost.

6. Extensions

In the former model, we have assumed that the seller adjusts the full price, the discounted price and the hassle level simultaneously under the dual pricing strategy. However, in practice, the seller may not be able to modify the full price at will, especially when they used to take the single pricing strategy, but decide to switch to the dual pricing strategy. We call this scenario as the "full-price-maintained" situation. Thus, we investigate the optimal pricing strategy in the full-price-maintained scenario in Section 6.1. Furthermore, since the dual pricing strategy is often used by online platforms, for which network effects play a critical role, we take network effects into consideration and assess the robustness of our results with network effects in Section 6.2. Thirdly, offering the dual pricing strategy may entail higher cost for the seller than offering the single pricing strartegy. Thus, we investigate the scenario that $C_2 > 0$ in Section 6.3. In Section 6.4, we compare the two pricing strategies and examine the impact of the dual pricing strategy on consumer surplus for the quadratic hassle cost function.

6.1. Full-price-maintained switching

With the development of e-commerce and the improvement in electronic information technology, many firms switch their pricing strategy from single pricing to dual pricing. In practice, sellers often maintain the full price when they switch the pricing strategies. For example, cosmetics firms, such as Estee Lauder, are used to charge a uniform price for products a few years ago, which is known as the "counter price". Recently, with the prosperity of discount websites, the cosmetic firms take the dual pricing strategy for the customers, however, the full price remains the same as the counter price. The cosmetics firms can adjust the discount rate and the difficulty of obtaining the discount to maximize their profits. In this section, we investigate the full-price-maintained strategy when the seller implementing the single pricing strategy decides to switch to a dual pricing strategy. After the switch, the seller sells at both full and discounted prices with the full priced unchanged.

Since the sellers adopt the single pricing strategy before switching to the dual pricing strategy and $p_s^* = \frac{1+c}{2}$ is the optimal single price under the full-price-maintained scenario, we assume that the full price p_f^f under the dual pricing strategy is $p_f^f = p_s^*$. Under the full-price-maintained dual pricing, the seller optimizes his expected profit by adjusting the discounted price p_d^f and the hassle level t^f. The seller's profit optimization problem can be rewritten as:

$$\max_{p_d^f, t^f} \pi_d^f = (p_s^* - c) D_f\left(p_s^*, p_d^f, t^f\right) + \left(p_d^f - c\right) D_d\left(p_s^*, p_d^f, t^f\right). \tag{12}$$

We present the optimal prices and expected profits under different strategies in Lemma 2. Parameter θ satisfies the condition (B15) in appendix B.

Lemma 2. *When consumers' hassle sensitivity depends on their product valuations and full-price-maintained dual pricing is applied, there exists a unique value θ such that the optimal discounted price, optimal hassle level, and seller's optimal expected profit are* $p_d^{f*} = \theta - g(\theta) \bullet \frac{\frac{1+c}{2} - \theta}{g\left(\frac{1+c}{2}\right) - g(\theta)}$, $t^{f*} = \frac{\frac{1+c}{2} - \theta}{g\left(\frac{1+c}{2}\right) - g(\theta)}$, *and* $\pi_d^{f*} = \left(\frac{1+c}{2} - \theta\right)\left[\theta - g(\theta) \bullet \frac{\frac{1+c}{2} - \theta}{g\left(\frac{1+c}{2}\right) - g(\theta)} - c\right] + \frac{(1-c)^2}{4}$, *respectively.*

By comparing the expected maximum profits under the two pricing strategies, we discuss the seller's pricing strategies in *Proposition 6*.

Proposition 6. *When the HSF is decreasing or convex increasing, the full-price-maintained dual pricing strategy is less profitable than the single pricing strategy; when the HSF is convex increasing, full-price-maintained switching is more profitable than the single pricing strategy if and only if* $H\left(\frac{1+c}{2}\right) > \frac{2}{1-c}$.

Under the dual pricing strategy discussed in Section 5, the seller optimizes his expected profit by adjusting the full price, discounted price, and the hassle level, while under the full-price-maintained dual pricing strategy, the seller optimizes his expected profit by adjusting the discounted price and the hassle level. Thus, the seller's optimal profit under the full-price-maintained dual pricing is lower than his profit under the dual pricing discussed in Section 5. Since the dual pricing strategy is less profitable than the single pricing strategy when the HSF is decreasing or convex increasing, the dual pricing strategy with the full price maintained cannot outperform the single pricing strategy. When the HSF is convex increasing and the relative increasing rate of hassle sensitivity is high (i.e., $H\left(\frac{1+c}{2}\right) > \frac{2}{1-c}$), some consumers who have low product valuation and who are not used to buy the product at the single pricing strategy are now willing to purchase the product at the discounted price due to their low hassle sensitivities. This increases the total demand under full-price-maintained switching and thus improves the seller's profit.

When the seller switches from the single pricing strategy to the dual pricing strategy, their marginal selling cost may increase. For example, some sellers need to pay commissions to discount websites when they implement the dual pricing strategy. Thus, under full-price-maintained switching, we analyze how the seller's profit, discounted price, and hassle level vary with the marginal selling cost.

Proposition 7. *When full-price-maintained dual pricing is implemented, the seller's optimal expected profit π_d^{f*} and optimal discounted price p_d^{f*} increase, while the optimal hassle level t^{f*} decreases in the product's marginal selling cost.*

When the product's marginal selling cost grows, the seller will increase the discounted price to compensate for the loss of unit profit. It reduces consumers' willingness to purchase the product. To cope with this, the seller reduces the hassle level to incentivize consumers to purchase at the discounted price. The increase in marginal selling cost reduces the seller's unit profit, resulting in the decrease in the seller's optimal expected profit.

6.2. Network effects

The dual pricing strategy is often applied by two-sided platforms which connect with both merchants and consumers, such as Amazon, Taobao, JD.com, and Didi. At such platforms, an increase in demand attracts more merchants, which in turn affects consumers' willingness to purchase, which is known as network effects. Network effects have a significant impact on consumers' purchasing decisions at two-sided platforms (Chellappa and Mukherjee, 2021; Li et al., 2021). In this section, we extend our model by taking network effects into consideration. Following Sun et al. (2004) and Parker and Alstyne (2005), we denote network effects as γD_i^n $(i = d, f, s)$, where γ is the strength of network effects and D_i^n is the demand for the product. Without loss of generality, we assume $\gamma < 1$. With network effects, the utility of consumers buying at the single price under the single pricing strategy, at the full price under the dual pricing strategy and at the discounted price under the dual pricing strategy are $u_s = v - p_s + \gamma D_s^n$, $u_f = v - p_f + \gamma\left(D_f^n + D_d^n\right)$, and $u_d = v - g(v)t - p_d + \gamma\left(D_f^n + D_d^n\right)$, respectively. Then, the seller's single pricing decision problem with network effects is given by:

$$\max_{p_s^n} \pi_s^n = \frac{(p_s^n - c) \bullet (1 - p_s^n)}{1 - \gamma}. \tag{13}$$

The seller's dual pricing decision problem with network effects is given by:

$$\max_{p_f^n, p_d^n, t^n} \pi_d^n = \left(p_f - c\right) D_f^n\left(p_f, p_d, t\right) + (p_d - c) D_d^n\left(p_f, p_d, t\right)$$

$$= \pi_d + \gamma\left[D_f^n\left(p_f, p_d, t\right) + D_d^n\left(p_f^n, p_d^n, t^n\right)\right]^2. \tag{14}$$

We derive the seller's expected maximization profits under the two pricing strategies with network effects, which are denoted as $\pi_s^{n^*}$ and $\pi_d^{n^*}$, respectively. We discuss the effects of network effects on the seller's pricing strategies in the following proposition.

Proposition 8. *In a market with either positive or negative network effects, when the HSF is decreasing or concave increasing, dual pricing with purchase hassle is less profitable than single pricing; when the HSF is convex increasing, the dual pricing strategy is more profitable than the single pricing strategy if* $H\left(\frac{1+c-2\gamma}{2-2\gamma}\right) > \frac{2(1-\gamma)}{1-c}$.

Network effects affect consumers' purchase willingness but not consumers' hassle costs. Therefore, it does not affect consumers' price preference. When the HSF is decreasing, the price discrimination effect under the dual pricing strategy diminishes, which causes the dual pricing strategy to be less profitable than the single pricing strategy with network effects. When the HSF is concave increasing, the difference in consumers' price preference is not significant, which weakens the price discrimination effect under the dual pricing strategy. As a result, the increase in total demand through the dual pricing strategy is not significant, so network effects are not significant either. In addition, the discounted price reduces the unit profit, which has a negative effect on the seller's profit. Therefore, even when network effects are accounted for, the negative effect of low unit profit remains dominant, causing the dual pricing strategy to be less profitable than the single pricing strategy. When the HSF is convex increasing, and the relative increasing rate of hassle sensitivity is high (i.e., $H\left(\frac{1+c-2\gamma}{2-2\gamma}\right) > \frac{2(1-\gamma)}{1-c}$), the significant difference in consumers' price preferences results in a strong price discrimination effect, making the dual pricing strategy more profitable than the single pricing strategy for the seller.

6.3. Cost difference between single and dual pricing strategies

In this extension, we consider the setting where the cost for offering the dual pricing strategy is higher than offering the single pricing strategy for the seller, that is, $C_2 > 0$.

Proposition 9. *(i) When the HSF is decreasing or concave increasing, the dual pricing strategy is still less profitable than the single pricing strategy. (ii) When the HSF is convex increasing, and there exists* $v \epsilon \left(c, \frac{1+c}{2}\right]$ *such that* $H(v) > 1/(v - c)$, *there is an threshold* δ *for* C_2, *such that, if* $C_2 < \delta$, *the dual pricing strategy can still be more profitable than the single pricing strategy. The optimal prices and hassle level do not change with* C_2.

Intuitively, the additional cost for offering the dual pricing strategy reduces the seller's profit under dual pricing. Thus, if the dual pricing strategy is less profitable than the single pricing strategy when $C_2 = 0$, the dual pricing strategy is still less profitable when $C_2 > 0$. Recalling Proposition 3, when $C_2 = 0$, if the HSF is convex increasing, and there exists $v \epsilon \left(c, \frac{1+c}{2}\right]$ such that $H(v) > \frac{1}{v-c}$, the dual pricing is more profitable than the single pricing strategy. This result remains valid, if this excess profit over the single pricing is higher than the cost for offering the dual pricing (C_2). Although the cost for offering the dual pricing strategy reduces the seller's profit under the dual pricing strategy, it does not influence consumers' purchasing decisions. Thus, the optimal prices and hassle level do not change with C_2.

6.4. Demand and consumer surplus

This section aims to further explore and compare two pricing strategies, focusing on prices and demand sizes, and to investigate the effects of dual pricing on consumer surplus and social welfare. According to the primary model, the seller benefits from dual pricing when consumer hassle sensitivity increases convexly with product valuations. The lack of a specific functional form has constrained a deeper investigation into the properties. Next, we introduce a quadratic cost function, that is, $g(v) = av^2$ $(a > 0)$, which is widely used to describe the convex increasing nature of cost functions (Szwarc et al., 1988; Xia et al., 2019; Yang et al., 2020). Additionally, we used a more general form of the quadratic cost function for numerical computations to verify the results, which is presented in Appendix C.

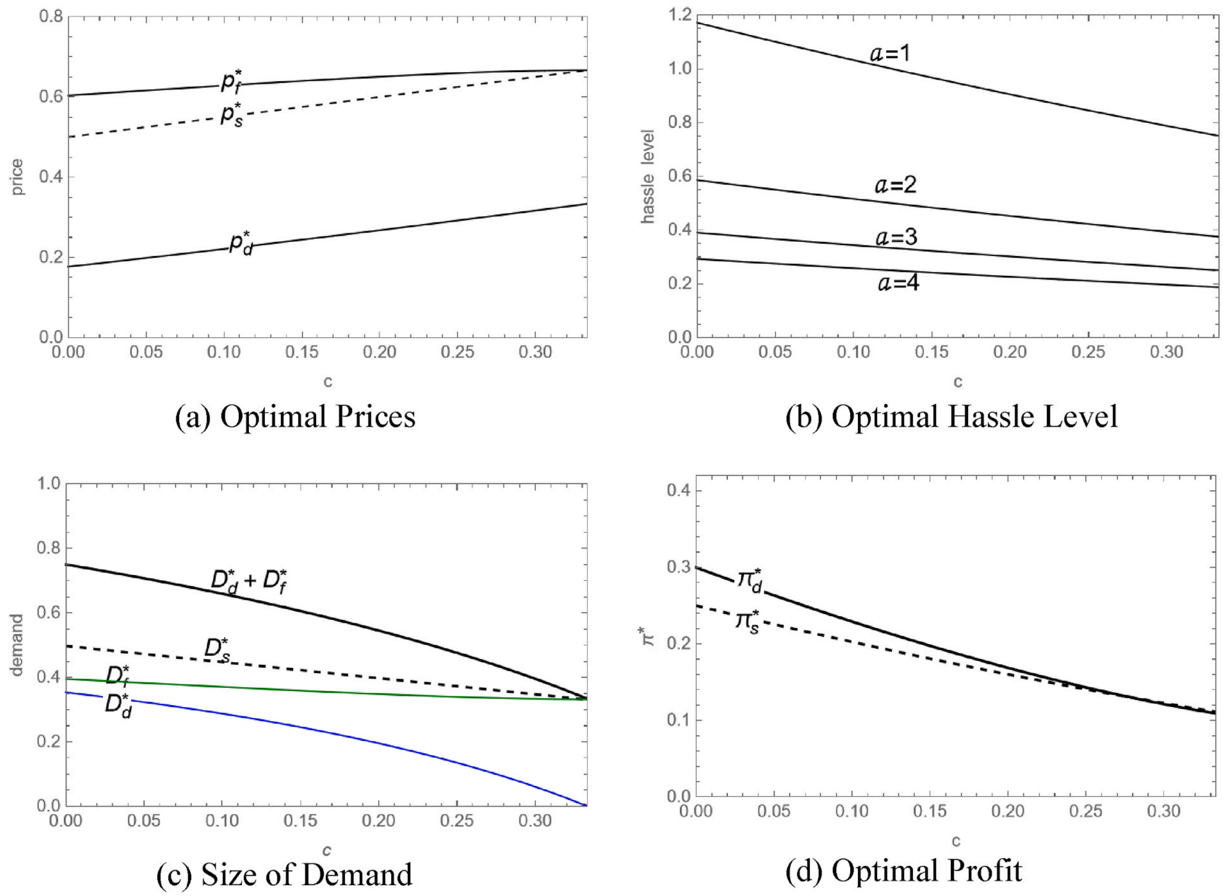
For $g(v) = av^2$, the seller's dual pricing decision problem (11) can be rewritten as:

$$\begin{aligned}
\max_{p_f, p_d, t} \pi_d &= \left(p_f - c\right) \bullet \left(1 - \max\left\{p_f, \sqrt{\frac{p_f - p_d}{at}}\right\}\right) \\
&\quad + (p_d - c) \bullet \left(\sqrt{\frac{p_f - p_d}{at}} - p_d - a{v_d}^2 t\right) \\
&\text{s.t. } 1 - \max\left\{p_f, \sqrt{\frac{p_f - p_d}{at}}\right\} > 0, \\
&\quad \sqrt{\frac{p_f - p_d}{at}} - p_d - a{v_d}^2 t > 0, \\
&\quad t > 0.
\end{aligned} \tag{15}$$

The seller's optimization problem (16) is equivalent to:

$$\begin{aligned}
\max_{v_f, v_d, t} \pi_d &= (v_f - c) \bullet \left(1 - \max\left\{v_f, \sqrt{\frac{v_f - v_d}{at} + {v_d}^2}\right\}\right) \\
&\quad + \left(v_d - a{v_d}^2 t - c\right) \bullet \left(\sqrt{\frac{v_f - v_d}{at} + {v_d}^2} - v_d\right) \\
&\text{s.t. } 1 - \max\left\{v_f, \sqrt{\frac{v_f - v_d}{at} + {v_d}^2}\right\} > 0, \\
&\quad \sqrt{\frac{v_f - v_d}{at} + {v_d}^2} - v_d > 0, \\
&\quad t > 0.
\end{aligned} \tag{16}$$

By solving the optimization problem (17), we can derive the seller's optimal dual pricing strategy. The analytical expressions for the optimal prices and hassle level can be found in Appendix B. We first compare the solutions of optimization problems (1) and (17), i.e., the optimal prices, the optimal hassle level, and the seller's profit under the two pricing strategies (see Fig. 5).



(a) Optimal Prices (b) Optimal Hassle Level

(c) Size of Demand (d) Optimal Profit

Fig. 5. Comparison of single pricing and dual pricing for $g(v) = av^2$.

Corollary 1. *For $g(v) = av^2$, the dual pricing strategy is more profitable than the single pricing strategy if and only if $c < \frac{1}{3}$ (equivalently, $H\left(\frac{1+c}{2}\right) > \frac{2}{1-c}$).*

The sufficient condition in the general model (in Proposition 4) becomes the necessary and sufficient condition for the quadratic hassle cost function. Additionally, we find that the lower the marginal cost c, the greater the advantage of the dual pricing strategy for the seller. This is because a lower marginal cost leads to a larger number of potential consumers whose product valuations exceed the marginal cost (i.e., $v > c$). Consequently, the seller can increase profits by using price discrimination of the dual pricing strategy to attract more consumers. However, when the marginal cost c is high ($c > \frac{1}{3}$), there is a small number of potential consumers whose product valuations exceed the marginal cost. Meanwhile, these potential consumers have high hassle sensitivity, resulting in a low willingness to purchase at the discounted price. Consequently, the advantages of price discrimination in the dual pricing strategy diminish, and so the single pricing strategy is superior to the dual pricing strategy.

Proposition 10. *For $g(v) = av^2$, under the dual pricing strategy, when the marginal cost c increases, the optimal full price p_f^* increases, the optimal discounted price p_d^* increases (see Fig. 5(a)), the optimal hassle level t^* decreases (see Fig. 5(b)), and the seller's optimal profit decreases (see Fig. 5(d)).*

As the marginal cost c increases, both the full and discounted prices (p_f^* and p_d^*) under the dual pricing strategy rise. Consequently, only consumers with higher product valuations will purchase the product. Consumers with higher product valuations are more sensitive to the hassle level. Therefore, the seller reduces the hassle level t^*. Reducing hassle level not only decreases consumers' hassle costs but also narrows the differences in hassle costs between consumers. This reduces the difference in consumers' price preferences under the dual pricing strategy. Consequently, the effectiveness of price discrimination under dual pricing weakens, resulting in a smaller increase in total demand compared to single pricing ($D_d^* + D_f^* - D_s^*$). The decrease in both marginal profit and total demand diminishes the advantage of dual pricing, thereby reducing the profit growth for the seller.

Having compared the seller's profit under the two pricing strategies, we now take the perspective of a social planner to examine consumer surplus and social welfare differences between the two pricing strategies. Consumer surplus under the single pricing strategy and the dual pricing strategy are:

$$CS_s = \int_{v_s^*}^{1} v - p_s^* dv, \tag{17}$$

$$CS_d = \int_{v_d^*}^{v_0^*} v - av^2 t - p_d^* dv + \int_{v_0^*}^{1} v - p_f^* dv \ . \tag{18}$$

Accordingly, social welfare under the single pricing strategy and the dual pricing strategy, which is the sum of consumer surplus and the seller's profit, are:

$$SW_s = \pi_s^* + CS_s, \tag{19}$$

$$SW_d = \pi_d^* + CS_d \ . \tag{20}$$

Proposition 11. *For $g(v) = av^2$, compared with the single pricing strategy, (i) the dual pricing strategy decreases consumer surplus (Fig. 6(a)); (ii) there is a threshold c_0 (Fig. 6(b)): when $c \le c_0$, the dual pricing strategy improves social welfare; when $c > c_0$, the dual pricing strategy decreases*

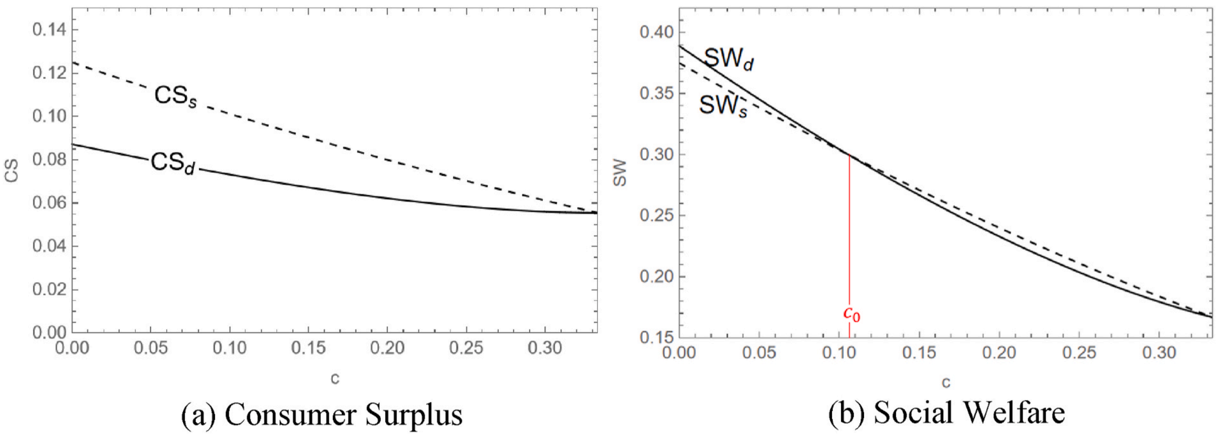


Fig. 6. Consumer surplus and social welfare for $g(v) = av^2$.

social welfare.

Compared to the single pricing strategy, the dual pricing strategy increases total demand, positively affecting social welfare. However, it also reduces consumer surplus, which negatively impacts social welfare. Whether positive or negative effects dominate depends on the marginal cost c. When the marginal cost is low ($c \le c_0$), the dual pricing strategy significantly boosts total demand, leading to increased social welfare. When the marginal cost is high ($c > c_0$), the increase in total demand is relatively small, and the reduction in consumer surplus predominates, resulting in decreased social welfare.

7. Conclusions and managerial implications

This paper investigates the dual pricing strategy with purchase hassle, under which sellers intentionally increase consumers' hassle costs and use hassle costs as the instrument of price discrimination. We develop an analytical model in which the seller, using the hassle level and prices, discriminates against consumers with different hassle sensitivities to maximize his profit.

7.1. Conclusions

We find that, first, when consumers' hassle sensitivity is PVI, the hassle costs cannot act as the instrument of price discrimination, making the dual pricing strategy less profitable than the single pricing strategy. Second, when consumers' hassle sensitivity is PVD, if consumers' HSF is convex increasing and the relative increasing rate is high (that is, as the hassle level increases, consumers' utility declines fast enough, meanwhile, the utility of consumers with higher product valuation declines faster), the dual pricing strategy with purchase hassle benefits the seller. The reason is that the convex increasing relationship between consumers' hassle sensitivity and product valuations strengthens the difference in purchase decisions between consumers with different product valuations and then strengthens the price discrimination effect.

We extend our model in four ways. First, we take the full-price-maintained scenario into consideration, where the sellers maintain the full price when they switch from the single pricing strategy to the dual pricing strategy. Second, since the dual pricing strategy is implemented by many online platforms, we take network effects into consideration. We find that under the full-price-maintained scenario or considering network effects, when the HSF is decreasing or concave increasing, dual pricing is still less profitable than single pricing; when the HSF is convex increasing, and the relative increase rate is high, the dual pricing strategy still benefits the seller. Third, we investigate the case that offering the dual pricing strategy is more costlier than the single pricing ($C_2 > 0$), and find that findings in the main model remain applicable. Finally, we use the quadratic hassle cost function to validate computations and to examine the implications of the dual pricing strategy on consumer surplus and social welfare.

7.2. Managerial implications

Our theoretical analysis provides some worthwhile managerial insights to help the sellers decide whether to adopt and how to apply dual pricing with purchase hassle. Specifically, the heterogeneity of consumers' hassle costs is the prominent factor that the seller should consider. The theoretical implications are shown below.

Firstly, sellers can use hassle costs as a tool for price discrimination, facilitating the implementation of dual pricing. Traditionally, price discrimination often generates negative sentiments among consumers who view it as unfair. Fairness concerns of price discrimination have consequently attracted widespread attention. However, when hassle costs are employed, consumers can voluntarily choose the prices they pay, which may mitigate their negative perceptions. This provides sellers with a new approach to mitigate the negative impacts of price discrimination in dual pricing. With advancements in electronic information technology and the rise of online shopping, this dual pricing strategy incorporating purchase hassle is feasible. Sellers can adjust hassle costs by setting tasks to obtain coupons, such as requiring time spent on an official webpage or sharing a link with a specified number of people.

Secondly, this dual pricing strategy is applicable when consumers' hassle costs positively and convexly relate to their product valuations. Marshall (2015) finds through empirical research that consumers who purchase at the discounted prices place less emphasis on hassle costs, aligning with our findings. He also finds that offering a refillable option (which is inconvenient but cheaper for consumers) in the soda market, where only non-refillable options exist, can enhance the seller's profit. Our results offer a reasonable explanation for this phenomenon and the conditions under which dual pricing is more profitable than single pricing, thereby helping sellers implement such strategies.

Thirdly, when sellers implement the dual pricing strategy, compared with the single pricing strategy, the full price is higher than the single price, while the discounted price is lower. Consequently, this strategy can enhance utility for some consumers while diminishing it for others. Although consumers have the right to choose their purchase price, the dual pricing strategy still reflects features of price discrimination, which may reduce consumer surplus. This finding sheds light on how dual pricing affects consumer utility.

Finally, despite the decrease in consumers' willingness to purchase due to hassle costs, the dual pricing strategy can still enhance social welfare. By analyzing the quadratic hassle cost function, we find that when consumers' hassle sensitivity increases convexly with their product valuations and the marginal cost of the product is low, the dual pricing strategy can improve social welfare. This insight is crucial for understanding the social implications of dual pricing and offers valuable guidance for policymakers and social managers.

7.3. Limitations and future work

First, this paper examines the role of hassle as a tool for price discrimination, encouraging consumers to purchase at different prices. In practice, purchase hassle can sometimes have other additional effects beyond this. For example, sharing product links to certain number of friends not only imposes hassle costs on consumers but also advertises the product. Similarly, watching live streaming shows imposes hassle costs to consumers but also enhances consumers' shopping experiences. Future research may consider the additional effects and further explore the dual pricing strategy.

Second, this paper uses a general model to analyze consumers' hassle sensitivity. The lack of a specific functional form limits us to fully explore the implications of the analytical expressions. To address this limitation, we use the quadratic function to further investigate the impact of dual pricing on consumer surplus and social welfare. Future research may empirically validate the precise relationship between consumers' hassle sensitivity and their product valuations to better understand the broader social and ethical implications of the dual pricing strategy.

Third, this paper considers product valuations, hassle costs, and prices to characterize consumer purchasing decisions, without accounting for consumers' purchasing psychological factors. The dual pricing strategy with purchase hassle offers consumers the right to choose which price to purchase, which weakens consumers' dissatisfaction with price discrimination to some extent. Changes in consumer psychology also affect consumers' purchasing behaviors. Researchers may empirically investigate how dual pricing with purchase hassle affects consumers' purchasing behaviors from the perspective of consumer psychology.

CRediT authorship contribution statement

Xuelan Zhang: Writing – review & editing, Writing – original draft, Validation, Methodology, Formal analysis, Conceptualization. **Jun Lin:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Yifu Li:** Writing – review & editing, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Yifu Li is the co-corresponding author. This work was supported by the National Natural Science Foundation of China [grant No. 72071154, 72201210], the USTC Research Funds of the Double First-Class Initiative Project [grant No. YD2040002026], and the University Synergy Innovation Program of Anhui Province [No. GXXT-2023-093]. We also appreciate The Youth Innovation Team of Shannxi Universities "Intelligent Decision Making and Optimization".

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijpe.2024.109479.

Data availability

No data was used for the research described in the article.

References

Anderson, E.T., Song, I., 2004. Coordinating price reductions and coupon events. J. Market. Res. 41 (4), 411–422.
Anderson, E.T., Dana, J.J.D., 2009. When is price discrimination profitable? Manag. Sci. 55 (6), 980–989.
Anderson, S.P., 1988. Equilibrium existence in the linear model of spatial competition. Economica 55, 479–491.
Banks, J., Moorthy, S., 1999. A model of price promotions with consumer search. Int. J. Ind. Organ. 17 (3), 371–398.
Blattberg, R., Thomas, B., Peacock, P., Sen, S., 1978. Identifying the deal-prone segment. J. Market. Res. 15, 369, 11.
Bo, H., Zheng, Y., Li, Y., He, S., 2024. Manufacturing resource outsourcing and matching: service mode selection and equilibrium evolution. J. Oper. Res. Soc. 1–18.
Chellappa, R.K., Mukherjee, R., 2021. Platform preannouncement strategies, the strategic role of Information in two-sided markets competition. Manag. Sci. 67 (3), 1527–1545.
Chiang, W.K., Chhajed, D., Hess, J.D., 2003. Direct marketing, indirect profits: a strategic analysis of dual-channel supply-chain design. Manag. Sci. 49 (1), 1–20.
Chintagunta, P.K., Chu, J., Cebollada, J., 2012. Quantifying transaction costs in online/off-line grocery channel choice. Market. Sci. 31 (1), 96–114.
Choudhary, V., Shivendu, S., 2017. Targeted couponing in online auctions. Inf. Syst. Res. 28 (3), 490–510.
Chen, Y., Narasimhan, C., Zhang, Z.J., 2001. Individual marketing with imperfect targetability. Market. Sci. 20 (1), 23–41.
Cohen, M.C., Elmachtoub, A.N., Lei, X., 2022. Price discrimination with fairness constraints. Manag. Sci. 68 (12), 8536–8552.
Cui, X., Li, Y., Li, X., Fang, S., 2023. Livestream e-commerce in a platform supply chain: a product-fit uncertainty reduction perspective. Int. J. Prod. Econ. 258, 108796.
D'Aspremont, C., Gabszewicz, J.J., Thisse, J.F., 1979. On hotelling's sability in competition. Econ. Times 47 (5), 1145–1150.
Despotakis, S., Yu, J., 2022. Multidimensional targeting and consumer response. Manag. Sci. 69 (8), 4518–4540.
Dukes, A., Zhu, Y., 2019. Why customer service frustrates consumers: using a tiered organizational structure to exploit hassle costs. Market. Sci. 38 (3), 500–515.
Ertekin, N., Gümüş, M., Nikoofal, M.E., 2022. Online-exclusive or gybrid? Channel merchandising strategies for ship-to-store implementation. Manag. Sci. 68 (8), 5828–5864.
Fattahi, A., Dasu, S., Ahmadi, R., 2022. Mass customization and the "parts-procurement planning problem". Manag. Sci. 68 (8), 5778–5797.
Gabel, S., Guhl, D., 2022. Comparing the effectiveness of rewards and individually targeted coupons in loyalty programs. J. Retailing 98 (3), 395–411.
Gao, F., Su, X., 2017. Online and offline information for omnichannel retailing. Manuf. Serv. Oper. Manag. 19 (1), 84–98.
Gerstner, E., Hess, J.D., 1991. A theory of channel price promotions. Am. Econ. Rev. 81 (4), 872–886.
Gerstner, E., Hess, J.D., 1995. Pull promotion and channel coordination. Market. Sci. 14 (1), 43–60.
Golrezaei, N., Nazerzadeh, H., Randhawa, R., 2020. Dynamic pricing for heterogeneous time-sensitive customers. Manuf. Serv. Oper. Manag. 22 (3), 562–581.
Hess, J.D., Chu, W., Gerstner, E., 1996. Controlling product returns in direct marketing. Market. Lett 7 (4), 307–317.
Herbon, A., 2017. Non-cooperative game of a duopoly under asymmetric information on consumer location. Int. J. Prod. Res. 55 (18), 5185–5201.
Hotelling, H., 1929. Stability in competition. Econ. J. 39, 41–57.
Hsiao, L., Chen, Y.J., 2012. Return policy and quality risk in e-business. Prod. Oper. Manag. 21 (3), 489–503.
Hu, M., Liu, J., Zhai, X., 2021. Intertemporal segmentation via flexible-duration group buying. Manuf. Serv. Oper. Manag. 23 (5), 1157–1174.
Huang, L., Liu, B., Zhang, R., 2024. Channel strategies for competing retailers: whether and when to introduce live stream? Eur. J. Oper. Res. 312 (2), 413–426.
Iyer, G., 1998. Coordinating channels under price and nonprice competition. Market. Sci. 17 (4), 338–355.
Kong, R., Luo, L., Chen, L., Keblis, M.F., 2020. The effects of BOPS implementation under different pricing strategies in omnichannel retailing. Transport. Res. E Logist. Transport. Rev. 141, 102014.
Krishna, A., Zhang, Z.J., 1999. Short- or long-duration coupons: the effect of the expiration date on the profitability of coupon promotions. Manag. Sci. 45 (8), 1041–1056.
Lambrecht, A., Tucker, C., 2012. Paying with money or effort: pricing when consumers anticipate hassle. J. Market. Res. 49 (1), 66–82.
Li, H., Shen, Q., Bart, Y., 2021. Dynamic resource allocation on multi-category two-sided platforms. Manag. Sci. 67 (2), 984–1003.
Li, Y., Li, G., Tayi, G.K., Cheng, T.C.E., 2019. Omni-channel retailing: do offline retailers benefit from online reviews? Int. J. Prod. Econ. 218, 43–61.
Liu, X., 2023. Dynamic coupon targeting using batch deep reinforcement learning: an application to livestream shopping. Market. Sci. 42 (4), 637–658.
Lu, Q., Moorthy, S., 2007. Coupons versus rebates. Market. Sci. 26 (1), 67–82.
Lu, T., Chen, Y.J., Tomlin, B., Wang, Y., 2019. Selling co-products through a distributor: the impact on product line design. Prod. Oper. Manag. 28, 1010–1032.

Malik, A., Contreras, I., Vidyarthi, N., 2022. Two-level capacitated discrete location with concave costs. Transport. Sci. 56 (6), 1703–1722.
Mandal, P., Basu, P., Saha, K., 2021. Forays into omnichannel: An online retailer's strategies for managing product returns. Eur. J. Oper. Res. 292 (2), 633–651.
Mandelbaum, A., Stolyar, A.L., 2004. Scheduling flexible servers with convex delay costs: heavy-traffic optimality of the generalized cμ-rule. Oper. Res. 52 (6), 836–855.
Marshall, G., 2015. Hassle costs and price discrimination: an empirical welfare analysis. Am. Econ. J. Appl. Econ. 7 (3), 123–146.
McWilliams, B., 2012. Money-back guarantees: helping the low-quality retailer. Manag. Sci. 58 (8), 1521–1524.
Morozov, I., Seiler, S., Dong, X., Hou, L., 2021. Estimation of preference heterogeneity in markets with costly search. Market. Sci. 40 (5), 871–899.
Nageswaran, L., Cho, S.H., Scheller-Wolf, A., 2020. Consumer return policies in omnichannel operations. Manag. Sci. 66 (12), 5558–5575.
Narasimhan, C., 1984. A price discrimination theory of coupons. Market. Sci. 3 (2), 128–147.
Neslin, S.A., Shoemaker, R.W., 1983. A model for evaluating the profitability of coupon promotions. Market. Sci. 2 (4), 361–388.
Nie, T., Song, B., Zhang, J., 2024. Sales pricing models based on returns: bundling vs. add-on. Omega 125, 103038.
Niu, B., Li, Q., Mu, Z., Chen, L., Ji, P., 2021. Platform logistics or self-logistics? Restaurants' cooperation with online food-delivery platform considering profitability and sustainability. Int. J. Prod. Econ. 234, 108064.
Parker, G.G., Alstyne, M.W.V., 2005. Two-sided network effects: a theory of information product design. Manag. Sci. 51 (10), 1494–1504.
Pindyck, R.S., Rubinfeld, D.L., 2005. The Basics of Supply and Demand. Microeconomics 43–86.
Reimers, I., Xie, C., 2018. Coupons expand or cannibalize revenue? Evidence from an e-market. Manag. Sci. 65 (1), 286–300.
Shaffer, G., Zhang, Z.J., 1995. Competitive coupon targeting. Market. Sci. 14 (4), 395–416.
Shin, J., Yu, J., 2021. Targeted advertising and consumer inference. Market. Sci. 40 (5), 900–922.
Su, M., Zheng, X., Sun, L., 2014. Coupon trading and its impacts on consumer purchase and firm profits. J. Retailing 90 (1), 40–61.
Sun, B., Xie, J., Cao, H.H., 2004. Product strategy for innovators in markets with network effects. Market. Sci. 23 (2), 243–254.
Szwarc, W., Posner, M.E., Liu, J.J., 1988. The single machine problem with a quadratic cost function of completion times. Manag. Sci. 34 (12), 1480–1488.
Tian, L.X., Feinberg, F.M., 2020. Optimizing price menus for duration discounts: a subscription selectivity field experiment. Market. Sci. 39 (6), 1181–1198.
Wan, Q., Yang, S., Shi, V., Qiu, M., 2021. Optimal strategies of mobile targeting promotion under competition. Int. J. Prod. Econ. 237, 108143.
Wang, H., 2004. Do returns policies intensify retail competition? Market. Sci. 23 (4), 611–613.
Wang, R., Sahin, O., 2018. The impact of consumer search cost on assortment planning and pricing. Manag. Sci. 64 (8), 3649–3666.
Wang, J., Hu, M., 2020. Efficient inaccuracy: user-generated information sharing in a queue. Manag. Sci. 66 (10), 4648–4666.
Wu, D., Li, Y., Chen, Y.J., 2024. Licensing and Contracting in the Intellectual Property Contest. Available at: SSRN 4899326.
Xia, Y., Xiao, T., Zhang, G.P., 2019. Service investment and channel structure decisions in competing supply chains. Serv. Sci. 11 (1), 57–74.
Xin, W., Lin, J., Zhou, X., Yin, S., 2024. Envelopment strategies and contract design of two-sided platforms. Int. J. Prod. Econ. 269, 109158.
Xiong, H., Liu, J., 2023. Return insurance in a competitive market: benefiting the high-quality or low-quality retailer? Int. J. Prod. Econ. 255, 108719.
Yang, L., Li, X., Zhong, N., 2022. Omnichannel retail operations with mixed fulfillment strategies. Int. J. Prod. Econ. 254, 108608.
Yang, X., Cai, G., Ingene, C.A., Zhang, J., 2020. Manufacturer strategy on service provision in competitive channels. Prod. Oper. Manag. 29 (1), 72–89.
Zhang, Z., Ma, M., Leszczyc, P.T.L.P., Zhuang, H., 2020. The influence of coupon duration on consumers' redemption behavior and brand profitability. Eur. J. Oper. 281 (1), 114–128.
Zhang, C., Yu, M., Chen, J., 2022. Signaling quality with return insurance: theory and empirical evidence. Manag. Sci. 68 (8), 5847–5867.