A Rational Explanation of Hidden Price

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Abstract

Online platforms frequently employ drip-pricing strategies, where the base price is displayed first and compulsory fees are introduced only later in the purchasing process. Empirical evidence documents that consumers are often surprised by hidden fees. While firms can exploit consumer unawareness by revealing fees for optional add-ons after purchase, exploiting unawareness about mandatory fees seems paradoxical - mandatory fees must be disclosed at checkout, leaving consumers fully informed at the point of purchase. Nevertheless, empirical evidence consistently shows that sequentially revealing prices through hidden fees significantly increases demand relative to upfront pricing. Prior literature suggests that these findings can be explained if consumers exhibit behavioral biases at the point of purchase, such as salience effects or loss aversion. In this paper, we depart from the behavioral explanations emphasized in prior work and ask whether temporary unawareness alone, absent any additional biases, can be strategically exploited by firms. We consider a monopolist that imposes mandatory fees hidden during consumers' initial search but fully disclosed at checkout. In our model, consumers are unaware of the hidden fees while browsing, yet they behave fully rationally at the point of purchase, once all fees are disclosed. We model consumer search in a setting where individuals must exert effort to learn their valuation for a product. By presenting prices sequentially, sellers can induce consumers to begin searching in cases where they would not have searched at all under upfront pricing, and to continue searching in cases where early signals are unfavorable. In other words, the initially low base price encourages consumers to invest more effort in evaluating the product, increasing the likelihood that they accumulate enough positive signals to eventually justify a purchase. We fully characterize the seller's optimal pricing strategy. We find that, under certain conditions, the total price under hidden pricing can be lower than the price the firm would set if it were constrained to transparent pricing. Moreover, allowing hidden pricing can enhance social welfare.

1 Introduction

Consumers frequently encounter fees that are not reflected in the initial price of a product or service. A hotel stay, for instance, may involve charges for amenities such as Wi-Fi, parking, or access to a fitness center. Air travel often comes with additional costs for checked luggage, seat selection, or in-flight refreshments. Purchases made online or through ticketing platforms may carry service or processing fees that are added at checkout, increasing the total price beyond what was initially advertised.

If all consumers were fully rational, hidden charges would backfire, as consumers would anticipate the worst from a firm that shrouds its prices. Rational consumers will infer that hidden prices are likely to be high prices, creating strong incentives for firms to disclose information and for shrouding to unravel. Economic theory therefore predicts that all firms adopt transparent pricing in equilibria with rational consumers (Milgrom, 1981; Grossman, 1981; Grossman and Hart, 1980). Yet, this prediction contrasts sharply with observed market behavior, where hidden fees and surcharges are widespread. Ellison (2005) proposes the existence of unsophisticated consumers who do not anticipate add-on charges as "the most promising explanation for why add-on prices are not advertised." The seminal contribution of Gabaix and Laibson (2006) formalizes this insight, showing that shrouding can persist in equilibrium when some consumers fail to foresee hidden costs, thereby offering a compelling resolution to the puzzle of why hidden fees remain prevalent.

The assumption that consumers are myopic with respect to hidden fees receives strong empirical support. A substantial body of empirical literature documents that consumers tend to be insufficiently skeptical (or naive) about non-disclosed information (Jin, Luca, and Martin, 2021; Montero and Sheth, 2021; Brown, Hossain, and Morgan, 2010; Brown, Camerer, and Lovallo, 2012; Sheth, 2021; Sah and Read, 2020). Consumers tend to underestimate the likelihood or magnitude of hidden fees and, as a result, some shoppers are caught off guard when additional charges appear at checkout. Hall (1997) surveyed owners of inkjet printers and found that over 40% were unaware of the cost of replacement ink cartridges at the time of purchase. Among those who believed they were informed, more than two-thirds underestimated the actual cost of the cartridges. Seim and Vitorino (2024) find that about 25% of students are unaware of the fee for repeating a driving exam when signing up for a driving school. Feldman and Ruffle (2015) conducted an experiment in which participants were presented with tax-exclusive prices and explicitly informed that taxes were not included, yet a post-experiment questionnaire found that 30% had forgotten about the tax and were surprised when it was added at checkout. Anecdotal evidence from consumer forums, blogs, and other online platforms abounds, with numerous posts capturing consumers' surprise when confronted with either fees they did not expect or fees that were higher than they anticipated.

Gabaix and Laibson (2006) highlight an important distinction between optional add-ons and unavoidable fees. Add-ons are charges associated with secondary products that consumers may neglect when purchasing the main product. For instance, a consumer booking a hotel may not notice the cost of Wi-Fi during the reservation process and only become aware of it upon arrival. In contrast, mandatory fees are tied to the base product and disclosed before the consumer finalizes the purchase. For example, on platforms such as StubHub, consumers may initially focus on the displayed ticket prices while overlooking the presence of service fees; however, these fees are revealed at checkout, before the transaction is finalized.

Following Gabaix and Laibson (2006), a growing body of theoretical literature examines how consumer unawareness shapes equilibrium strategies in markets with add-ons (Armstrong and Vickers, 2012; Johnen and Somogyi, 2024; Heidhues, Kőszegi, and Murooka, 2016,?; Kosfeld and Schüwer, 2017; Shulman and Geng, 2013; Geng, Tan, and Wei, 2018; Erat and Bhaskaran, 2012). In these models, firms exploit the fact that consumers commit to purchasing the base good before fully accounting for the costs of add-ons. A classic example is the printer market, where consumers may be enticed by an attractively low price for the printer itself, only to later discover that replacement cartridges are unexpectedly expensive. The firm exploits the fact that the decision to purchase the base good occurs under conditions of unawareness of the add-on prices.

By contrast, unawareness regarding mandatory fees — such as processing charges levied by ticketing platforms — is inherently temporary. While consumers may neglect these charges when browsing, they are unavoidably revealed before the transaction is completed. Thus, when it comes to mandatory fees, consumers ultimately finalize their purchase decisions with full knowledge of the total cost.

Standard economic theory predicts that temporary unawareness about mandatory fees should have no impact on consumer choices, since decisions are made once all relevant information is disclosed. Yet, a growing body of empirical and experimental evidence suggests otherwise. Numerous studies find that hidden mandatory fees significantly affect consumer demand, even though the fees are revealed prior to purchase (Chetty, Looney, and Kroft, 2009; Brown, Hossain, and Morgan, 2010; Feldman and Ruffle, 2015; Feldman, Goldin, and Homonoff, 2018; Bradley and Feldman, 2020). Blake et al. (2021) provide particularly striking evidence from a field experiment on StubHub. Consumers were randomly assigned to either an upfront-pricing condition, in which the full ticket price (including fees) was displayed from the outset, or a backend-pricing condition, in which only the base ticket price was shown initially, with fees revealed at checkout. Notably, at the point of purchase, both groups faced the same prices and had the same information. Nonetheless, consumers in the backend condition were 14% more likely to complete a purchase.

These findings point to an important gap between standard models and observed behavior. To explain these puzzling findings, theoretical work has incorporated additional behavioral biases such as limited attention, salience effects (Chetty, Looney, and Kroft, 2009; Goldin and Homonoff, 2013) or loss-aversion (Kőszegi and Rabin, 2006).[1] Blake et al. (2021) articulate this view: "[Consumers] may believe that they have found a cheap enough ticket to warrant purchase, and proceed to the checkout page with that ticket in hand. Upon reaching the checkout and purchase page, the ticket's actual price - including all fees - is revealed. Absent behavioral biases, the consumer ought to exit without buying the ticket, but we assume that some consumers will complete their purchase due to loss aversion or other behavioral biases."

In this paper, we depart from the behavioral explanations emphasized in prior work and ask whether temporary unawareness alone, absent any additional biases, can be strategically exploited by firms. Specifically, we study a monopolist that employs mandatory fees which are hidden during consumers' initial search but are fully disclosed at checkout. In our framework, consumers are fully rational at the moment of purchase.

We model consumer search in a setting where individuals must exert effort to learn their valuation for a product. Consumers initially observe a base price and decide how much search effort to

[1] Some models without behavioral assumptions show that hidden fees can soften price competition in oligopoly settings (e.g., Chen, 2023; Heidhues, Johnen, and Kőszegi, 2021), though a monopolist would never benefit from such fees.

exert, treating this first-stage decision as if it were binding. In reality, the purchase is only finalized after the consumer is presented with the full price, which includes a hidden fee. Because consumers are unaware of the hidden component during search, they respond to the base price alone when deciding how much effort to invest in learning their valuation.

Under upfront pricing, the consumer makes a single decision: whether or not to purchase at the posted total price. By contrast, under sequential pricing with a base price and a hidden fee, the consumer makes two decisions. The first occurs when the consumer is unaware of the hidden fee and believes the base price is the final price; the second occurs when the hidden fee is revealed and the consumer evaluates the full price. Importantly, at the second stage, the consumer behaves exactly as he would if the total price had been disclosed upfront: the amount of positive information required to justify purchase is the same. The difference lies in the first stage. Because the consumer perceives the product as less expensive, he is more forgiving of negative signals and persists longer in searching.

This persistence is central to the mechanism. By presenting prices sequentially — first a base price and then a hidden fee — sellers can induce consumers to begin searching in cases where they would not have searched at all under upfront pricing, and to continue searching in cases where early signals are unfavorable. In other words, the low base price leads consumers to persist more, which increases the probability that they accumulate enough positive signals to eventually justify a purchase.

We fully characterize the seller's optimal pricing strategy in this setting. Our analysis shows that the hidden fee rises with the informativeness of search signals and marginal cost, and falls with search costs and initial consumer valuation. The base price, in contrast, increases with both initial valuation and marginal cost.

When consumers have heterogeneous initial valuations, we find that, under certain conditions, the total price under hidden pricing can be lower than the price the firm would set if it were constrained to transparent pricing. Moreover, allowing hidden pricing can enhance social welfare.

The key mechanism driving these results is that, without hidden fees, it may be unprofitable for sellers to serve low-valuation consumers, leading to high prices tailored to high-value segments. Hidden pricing enables sellers to profitably serve both high- and low-valuation consumers by adjusting price components appropriately, thereby lowering the effective price. These findings have important policy implications: although regulatory efforts often focus on banning hidden fees, our analysis identifies scenarios in which hidden pricing can increase both efficiency and welfare, suggesting a more nuanced view of policy interventions.

The remainder of the paper is organized as follows. Section 2 presents a simple model of one-shot learning. Section 3 presents the more general framework where consumers learn sequentially about multiple attributes. Section 4 solves the optimal strategies with and without a hidden price, and compares the equilibrium outcomes. Section 5 considers consumers with heterogeneous initial values or learning speeds. Section 6 examines an extension. Section 7 concludes.

2 A Simple Model of One-Attribute Learning

We begin our analysis with a simplified setting in which consumers face uncertainty about only a single product attribute. The consumer's valuation v for the product is drawn from distribution F. The consumer does not observe the realized value of v, but she has correct beliefs regarding its distribution. The consumer may choose to incur a deliberation cost $c > 0$ to learn the exact realization of her valuation. We assume that the revenue function $R(p) = p[1 - F(p)]$ is single-peaked, and we define p^* as the value that maximizes $R(p)$.

The game unfolds as follows. The firm sets a posted price $p_{Initial}$ and a hidden fee h. The consumer observes the posted price but is unaware of the hidden fee, effectively believing that $h = 0$. She first decides whether to incur the deliberation cost c to learn her valuation. Following this decision, the consumer chooses whether to leave without purchasing or to proceed to checkout. At checkout, the hidden fee is revealed, and the consumer becomes fully informed of the final price $p_{Final} = p_{Initial} + h$. If she has not previously learned her valuation, she may choose to do so by incurring the deliberation cost. Finally, the consumer decides whether to complete the purchase.

2.1 Optimal consumer search strategy

We start by analyzing the consumer's decision in the first-stage, after observing $p_{Initial}$. Because the consumer is unaware of the hidden fee, she acts as if $p_{Initial}$ is the final price. The consumer has three options: i) learn her valuation and decide whether to proceed to checkout; ii) proceed to checkout, without learning her valuation; iii) leave without purchase. If she chooses to learn her valuation, she will proceed to checkout if and only if her valuation is larger than the price. Her expected surplus under deliberation is

$$U(learn) = \int_{p_{Initial}}^{\infty} (v - p_{Initial})\,\mathrm{d}F(v) - c. \tag{1}$$

If she proceeds to checkout without learning her valuation, she obtains an expected surplus of

$$U(purchase) = \int_{0}^{\infty} (v - p_{Initial})\,\mathrm{d}F(v). \tag{2}$$

She will prefer to learn her valuation over purchasing without learning if $U(learn) > U(purchase) \iff p_{Initial} > \underline{p}$, where $\underline{p}$ satisfies the condition below.

$$c = \int_{0}^{\underline{p}} (\underline{p} - v)\,\mathrm{d}F(v) \tag{3}$$

If, instead, the consumer leaves without purchasing, she obtains zero surplus. Hence, she will prefer to learn her valuation over leaving without purchasing if $U(learn) > 0 \iff p_{Initial} < \bar{p}$, where $\bar{p}$ satisfies the condition below.

$$c = \int_{\bar{p}}^{1} (v - \bar{p})\,\mathrm{d}F(v) \tag{4}$$

It follows that the consumer will choose to learn her valuation if $\underline{p} \leq p_{Initial} \leq \bar{p}$. There is a range of prices under which deliberation is optimal provided that the deliberation cost is not too large, as characterized below.

Lemma 1. *If $c < \bar{c} \equiv \int_0^{E(v)} (E(v) - v)\,\mathrm{d}F(v)$ then $\underline{p} < \bar{p}$.*

Throughout the rest of the analysis, we assume that $c < \bar{c}$, so that there is a range of prices under which deliberation is optimal. We characterize the consumer first-stage deliberation strategy below.

Lemma 2 (First-stage deliberation)**.** *After observing $p_{Initial}$,* *i) The consumer proceeds to checkout if* $p_{Initial} < \underline{p}$;

ii) The consumer leaves without purchasing if $p_{Initial} > \bar{p}$;

iii) The consumer deliberates if $p_{Initial} \in [\underline{p}, \bar{p}]$. *She then proceeds to checkout if* $v \geq p_{Initial}$.

In case the consumer proceeds to checkout, she observes the final price $p_{Final} = p_{Initial} + h$. If she has already learned her valuation, she will proceed to purchase if $v \geq p_{Final}$. Otherwise, she can either leave without purchase, purchase immediately, or incur the deliberation cost to learn her valuation.

Lemma 3 (Second-stage decision)**.** *If the consumer has learned her valuation, she purchases if and only if* $p_{Final} \leq v$. *If she has not learned her valuation in the first stage she will*

i) purchase if $p_{Final} < \underline{p}$;

ii) leave without purchasing if $p_{Final} > \bar{p}$;

iii) deliberate if $p_{Final} \in [\underline{p}, \bar{p}]$. *She then proceeds to purchase if* $v \geq p_{Final}$.

2.2 Optimal pricing strategy

2.2.1 Without hidden fees

We start with the case in which the firm is not able to use hidden fees (for example, due to government regulations or to restrictions set by the platform). In this case, $h = 0$ and we denote by p_{wo} the price that the firm sets. If $p_{wo} \leq \underline{p}$ the consumer purchases without learning her valuation - in this case, it is optimal to set $p_{wo} = \underline{p}$. If $p_{wo} > \bar{p}$, the consumer does not purchase and the firm does not make profit. Finally, if $p_{wo} \in [\underline{p}, \bar{p}]$, the consumer deliberates and purchases with probability $(1 - F(p_{wo}))$ - due to the assumption of single-peaked revenue, it follows that if it is optimal for the firm to induce deliberation, the optimal price is $p_{wo} = \min\{\bar{p}, p^*\}$.

Below, we characterize the optimal price in absence of hidden fees.

$$p^*_{wo} = \begin{cases} \underline{p} & \text{if } \underline{p} \geq \min\{\bar{p}, p^*\}[1 - F(\min\{\bar{p}, p^*\})] \\ \min\{\bar{p}, p^*\} & \text{otherwise} \end{cases} \tag{5}$$

2.2.2 With hidden fees

We now analyze the case in which the firm chooses both $p_{Initial}$ and h. First notice that if $p_{Initial}$ does not induce the consumer to deliberate, then the hidden fee is not playing any role. Indeed, if the consumer proceeds to checkout she observes p_{Final} and behaves exactly the same way as she would if she were immediately presented with p_{Final}. Hence, if the firm wants to sell to the consumer without having her learning her valuation, the most the firm can charge is $p_{Initial}+h=\underline{p}$.

Let us now consider the case in which $p_{Initial} \in [\underline{p}, \bar{p}]$ so that the consumer learns her valuation before proceeding to checkout. At checkout, the consumer becomes aware of the hidden fee and purchases if $v \geq p_{Initial}+h$. The firm's profit is $(p_{Initial}+h)[1-F(p_{Initial}+h)]$.

Suppose $p^* > \bar{p}$. In this case, if the consumer was informed about her valuation, it would be optimal for the firm to set price p^*. However, at such price the consumer does not incur the deliberation cost and leaves without purchase. The firm can leverage the hidden fee by offering an attractive initial price $p_{Initial} \leq \bar{p}$ that induces the consumer to learn her valuation, and then use the hidden fee so that the final price is p^*.

Proposition 1. *If $p^* \leq \bar{p}$, the firm's profit is the same with or without hidden fees. If $p^* > \bar{p}$ and $\underline{p} < p^*[1-F(p^*)]$ then the firm benefits from using hidden fees, and the optimal prices are such that $p_{Initial} \in [\underline{p}, \bar{p}]$ and $p_{Initial}+h=p^*$.*

2.3 A numerical example

We illustrate the results with a simple numerical example. Let the distribution of valuations, previously denoted by F, be the Beta distribution with parameters $\alpha = 0.15$ and $\beta = 0.2$, and let the deliberation cost be $c = 0.1$. We can then use (3) and (4) to obtain $\underline{p} \approx 0.24$ and $\bar{p} \approx 0.67$. Moreover $p^* = \arg\max p[1-F(p)] \approx 0.81$ i.e. if consumers were informed about their valuations, the optimal price would be p^* and the firm would extract profit $p^*(1-F(p^*)) \approx 0.267$.

When the firm cannot use hidden fees, it cannot sell to the consumer at price p^*; at such price, the consumer does not incur the deliberation cost and she leaves without purchase. In order to induce deliberation, the firm can charge at most $\bar{p}$. At such price the firm's profit is $\bar{p}(1-F(\bar{p})) \approx 0.253$. Alternatively, the firm can set price $\underline{p}$ in which case the consumer purchases without deliberation, and the firm makes profit $\underline{p} \approx 0.24$. It follows that the optimal price in absence of hidden fees is $\bar{p}$. Notice that the profit that the firm makes is lower than what it would make if consumers were fully informed about their valuation, in which case the firm would sell at p^*.

Let us now consider the case in which the firm can use hidden fees. In this case, the firm can induce the consumer to learn her valuation provided that $p_{Initial} \in [\underline{p}, \bar{p}]$. The hidden fee will only be disclosed after the consumer has learned her valuation, at which point it is optimal to set the final price at p^*, i.e. $p_{Initial} + h = p^*$. By using hidden fees, the firm can present consumers with a low initial price that induce consumers to learn their valuations, while selling at a final price that would discourage them from incurring the deliberation cost.

The one-attribute model provides intuition for how firms may exploit hidden fees even when consumers are fully rational at the point of purchase, once all fees have been disclosed. However, this framework captures only part of the relevant mechanisms. For example, it cannot answer questions about the consumer's expected search time. In practice, consumer learning is not a one-shot process but rather occurs gradually over time and across different product dimensions. In the following section, we extend the analysis to the multi-attribute setting, which addresses these limitations and yields additional insights. Moreover, while in the one-attribute case, the firm's choice of optimal price and hidden fee is not uniquely determined, the multi-attribute case yields a unique equilibrium outcome.

3 Base Model

A firm offers a product with a marginal cost of m and price p. A rational consumer decides whether to buy it. The consumer has an initial valuation v_0 about the product, which is common knowledge.[2] She can search for information before making a decision. If the consumer searches for information, she incurs a flow search cost cdt per dt period of time, and her valuation v_t evolves as

[2] There can be two interpretations for the initial valuation. The first one is that consumers have homogenous valuations. The second one is that consumers have heterogeneous valuations, but the firm knows each individual consumer's initial valuation.

a Brownian motion with a constant variance σ^2.

$$dv_t = \sigma dW_t,$$

where W_t is a standard Brownian motion. This can be interpreted as the consumer learning over time about equally important and independent attributes, and there being an infinite number of attributes (e.g., Branco, Sun, and Villas-Boas (2012)). We assume that there is no discounting because the entire process is usually quick.

3.1 Without a Hidden Price

The firm may be banned from charging a hidden price by regulations, or may choose not to adopt such strategies. If there is no hidden price, the firm chooses a single posted price p_{wo}, which is observed by the consumer. At any time t, the consumer's expected payoff from purchasing the product given her valuation v_t is $v_t - p_{wo}$.

3.2 With a Hidden Price

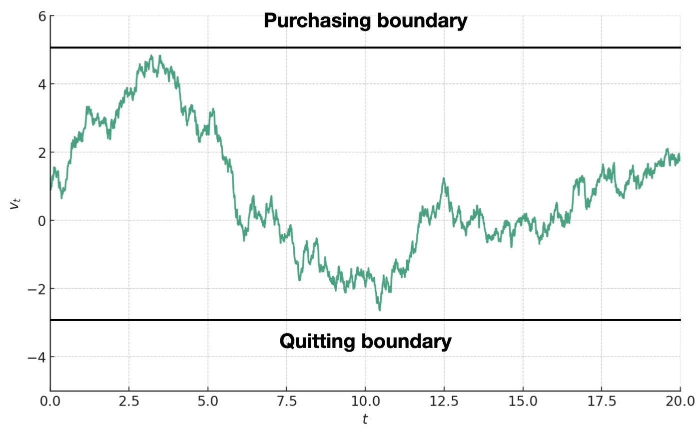
The firm chooses an initial price $p_1 \geq 0$ and a hidden price $\Delta p > 0$.[3] The consumer observes p_1 initially but is unaware of the existence of a hidden price. When the consumer's valuation v_t becomes high enough, the consumer decides to buy and go to the checkout page. At that time, the consumer will see an additional hidden price $\Delta p > 0$. Without behavioral bias, she will not buy the product because the hidden price raises the consumer's purchasing threshold. The consumer faces an updated search problem at the checkout page.

[3] The problem becomes the optimal pricing without a hidden price if $\Delta p = 0$. In some scenarios, it may not be feasible for the firm to offer a product for free initially. In such cases, a more reasonable assumption is that $p_1 \geq r$ for a constant $r > 0$. Our analysis and mechanisms can easily extend to this case.

4 Analysis

4.1 Without a Hidden Price

According to Branco, Sun, and Villas-Boas (2012), the consumer's optimal strategy is to purchase if the valuation is sufficiently high, $v_t \geq \bar{V}_1(p_{wo}) := \sigma^2/4c + p_{wo}$ (purchasing threshold), to quit if the valuation is sufficiently low, $v_t \leq \underline{V}_1(p_{wo}) := -\sigma^2/4c + p_{wo}$ (quitting threshold), and to keep searching if the valuation is intermediate, $\underline{V}_1(p_{wo}) < v_t < \bar{V}_1(p_{wo})$. Figure 1 illustrates the consumer's optimal search strategy.



$v_0 = 1,\ p = 1$

Figure 1: Consumer's search strategy

It has been shown that for a given valuation v and price p_{wo}, the consumer's purchasing probability is:

$$Q_1(v, p_{wo}) = \begin{cases} 1, & if\ p_{wo} \leq v - \frac{\sigma^2}{4c}, \\ \frac{v + \frac{\sigma^2}{4c} - p_{wo}}{\frac{\sigma^2}{2c}}, & if\ v - \frac{\sigma^2}{4c} < p_{wo} < v + \frac{\sigma^2}{4c}, \\ 0, & if\ p_{wo} \geq v + \frac{\sigma^2}{4c}, \end{cases} \tag{6}$$

The firm's expected profit is $(p^*_{wo} - m) \cdot Q_1(v_0, p_{wo})$, and thus the optimal price is:[4]

[4] The firm cannot make any profit if $v_0 \leq -\sigma^2/4c + m$.

$$p^*_{wo} = \begin{cases} v_0 - \frac{\sigma^2}{4c},\ if\ v_0 \geq \frac{3\sigma^2}{4c} + m \\ \\ \frac{v_0}{2} + \frac{\sigma^2}{8c} + \frac{m}{2},\ if\ -\frac{\sigma^2}{4c} + m < v_0 < \frac{3\sigma^2}{4c} + m \end{cases} \tag{7}$$

The ex-ante purchasing probability under the optimal price is

$$Q_1(v_0, p^*_{wo}) \begin{cases} 1,\ if\ v_0 \geq \frac{3\sigma^2}{4c} + m, \\ \\ \frac{c}{\sigma^2}(v_0 + \sigma^2/4c - m),\ if\ -\frac{\sigma^2}{4c} + m < v_0 < \frac{3\sigma^2}{4c} + m, \\ \\ 0,\ if\ v_0 \leq -\frac{\sigma^2}{4c} + m \end{cases} \tag{8}$$

As we can see, when the hidden price is not feasible, the firm cannot sell any product if $v_0 \leq -\sigma^2/4c + m$. This is because the firm must charge a posted price of at least the marginal cost m to avoid incurring losses. When the consumer's initial valuation is too low, the consumer needs to accumulate lots of positive signals to reach the purchasing decision, even under this minimal price. As a result, the consumer is better off not searching to save the search cost.

Expected Search Time and Consumer Welfare

When $v_0 \leq -\frac{\sigma^2}{4c} + m$, the consumer will quit directly. The search time and consumer welfare are zero. When $v_0 \geq \frac{3\sigma^2}{4c} + m$, the consumer will purchase directly. The search time is zero and the consumer welfare is $v_0 - p^*_{wo} = \sigma^2/4c$.

When $-\frac{\sigma^2}{4c} + m < v_0 < \frac{3\sigma^2}{4c} + m$, the consumer will search for information before making a purchasing decision. Using Dynkin's formula, one can derive the expected search time (expectation of the stopping time) under the optimal price:

$$\mathbf{E}(\tau_{wo}) = \frac{\frac{\sigma^4}{16c^2} - (v_0 - p^*_{wo})^2}{\sigma^2} = \frac{\frac{\sigma^4}{16c^2} - (\frac{v_0 - m}{2} - \frac{\sigma^2}{8c})^2}{\sigma^2}$$

Because the consumer's valuation at purchasing is always $\bar{V}_1(p^*_{wo})$, the consumer's payoff from purchasing the product must be $\bar{V}_1(p^*_{wo}) - p^*_{wo} = \sigma^2/4c$. Hence, the expected consumer surplus under the optimal price has the following closed-form:[5]

$$
\begin{aligned}
\mathbf{E}(consumer\ surplus) &= -\,c\cdot\mathbf{E}(\tau_{wo}) + \frac{\sigma^2}{4c}\cdot Q_1(v_0, p^*_{wo})\\
&= -\,c\cdot\frac{\frac{\sigma^4}{16c^2} - (v_0 - p^*_{wo})^2}{\sigma^2} + \frac{v_0 + \frac{\sigma^2}{4c} - p^*_{wo}}{2}\\
&= -\,c\cdot\frac{\frac{\sigma^4}{16c^2} - (\frac{v_0-m}{2} - \frac{\sigma^2}{8c})^2}{\sigma^2} + \frac{\frac{v_0-m}{2} + \frac{\sigma^2}{8c}}{2}
\end{aligned}
$$

4.2 With a Hidden Price

In the first stage, the consumer faces the same search problem as in the case without a hidden price. So, the purchasing and quitting threshold is the same as those in the previous section.

When the consumer's valuation v_t reaches the purchasing threshold $\bar{V}_1(p_1) = \sigma^2/4c + p_1$, the consumer decides to buy and go to the checkout page. At that time, the consumer will see an additional hidden price $\Delta p > 0$. Without behavioral bias, she will not buy the product because the hidden price raises the purchasing threshold from $\bar{V}_1(p_1)$ to $\bar{V}_1(p_1 + \Delta p)$. The consumer faces an updated search problem. She will quit if $v_t \leq \underline{V}_1(p_1 + \Delta p)$, purchase if $v_t \geq \bar{V}_1(p_1 + \Delta p)$, and keep searching if $\underline{V}_1(p_1 + \Delta p) < v_t < \bar{V}_1(p_1 + \Delta p)$. Figures 2 and 3 illustrate the consumer's optimal search strategy with a hidden price.

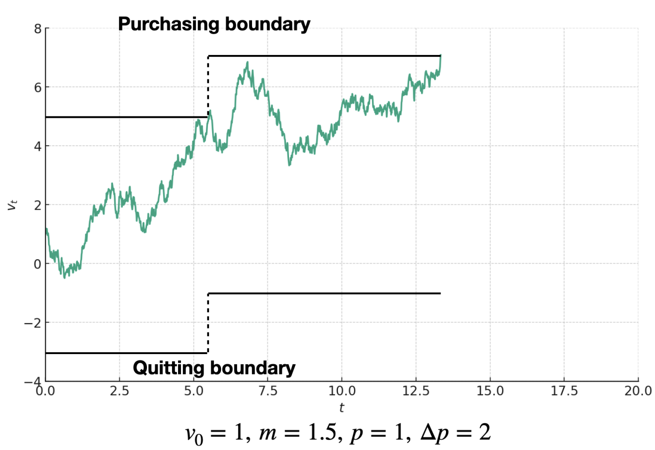


Figure 2: Consumer's sample path with hidden price (purchase)

If the initial price p_1 induces immediate purchase or quit, then the problem becomes the same

[5] The consumer's expected welfare can also be derived by solving the consumer's value function.

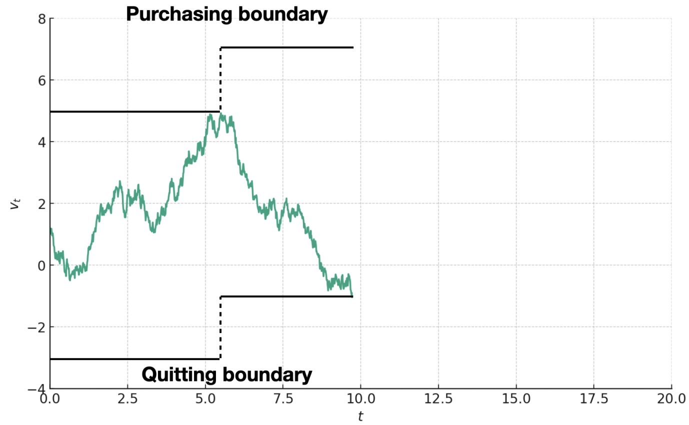


Figure 3: Consumer's sample path with hidden price (no purchase)

as the case without a hidden price. So, we will focus on the case where the initial price p_1 induces search in the first stage, $v_0 \in (p_1 - \sigma^2/4c, p_1 + \sigma^2/4c) \Leftrightarrow p_1 \in (v_0 - \sigma^2/4c, v_0 + \sigma^2/4c)$. For a given initial price p_1, the probability that the consumer goes to the checkout page (v_t reaches $\bar{V}_1(p_1)$ before hitting $\underline{V}_1(p_1)$) is:

$$Q_1(v_0, p_1) = \frac{v_0 + \frac{\sigma^2}{4c} - p_1}{\frac{\sigma^2}{2c}} = \frac{2c}{\sigma^2}(v_0 + \frac{\sigma^2}{4c} - p_1).$$

Conditional on reaching the checkout page, the firm charges a hidden fee $\Delta p > 0$. If this hidden fee is too high, $\Delta p > \sigma^2/2c$, it will move the consumer's quitting threshold above $\bar{V}_1(p_1)$. Then, the consumer will quit immediately. So, in equilibrium, the hidden fee must be moderate, $\Delta p \in (0, \sigma^2/2c)$. Given the consumer's valuation $\bar{V}_1(p_1)$ and the hidden fee Δp, the purchasing probability conditional on the consumer reaching the checkout page is:

$$Q_2(\Delta p) = 1 - \frac{\Delta p}{\sigma^2/2c} = 1 - \frac{2c}{\sigma^2}\Delta p. \tag{9}$$

The firm's overall expected profit is:

$$
\begin{aligned}
&\Pi_w(p_1, \Delta p)\\
=&\underbrace{(p_1+\Delta p-m)}_{\text{profit per sale}}\cdot \underbrace{Q_1(v_0,p_1)}_{\text{probability of reaching the checkout page}} \cdot \underbrace{Q_2(\Delta p)}_{\text{conditional probability of purchasing}}\\
=&(p_1+\Delta p-m)\cdot\frac{2c}{\sigma^2}(v_0+\frac{\sigma^2}{4c}-p_1)\cdot(1-\frac{2c}{\sigma^2}\Delta p).
\end{aligned}
$$

In sum, the firm's constrained optimization problem is:[6]

$$
\begin{aligned}
\max_{p_1,\Delta p}\ &(p_1+\Delta p-m)\cdot\frac{2c}{\sigma^2}(v_0+\frac{\sigma^2}{4c}-p_1)\cdot(1-\frac{2c}{\sigma^2}\Delta p) \qquad (P_w)\\
s.t.\ &p_1\geq 0,\\
&p_1\in(v_0-\sigma^2/4c, v_0+\sigma^2/4c),\\
&\Delta p\in[0,\sigma^2/2c).
\end{aligned}
$$

Proposition 2. *If* $\max\{-m/2, -3\sigma^2/4c+m\}<v_0<3\sigma^2/4c+m$, *then the optimal initial price is* $p_1^*=2v_0/3+m/3$ *and the optimal hidden price is* $\Delta p^*=\sigma^2/4c+(m-v_0)/3$. *The optimal total price is* $p_1^*+\Delta p^*=v_0/3+\sigma^2/4c+2m/3$, *which is strictly higher than the optimal price without a hidden price,* p_{wo}^*.

If $-\sigma^2/4c<v_0\leq -m/2$, *then the optimal initial price is* $p_1^*=0$ *and the optimal hidden price is* $\Delta p^*=\sigma^2/4c+m/2$.

The following corollary summarizes the comparative statics of the optimal price.

Corollary 1. *(Comparative statics)*

1. *The hidden price* Δp *increases in the signal informativeness* σ^2, *the marginal cost* m, *and decreases in the search cost* c, *the initial valuation* v_0.

2. *The initial price* p *increases in* v_0 *and* m, *and does not depend on* σ^2 *and* c.

3. *The total price* $p+\Delta p$ *increases in* v_0, σ^2, *and* m, *and decreases in* c.

[6] More generally, we can replace the constraint $p_1\geq 0$ with $p_1\geq \underline{p_1}$ for a positive $\underline{p_1}$. It will not qualitatively change the main results.

Figure 4 demonstrates the optimal price with a hidden price. When the initial valuation is low, the consumer has a low incentive to search. A high initial price will further reduce the consumer's benefit from searching, and accelerate consumer quit. So, the firm charges zero initial price. The first stage then serves as a screening device. The consumer will quit after gathering some negative information. If the consumer instead obtains enough positive signals and arrives at the checkout page, she will have an improved valuation compared to the initial one. At that point, the firm can afford to increase the price by charging a hidden price without immediately driving the consumer out of the market.

As the initial valuation increases, the consumer has a higher incentive to purchase the product. Therefore, the firm can afford to charge a higher initial price without deterring search. When the consumer reaches the checkout page, the consumer's valuation is also higher. The opportunity cost for the firm is high if the consumer searches for too long in the second stage and eventually quits after receiving too much negative information. So, the firm charges a lower hidden price to induce a quick purchase. When the initial valuation is high enough, the firm stops using a hidden price to induce immediate purchase once the consumer goes to the checkout page.

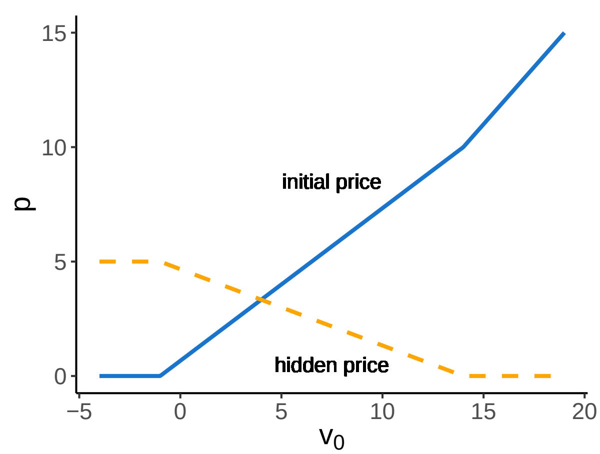


Figure 4: Optimal price with hidden price

Expected Search Time and Consumer Welfare

If $v_0 \leq \max\{-m/2, -3\sigma^2/4c + m\}$, the consumer will quit directly. The expected search time and consumer welfare are zero. If $v_0 \geq 3\sigma^2/4c + m$, the consumer will directly buy the product. The expected search time is zero and the consumer welfare is $\sigma^2/4c$. In other cases, the consumer will search for information before making a purchasing decision.

If $\max\{-m/2, -3\sigma^2/4c + m\} < v_0 < 3\sigma^2/4c + m$, then, by Dynkin's formula, the expected search time in the first stage under the optimal price is:

$$\mathbf{E}(\tau_1) = \frac{\frac{\sigma^4}{16c^2} - (v_0 - p_1^*)^2}{\sigma^2} = \frac{\frac{\sigma^4}{16c^2} - (\frac{v_0 - m}{3})^2}{\sigma^2}.$$

The probability of reaching the checkout page is $Q_1(v_0, p_1^*)$. Conditional on that, the expected search time in the second stage is:

$$\mathbf{E}(\tau_2) = \frac{\frac{\sigma^4}{16c^2} - (\frac{\sigma^2}{4c} - \Delta p^*)^2}{\sigma^2} = \frac{\frac{\sigma^4}{16c^2} - (\frac{v_0 - m}{3})^2}{\sigma^2} = \mathbf{E}(\tau_1).$$

As we can see, the optimal price is such that, the consumer will search for the same amount of time in each stage. The firm perfectly smooths consumers' search behavior. The intuition is the following. For a fixed total price, the firm does not want to charge an initial price too high, such that the quitting boundary is close to a consumer's initial valuation. This is because the consumer will quit quickly if she gathers a few negative signals early on in the search process. The firm also does not want to charge an initial price that is too high, such that the purchasing boundary is close to the consumer's initial valuation. Though the consumer will go to the checkout stage with a high probability in such cases, she will face a high hidden price, which pushes the quitting boundary close to her valuation at the beginning of the second stage. The consumer will then quit with a high likelihood in the second stage. The optimal price balances the consumer's likelihood of going to the checkout page and making the final purchase, and thus the consumer's search behavior across two stages.

The consumer's expected total search time under the optimal price is:

$$\mathbf{E}(\tau_w) = \mathbf{E}(\tau_1) + Q_1(v_0, p_1^*) \cdot \mathbf{E}(\tau_2)$$

If $-\sigma^2/4c < v_0 \leq -m/2$, then the expected search time in the first stage under the optimal price is:

$$\mathbf{E}(\tau_1) = \frac{\frac{\sigma^4}{16c^2} - v_0^2}{\sigma^2}$$

The probability of reaching the checkout page is $Q_1(v_0, p_1^*)$. Conditional on that, the expected search time in the second stage is:

$$\mathbf{E}(\tau_2) = \frac{\frac{\sigma^4}{16c^2} - (\frac{\sigma^2}{4c} - \Delta p^*)^2}{\sigma^2} = \frac{\frac{\sigma^4}{16c^2} - \frac{m^2}{4}}{\sigma^2} > \mathbf{E}(\tau_1).$$

Different from the previous case, the consumer will search for a longer time in the second stage under the optimal price. The reason is that, the consumer's initial valuation is very low in this case. Even with a low initial price, the consumer's expected payoff from purchasing the product is low. So, she will quit the search process relatively quickly. But if she gathers a sufficient amount of positive signals and reaches the checkout page, she will have a much higher valuation at the beginning of the second stage, and will be willing to keep searching even if she receives some negative signals at the second stage. The low initial valuation makes it impossible for the firm to perfectly smooth the consumer's search behavior.

The consumer's expected total search time under the optimal price is:

$$\mathbf{E}(\tau_w) = \mathbf{E}(\tau_1) + Q_1(v_0, p_1^*) \cdot \mathbf{E}(\tau_2).$$

Because the consumer's valuation at purchasing is always $\bar{V}_1(p_1^* + \Delta p^*)$, the consumer's payoff from purchasing the product must be $\bar{V}_1(p_1^* + \Delta p^*) - (p_1^* + \Delta p^*) = \sigma^2/4c$. Hence, when the consumer searches for information before making a purchasing decision, $\max\{-\sigma^2/4c, -3\sigma^2/4c + m\} < v_0 <$

$3\sigma^2/4c + m$, the expected consumer surplus under the optimal price has the following closed-form:

$$\mathbf{E}(consumer\ surplus) = -\, c \cdot \mathbf{E}(\tau_w) + \frac{\sigma^2}{4c} \cdot Q_1(v_0, p_1^*) \cdot Q_2(\Delta p^*).$$

4.3 Comparison Between the Cases of With and Without a Hidden Price

Figure 5 shows that the optimal total price when a hidden price is feasible (the initial price p_1^* plus the hidden price Δp^*) is always (weakly) higher than the optimal single posted price p_{wo}^*.

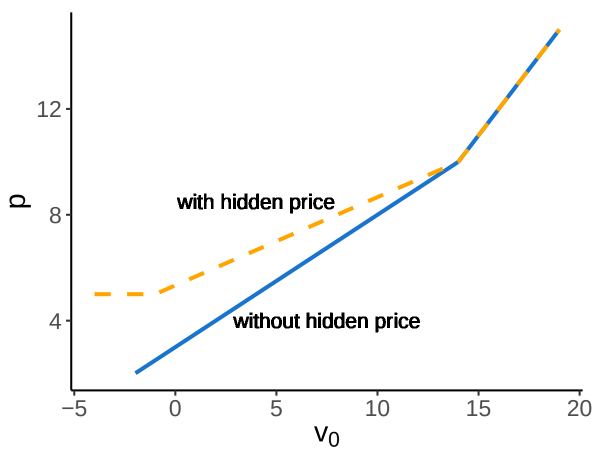


Figure 5: Optimal prices with and without hidden price

The next result characterizes necessary and sufficient conditions for the use of a hidden price to strictly increase the seller's expected profit.

Proposition 3. *The expected profit is strictly higher under the optimal strategy with a hidden price than under the optimal single posted price if and only if* $\max\{-\sigma^2/4c, -3\sigma^2/4c + m\} < v_0 < 3\sigma^2/4c + m$. *In such cases, the consumer's expected search time is also strictly higher under the optimal strategy with a hidden price than under the optimal single posted price.*

To understand the above result, we can divide the condition into two cases. The firm can make a positive profit with a hidden price but cannot sell any product without a hidden price if and only if:

$$\max\{-\sigma^2/4c, -3\sigma^2/4c + m\} < v_0 \leq -\sigma^2/4c + m.$$

We illustrate this case by an example where $v_0 = 0, \sigma^2 = 1$, and $m = 4$. Without a hidden price, the minimal price the firm will charge is the marginal cost 4, because it will lose money by charging any $p_{wo} < m$. However, even if it charges $p_{wo} = m$, the quitting threshold $\underline{V}_1(m) = 0$. So, the consumer will neither search nor purchase in this case.

In contrast, if the firm charges an initial price that is lower than the marginal cost, say $p_1 = 2$, then the consumer's quitting threshold will be -2, lower than the initial valuation v_0. The consumer will be better off by searching rather than quitting immediately. It is possible that the consumer gathers some negative signals and then quits. But with a positive probability, the consumer will gain enough positive signals and reaches the purchasing boundary $\bar{V}_1(p_1) = 6$. By the time she goes to the checkout page and see a hidden price of $\Delta p = 4$, she will not quit despite the total price she faces is higher than the marginal cost 4 because her valuation has improved over the initial valuation. It is optimal for the consumer to keep searching, and she may eventually purchase the product after hitting the new purchasing threshold of 10. Figure 6 illustrates a sample path of the consumer's valuation in this case.

In this case, the use of a hidden price creates a market for possible trade.

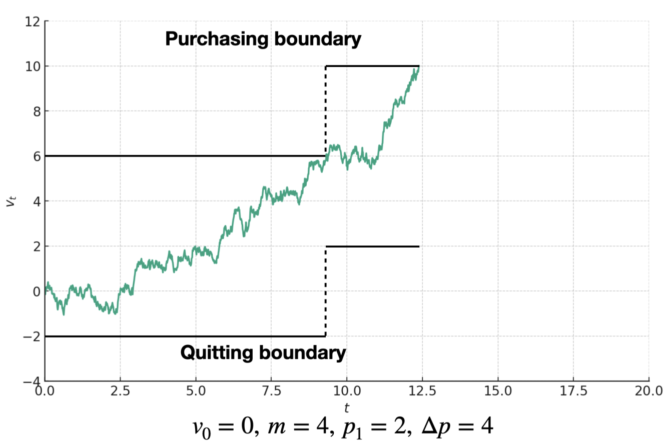


Figure 6: Consumer's sample path with hidden price (purchase)

More interestingly, even if the firm can earn a positive profit without a hidden price, it can obtain a strictly higher profit by using a hidden price if and only if:

$$-\sigma^2/4c + m < v_0 < 3\sigma^2/4c + m.$$

We illustrate its intuition by an example where $v_0 = 2, \sigma^2 = 1$, and $m = 2$. Without a hidden price, the firm can now induce consumer search even if it charges above the marginal price, because of the higher initial valuation. Suppose it charges $p_{wo} = 4$, which is low enough for the consumer to search. However, the consumer's initial valuation is close to the quitting boundary. So, the consumer will quit quickly if a small number of negative signals arrive at the beginning, resulting in a low purchasing likelihood. Figure 7 illustrates a sample path of the consumer's valuation in this case. Suppose instead the firm charges a lower initial price, say $p_1 = 2$. The consumer

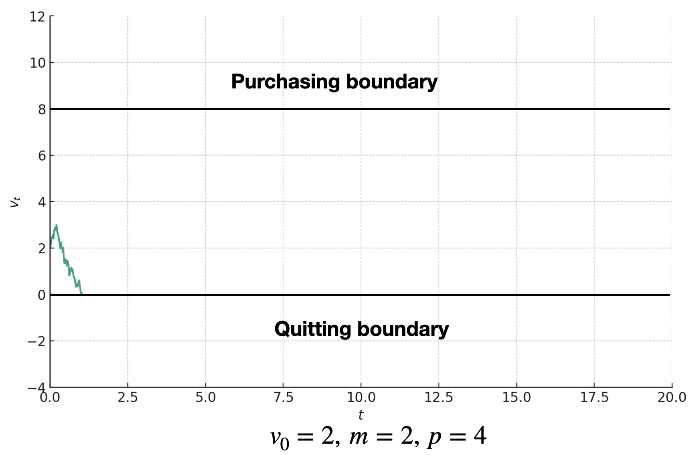


Figure 7: Consumer's sample path without hidden price (quit)

will have a lower quitting threshold, -2. Because the initial valuation is further away from the quitting boundary, the consumer will keep searching even if she receives some negative news at the beginning. By the time she goes to the checkout page and sees a hidden price of $\Delta p = 4$, her valuation will still be in a decent distance from the new quitting boundary. Thus, the consumer will not quit quickly in the second stage as well. In other words, the use of hidden price smoothes the consumer's search decision and makes it more robust to a small amount of negative news. Figure 8 illustrates a sample path of the consumer's valuation in this case.

5 Heterogeneous Consumers

In the base model, either consumers are homogeneous or the firm knows the individual consumer's characteristics. In reality, there are scenarios where consumers are heterogeneous and the

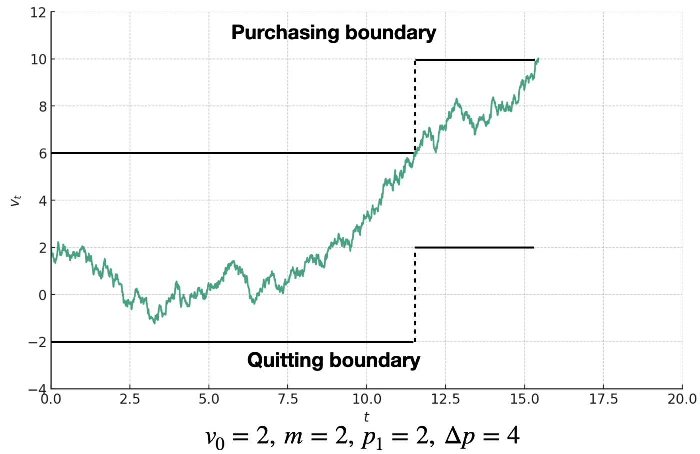


Figure 8: Consumer's sample path with hidden price (purchase)

firm cannot distinguish consumers. In this section, we consider two settings, one with heterogeneous initial valuations and one with heterogeneous learning speeds.

5.1 Heterogeneous Initial Valuations

The setup is the same as the base model, except that there are two groups of consumers with $v_0 \in \{v_0^H, v_0^L\}$, where $v_0^H > v_0^L$. Among consumers, $Prob(v_0 = v_0^H) = \rho_v$. The distribution of the initial valuation is common knowledge, whereas the realization of the initial valuation is each consumer's private information. In such cases, a firm's pricing decision can lead to different strategic effects. For instance, a higher price may generate higher profits among high-valuation consumers, but may drive low-valuation consumers out of the market. We find that, surprisingly, the optimal total price when the firm uses a hidden price (initial price plus hidden price) can be lower than the optimal single posted price under some conditions.

Proposition 4. *When the following condition holds, the optimal total price when the firm uses a hidden price is lower than the optimal single posted price, $p_1^* + \Delta p^* < p_{wo}^*$:*

(1) $\rho_v < \widehat{\rho_v}$, $v_0^H - v_0^L > \sigma^2/c$, and $\max\{-m/2, -3\sigma^2/4c + m\} < v_0^L < -\sigma^2/4c + m < v_0^H < 3\sigma^2/4c + m$;

or

(2) $\rho_v < \widehat{\rho_v}'$, $v_0^H - v_0^L > \sigma^2/c$, $-\sigma^2/4c < v_0^L < -\sigma^2/4c + m < v_0^H < 3\sigma^2/4c + m$, $v_0^L < -m/2$,

and $m < \sigma^2/2c$.[7]

The key mechanism behind this result is that, without hidden pricing, it may be unprofitable to serve low-valuation consumers, leading sellers to set high prices tailored to high-valuation segments. Hidden pricing enables sellers to profitably serve both types by adjusting price components accordingly, thereby lowering the effective price.

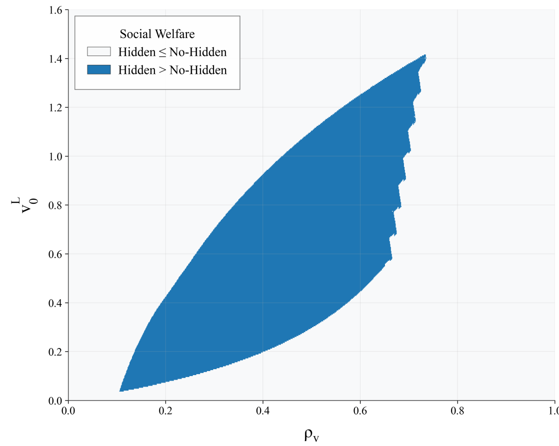
A crucial economic force behind the mechanism is the firm's incentive to expand its market coverage. For it to be profitable to extract surplus from low-type consumers at the expense of the profits from high-type consumers, there should be a sufficient proportion of low-type consumers. Therefore, both conditions of the proposition require the proportion of high-type consumers to be small.

For a hidden pricing strategy to attract low-type consumers as well, the initial price p_1^* must be lower than $v_0^L + \sigma^2/4c$ to induce low-type consumers to search in the first stage. Moreover, the hidden price must be lower than $\sigma^2/2c$ to ensure that the consumer will not quit immediately after seeing the hidden price at the checkout page. So, the optimal total price of selling to both types of consumers is bounded from above by $v_0^L + 3\sigma^2/4c$. Because the optimal single posted price p_{wo}^* of selling to only high-type consumers increases in the high-type consumer's initial valuation v_0^H, a sufficiently large gap between the two types' initial valuations, $v_0^H - v_0^L > \sigma^2/c$, ensures that the optimal total price when the firm uses a hidden price is lower than the optimal single posted price.

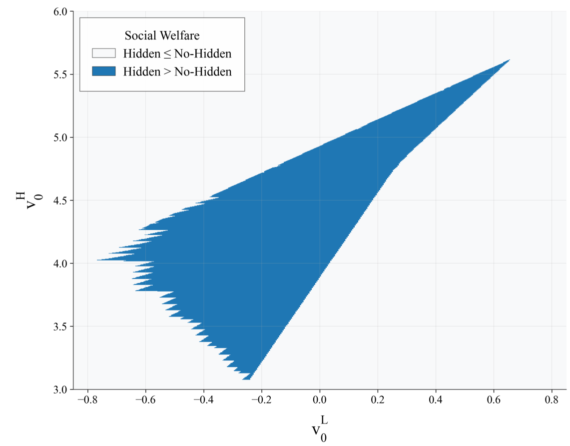
It is not tractable to analytically evaluate the impact of hidden pricing on social welfare. Nevertheless, numerical simulations show that there exist parameters such that the social welfare under the optimal price when the firm uses a hidden price is higher than the social welfare under the optimal single posted price. Figure 9 illustrates parameter ranges where allowing hidden pricing enhances social welfare. The mechanism of market coverage expansion with the help of hidden prices suggests that there shall be a sufficient number of low-type consumers (i.e., the proportion of high-type consumers ρ_v not too high), which is demonstrated by Figure 9a. When there is a sufficiently large gap between the initial valuations of high- and low-type consumers, the firm is more likely to reduce the total price to sell to low-type consumers, which can help with social welfare. However, such a gap cannot be too high. Otherwise, the firm will still abandon low-type

[7] The cutoffs $\widehat{\rho_v}$ and $\widehat{\rho_v}'$ are two constants specified in the appendix. Both constants $\in (0, 1)$.

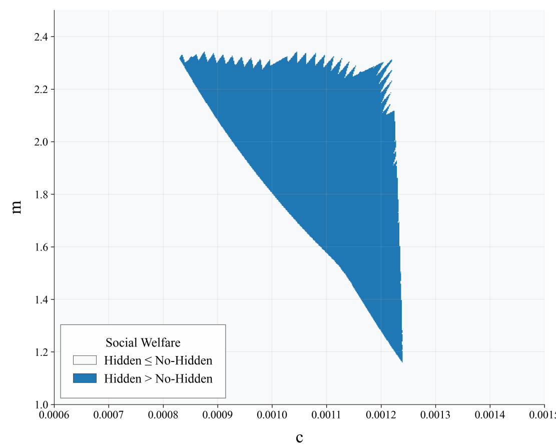
consumers. Figure 9b illustrates this.



(a)



(b)



(c)

Figure 9: (Heterogeneous initial valuations) Parameter range where allowing hidden pricing enhances social welfare.

5.2 Heterogeneous Learning Speeds

The setup is the same as the base model, except that there are two groups of consumers with $\sigma \in \{\sigma_H, \sigma_L\}$, where $\sigma_H > \sigma_L > 0$. Among consumers, $Prob(\sigma = \sigma_H) = \rho_\sigma$. The distribution of the learning speeds is common knowledge, whereas the realization of the learning speeds is each consumer's private information. Similar to the previous section, a firm's pricing decision can lead to different strategic effects. Again, we find that the optimal total price when the firm uses a hidden price can be lower than the optimal single posted price under some conditions.

Proposition 5. *When the following condition holds, the optimal total price when the firm uses a hidden price is lower than the optimal single posted price, $p_1^* + \Delta p^* < p_{wo}^*$:*

$\rho_\sigma < \widehat{\rho_\sigma}$, $\sigma_H > \sqrt{3}\sigma_L$, $\max\{-m/2, -\sigma_H^2/4c + m\} < v_0 < -3\sigma_L^2/4c + m$, *and* $\sigma_L^2/2c < m$.[8]

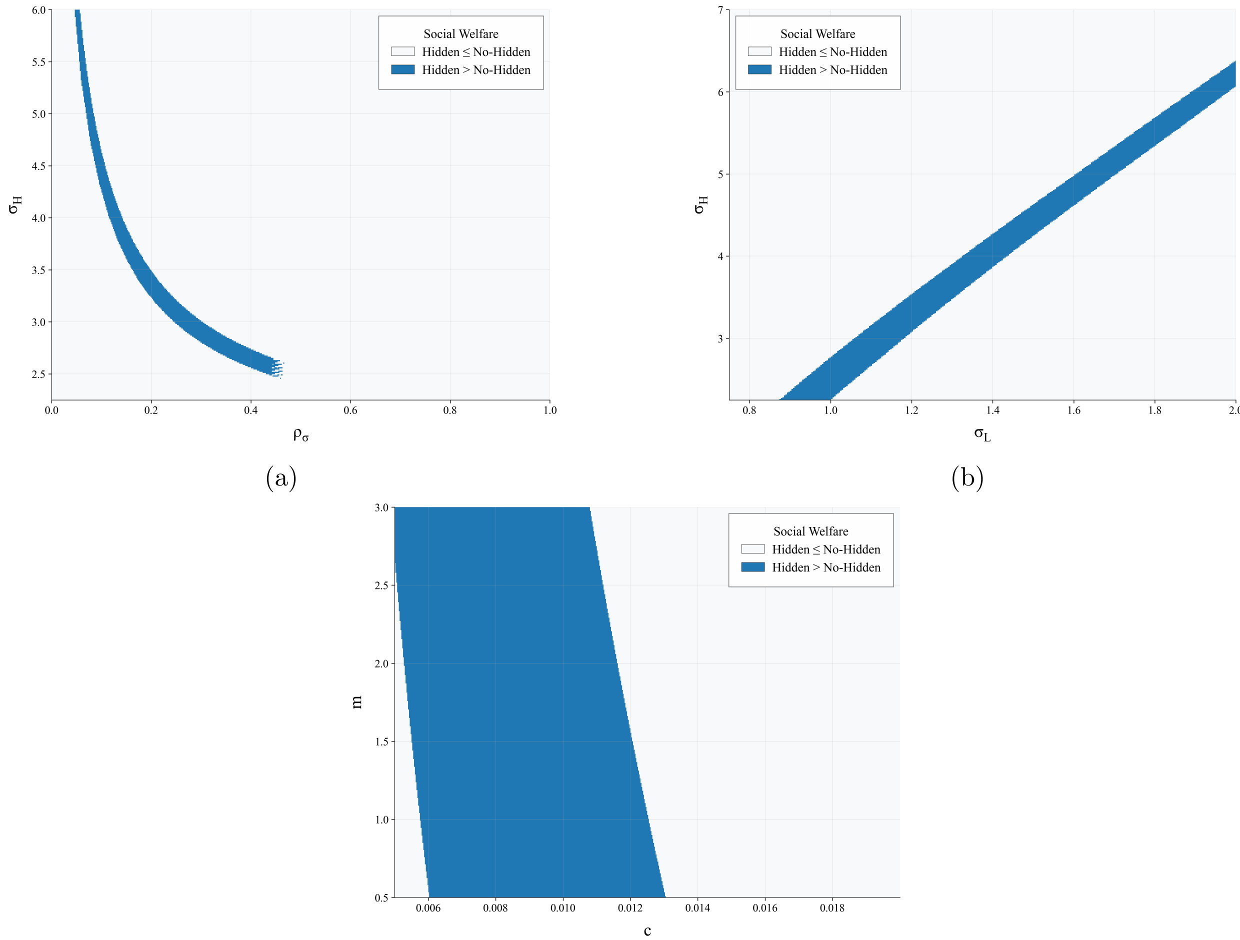
Similar to the previous section, for it to be profitable to extract surplus from low-type consumers at the expense of the profits from high-type consumers, there should be a sufficient proportion of low-type consumers. Therefore, the first condition of the proposition requires that the proportion of high-type consumers is small. The second condition ensures that the two types of consumers are sufficiently different so that the optimal single posted price for high-type consumers is higher than the optimal total price for both types of consumers.

Figure 10 shows numerically the parameter ranges where allowing hidden pricing enhances social welfare. Similar to the previous section, there shall be a sufficient number of low-type consumers (i.e., the proportion of high-type consumers ρ_σ not too high) for the firm to have an incentive to expand the market coverage when hidden prices are feasible, as illustrated by Figure 10a. A lower price can also improve social welfare. According to Proposition 5, a sufficiently large difference in consumers' learning speeds results in a lower total price when the firm employs a hidden price rather than a single posted price. In the meantime, the difference cannot be too large. Otherwise, the firm will always focus on the market of high-type consumers. Figure 10b demonstrates this.

5.3 Discussion

Our findings carry important policy implications. Despite recent regulatory efforts to ban hidden pricing, our analysis identifies scenarios under which it can be welfare-improving rather than harmful. Therefore, there is no one-size-fits-all approach for regulating the use of hidden prices. The regulator should take into account the composition of the customer base, especially the amount of heterogeneity among consumers, before imposing a policy.

[8] The cutoff $\widehat{\rho_\sigma} \in (0, 1)$ is a constant specified in the appendix.



(a) (b)

(c)

Figure 10: (Heterogeneous learning speeds) Parameter range where allowing hidden pricing enhances social welfare.

6 Extension

6.1 Awareness of the Hidden Price

Consumers are fully rational even in the base model - they choose the best response given all the available information. However, they lack information about the hidden price at the first stage. In this extension, we consider the case in which some consumers are aware of the possibility of hidden prices, whereas other consumers are unaware of it. Formally, we assume that ρ proportion of the consumers are unaware of the possibility of hidden prices, like in the main model. The remaining $1 - \rho$ proportion of the consumers are aware of the possibility of hidden prices, and rationally anticipate the seller's pricing strategies in the second stage. The following results show that the main insight in the base model extends to this scenario as long as there exist consumers who are unaware of the possibility of hidden prices.

Proposition 6. *For any $\rho > 0$, there exist parameters such that the firm's expected profit under the optimal strategy with a hidden price is strictly higher than the expected profit under the optimal single posted price.*

If all consumers are aware of the hidden price, then it is equivalent for the firm to use a hidden price or a single posted price. The above results show that, the mere existence of any proportion of consumers unaware of the possibility of hidden prices could make the use of hidden prices a strictly dominant strategy.

7 Conclusion

Previous literature explains the prevalence of hidden prices by consumers' behavioral biases, such as salience effects or loss aversion. This paper proposes a rational explanation of hidden price by taking into account consumer search. By presenting an initially low base price, sellers can induce consumers to begin searching in cases where they would not have searched at all under upfront pricing, and to continue searching in cases where early signals are unfavorable. In other words, sellers can encourage consumers to invest more effort in evaluating the product, increasing the likelihood that they accumulate enough positive signals to eventually justify a purchase. This paper shows that the use of hidden prices can increase firm profits within a wide range of parameters. Moreover, when consumers are heterogeneous, the total price under hidden pricing may be lower than the price the firm would set if it were constrained to a single posted price. Lastly, we find that allowing hidden pricing can even enhance social welfare.

Appendix

Proof of Lemma 1. We show that for $c < \bar{c}$, $\underline{p} < E(v)$ and $\bar{p} > E(v)$. Define

$$\Phi(x) := \int_0^x (x - v)\, dF(v), \qquad \Psi(x) := \int_x^1 (v - x)\, dF(v).$$

Then $\underline{p}$ is the unique solution of $\Phi(\underline{p}) = c$ and $\bar{p}$ is the unique solution of $\Psi(\bar{p}) = c$.

First, note that $\Phi(x)$ is continuous and strictly increasing; moreover, because $\Phi(0) = 0$ and $\Phi(E(v)) = \bar{c}$, it follows that $\underline{p} < E(v)$ for $c < \bar{c}$.

Second, $\Psi(x)$ is continuous and strictly decreasing. Moreover, we show below that $\Psi(E(v)) = \bar{c}$.

$$\begin{aligned}
\Psi(\mathbb{E}[v]) &= \int_{\mathbb{E}[v]}^1 \big(v - \mathbb{E}[v]\big)\, dF(v) \\
&= \int_0^1 \big(v - \mathbb{E}[v]\big)\, dF(v) - \int_0^{\mathbb{E}[v]} \big(v - \mathbb{E}[v]\big)\, dF(v) \\
&= - \int_0^{\mathbb{E}[v]} \big(v - \mathbb{E}[v]\big)\, dF(v) \\
&= \bar{c}.
\end{aligned}$$

It then follows that $\bar{p} > E(v)$ for $c < \bar{c}$. □

Proof of Lemma 2. The consumer deliberates if $U(learn) \geq U(purchase)$ and $U(learn) \geq 0$. It follows from the text that both these conditions hold for $p_{Initial} \in [\underline{p}, \bar{p}]$. The consumer proceeds to checkout if $U(purchase) > U(learn)$ and $U(purchase) > 0$. We show in the text that the first condition holds if $p_{Initial} < \underline{p}$. Moreover, the second condition holds if $p_{Initial} < E(v)$. In the proof of Lemma 1 we show that $\underline{p} < E(v)$. It then follows that the consumer proceeds to checkout if $p_{Initial} < \underline{p}$. Finally, the consumer leaves without purchase if $0 > U(purchase)$ and $0 > U(learn)$. The first condition holds for $p_{Initial} > E(v)$ and the second holds for $p_{Initial} > \bar{p}$. Because $\bar{p} > E(v)$, as shown in the proof of Lemma 1, it follows that both conditions hold for $p_{Initial} > \bar{p}$. □

Proof of Lemma 3. Similar to the proof of Lemma 2. Notice that in the first-stage decision the consumer behaves as if $p_{Initial}$ is the final price. □

Proof of Proposition 1. First notice that the firm's profit is weakly higher when it can use hidden fees (indeed, the firm has the option to set $h = 0$, and attain the same profit as it would in absence of hidden fees). When $p^* \leq \bar{p}$, the optimal price under deliberation is achievable even without hidden fees, i.e. if a firm sells at p^* the consumer deliberates. In that case, the firm's profit is the same with or without hidden fees. If, however, $p^* > \bar{p}$ the firm cannot sell at p^* without hidden fees - at such price the consumer leaves without purchase. Under hidden fees, the firm is able to sell at p^*. Finally, in order for the firm's profit to be higher under hidden fees, it must be that by selling at p^* the firm makes a higher profit than it would make by selling at $\underline{p}$ in which case all consumers purchase without deliberation. This occurs when $\underline{p} < p^*[1 - F(p^*)]$. □

Proof of Proposition 2. There are two cases:

1. $p_1 \geq 0$ is not binding

   The first-order-conditions with regard to p_1 and Δp for the objective function in problem (P_w) are:

$$\begin{cases} 2p_1 + \Delta p = v_0 + \sigma^2/4c + m \\ p_1 + 2\Delta p = \sigma^2/2c + m \end{cases}$$

$$\Rightarrow \begin{cases} p_1 = 2v_0/3 + m/3 \\ \Delta p = \sigma^2/4c + (m - v_0)/3 \end{cases}$$

$$\Rightarrow p_1 + \Delta p = v_0/3 + \sigma^2/4c + 2m/3.$$

   One can see that $p_1 > 0 \Leftrightarrow 2v_0/3 + m/3 > 0 \Leftrightarrow v_0 > -m/2$, which is the condition for $p_1 \geq 0$ not to be binding. Also, the firm can make positive profits if and only if $p_1 + \Delta p > m \Leftrightarrow v_0 > -3\sigma^2/4c + m$. Lastly, $\Delta p > 0 \Leftrightarrow v_0 < 3\sigma^2/4c + m$. If $v_0 \geq 3\sigma^2/4c + m$, then it is optimal to sell without a hidden price, $p^*_{wo} = v_0 - \sigma^2/4c$.

2. $p_1 \geq 0$ is binding

Omitting the constant term $2c/\sigma^2$, the Lagrangian is:

$$\mathcal{L} = (p_1 + \Delta p - m) \cdot (v_0 + \frac{\sigma^2}{4c} - p_1) \cdot (1 - \frac{2c}{\sigma^2}\Delta p) + \lambda p_1$$

Using the standard constrained optimization method, we have:

$$\begin{cases} \frac{\partial \mathcal{L}}{\partial p_1} = (v_0 + \frac{\sigma^2}{4c} - p_1 - p_1 - \Delta p + m)(1 - \frac{2c}{\sigma^2}\Delta p) + \lambda = 0 \\ \frac{\partial \mathcal{L}}{\partial \Delta p} = [1 - \frac{2c}{\sigma^2}\Delta p - \frac{2c}{\sigma^2}(p_1 + \Delta p - m)](v_0 + \frac{\sigma^2}{4c} - p_1) = 0 \\ \lambda p_1 = 0,\ \lambda \geq 0,\ p_1 \geq 0 \end{cases}$$

$$\overset{p_1 \geq 0 \text{ is binding}}{\Rightarrow} \begin{cases} p_1 = 0 \\ \Delta p = \sigma^2/4c + m/2 \\ \lambda = -(v_0 + m/2)(1 - 2c/\sigma^2 \Delta p) \geq 0 \Leftrightarrow v_0 \leq -m/2 \end{cases}$$

$$p_1 + \Delta p = \sigma^2/4c + m/2$$

One can see that the firm can make positive profits if and only if $p_1 + \Delta p > m \Leftrightarrow m < \sigma^2/2c$. Also, we must have $v_0 - p_1 > -\sigma^2/4c \Leftrightarrow v_0 > -\sigma^2/4c$ so that the consumer will not directly quit in the first stage.

□

Proof of Proposition 3. If $v_0 \leq \max\{-\sigma^2/4c, -3\sigma^2/4c + m\}$, the firm cannot sell any product at a price above the marginal cost with or without a hidden price.

If $\max\{-\sigma^2/4c, -3\sigma^2/4c + m\} < v_0 \leq -\sigma^2/4c + m$, the firm cannot sell any product at a price above the marginal cost without a hidden price. So, the expected profit is zero. The expected search time is zero. In contrast, with a hidden price, the optimal total price $p_1^* + \Delta p^* > m$ and the purchasing probability is strictly positive, according to Proposition 2. So, the expected profit is strictly positive. One can see that the expected search time is also strictly positive.

If $-\sigma^2/4c + m < v_0 < 3\sigma^2/4c + m$, the seller can make a positive profit with or without a hidden price. Note that the strategy space of the problem (P_w) includes charging a single posted price as a special case $(\Delta p = 0)$. The expected profit must be strictly higher than the expected profit from charging an optimal single posted price if $\Delta p^* > 0$ in the solution to (P_w). According to Proposition 2, if $v_0 \leq -m/2$, then $\Delta p^* = \sigma^2/4c + m/2 > 0$; if $v_0 > -m/2$, then $\Delta p^* = \sigma^2/4c + (m - v_0)/3 > 0 \Leftrightarrow v_0 < 3\sigma^2/4c + m$.

Consider the expected search time. If $v_0 > -m/2$, we have:

$$\begin{aligned}\mathbf{E}(\tau_w) - \mathbf{E}(\tau_{wo}) =& \frac{\frac{\sigma^4}{16c^2} - (\frac{v_0-m}{3})^2}{\sigma^2} + \frac{2c}{\sigma^2}(\frac{v_0}{3} - \frac{m}{3} + \frac{\sigma^2}{4c}) \cdot \frac{\frac{\sigma^4}{16c^2} - (\frac{v_0-m}{3})^2}{\sigma^2} - \frac{\frac{\sigma^4}{16c^2} - (\frac{v_0-m}{2} - \frac{\sigma^2}{8c})^2}{\sigma^2} \\ =& \frac{1}{\sigma^2}(\frac{m^2}{12} + \frac{2cm^3}{27\sigma^2} + \frac{m\sigma^2}{12c} + \frac{3\sigma^4}{64c^2}) > 0.\end{aligned}$$

If $v_0 \leq -m/2$, we have:

$$\begin{aligned}\mathbf{E}(\tau_w) - \mathbf{E}(\tau_{wo}) =& \frac{\frac{\sigma^4}{16c^2} - v_0^2}{\sigma^2} + \frac{2c}{\sigma^2}(v_0 + \frac{\sigma^2}{4c}) \cdot \frac{\frac{\sigma^4}{16c^2} - \frac{m^2}{4}}{\sigma^2} - \frac{\frac{\sigma^4}{16c^2} - (\frac{v_0-m}{2} - \frac{\sigma^2}{8c})^2}{\sigma^2} \\ =& \frac{1}{\sigma^2}\frac{8c^2m^2 + 8cm\sigma^2 + 3\sigma^4}{64c^2} > 0.\end{aligned}$$

If $v_0 \geq 3\sigma^2/4c + m$, the constraint $\Delta p \geq 0$ in the firm's problem (P_w) is binding. So, $\Delta p^* = 0$ and thus it is optimal to charge a single posted price even if it is feasible to charge a hidden price. □

Proof of Proposition 4. We first consider the case without a hidden price. When $v_0^L < -\sigma^2/4c+m$, the firm will not sell to low-type consumers without a hidden price, according to equation (7). The optimal single posted price is the optimal p^*_{wo} in equation (7) when $v_0 = v_0^H$:

$$p^*_{wo} = \frac{v_0^H}{2} + \frac{\sigma^2}{8c} + \frac{m}{2}.$$

The corresponding profit is:

$$\rho_v \cdot (\frac{v_0^H}{2} + \frac{\sigma^2}{8c} + \frac{m}{2} - m) \cdot \frac{c}{\sigma^2}(v_0^H + \sigma^2/4c - m)$$

We now consider the case with a hidden price. The firm can either only selling to high-type consumers or selling to both types of consumers. If the consumer directly go to the checkout page without search, then the consumer's problem is as if the firm uses a single posted price of

$p_{wo} = p_1 + \Delta p$. The use of a hidden price does not increase the profit. This leads to the following result.

Lemma 4. *A necessary condition for the use of a hidden price $(p_1, \Delta p)$ to increase the firm's expected profit over the optimal profit with a single posted price is that the initial price p_1 must induce consumer search in the first stage for at least one type of consumers, $v_0 - p \in (-\sigma^2/4c, \sigma^2/4c)$ for at least one $v_0 \in \{v_0^H, v_0^L\}$.*

1. The firm only sells to high-type consumers.

   (a) According to the proof of Proposition 2, if $v_0^H > -m/2$ and $\max\{-\sigma^2/4c, -3\sigma^2/4c + m\} < v_0^H < 3\sigma^2/4c + m$, the optimal price is $(p_1, \Delta p) = (2v_0^H/3 + m/3, \sigma^2/4c + (m - v_0^H)/3)$, and the total price is $p_1 + \Delta p = v_0^H/3 + \sigma^2/4c + 2m/3$. One can verify that:

$$\begin{aligned}
v_0^L - p_1 &= v_0^L - \frac{2}{3}v_0^H - \frac{1}{3}m \\
&= \frac{1}{3}v_0^L - \frac{2}{3}(v_0^H - v_0^L) - \frac{1}{3}m \\
&< \frac{1}{3}[v_0^H - (v_0^H - v_0^L)] - \frac{2}{3}\frac{\sigma^2}{2c} - \frac{1}{3}m \\
&< \frac{1}{3}(\frac{3\sigma^2}{4c} - \frac{\sigma^2}{2c}) - \frac{2}{3}\frac{\sigma^2}{2c} - \frac{1}{3}m \\
&= -\frac{\sigma^2}{4c}
\end{aligned}$$

   So, low-type consumers will directly quit in the first stage. The expected profit is:

$$\begin{aligned}
\Pi_1^H &= \rho_v \cdot \underbrace{(p_1 + \Delta p - m)}_{\text{profit per sale}} \cdot \overbrace{(v_0^H + \frac{\sigma^2}{4c} - p_1)\frac{2c}{\sigma^2}}^{\text{probability of reaching the checkout page}} \cdot \underbrace{(1 - \frac{2c}{\sigma^2}\Delta p)}_{\text{conditional probability of purchasing}} \\
&= \rho_v \frac{2c}{\sigma^2}\left(\frac{v_0^H}{3} + \frac{\sigma^2}{4c} - \frac{m}{3}\right)^2 \left[1/2 - \frac{2c(m - v_0^H)}{3\sigma^2}\right] \qquad (10)
\end{aligned}$$

   (b) If $-\sigma^2/4c < v_0^H < -m/2$ and $m < \sigma^2/2c$, the optimal price is $(p_1, \Delta p) = (0, \sigma^2/4c + m/2)$, and the total price is $p_1 + \Delta p = \sigma^2/4c + m/2$. One can verify that $v_0^L < v_0^H - \sigma^2/2c < -\sigma^2/2c < p_1 - \sigma^2/4c$. So, low-type consumers will directly quit in the first stage. The expected profit is:

$$\Pi_2^H = \rho_v \cdot \underbrace{(p_1 + \Delta p - m)}_{\text{profit per sale}} \cdot \overbrace{(v_0^H - p_1 + \frac{\sigma^2}{4c})\frac{2c}{\sigma^2}}^{\text{probability of reaching the checkout page}} \cdot \underbrace{(1 - \frac{2c}{\sigma^2}\Delta p)}_{\text{conditional probability of purchasing}}$$

$$= \rho_v \frac{2c}{\sigma^2}\left(\frac{\sigma^2}{4c} - \frac{m}{2}\right)\left(v_0^H - \frac{m}{2}\right)\left(1/2 - \frac{mc}{\sigma^2}\right) \tag{11}$$

2. The firm sells to low-type consumers.

To prevent low-type consumers from quitting directly, p_1 must be strictly less than $v_0^L + \sigma^2/4c$. The condition $v_0^H - v_0^L > \sigma^2/2c$ then implies that $v_0^H - \sigma^2/4c > v_0^L + \sigma^2/4c > p_1$. Hence, the high-type consumer will go to the checkout page immediately. Lemma 4 implies that for hidden pricing to increase profits, p_1 must be strictly higher than $v_0^L - \sigma^2/4c$. Therefore, we will focus on the case of $p_1 \in (v_0^L - \sigma^2/4c, v_0^L + \sigma^2/4c)$.

Instead of directly characterizing the optimal price and profit in this case, we instead examine the optimal profit of *only* considering low-type consumers, which is a lower bound of the optimal profit of selling to low-type consumers.

(a) Similar to the previous part of the proof, if $v_0^L > -m/2$ (which implies $v_0^H > -m/2$), the optimal price of only selling to low-type consumers is $(p_1, \Delta p) = (2v_0^L/3 + m/3, \sigma^2/4c + (m - v_0^L)/3)$, and the total price is $p_1 + \Delta p = v_0^L/3 + \sigma^2/4c + 2m/3$. The expected profit from the low-type consumers is:

$$\Pi_1^L = (1 - \rho_v)\frac{2c}{\sigma^2}\left(\frac{v_0^L}{3} + \frac{\sigma^2}{4c} - \frac{m}{3}\right)^2 \left[1/2 - \frac{2c(m - v_0^L)}{3\sigma^2}\right] \tag{12}$$

A sufficient condition for the profit of selling to low-type consumers to be higher than the profit of only selling to high-type consumers is:

$$
\begin{aligned}
\Pi_1^L > \Pi_1^H &= (1-\rho_v)\frac{2c}{\sigma^2}\left(\frac{v_0^L}{3}+\frac{\sigma^2}{4c}-\frac{m}{3}\right)^2\left[1/2-\frac{2c(m-v_0^L)}{3\sigma^2}\right] \\
&> \rho_v\frac{2c}{\sigma^2}\left(\frac{v_0^H}{3}+\frac{\sigma^2}{4c}-\frac{m}{3}\right)^2\left[1/2-\frac{2c(m-v_0^H)}{3\sigma^2}\right] \\
\Leftrightarrow \rho_v < \widehat{\rho_v} &:= \frac{\left(\frac{v_0^L}{3}+\frac{\sigma^2}{4c}-\frac{m}{3}\right)^2\left[1/2-\frac{2c(m-v_0^L)}{3\sigma^2}\right]}{\left(\frac{v_0^L}{3}+\frac{\sigma^2}{4c}-\frac{m}{3}\right)^2\left[1/2-\frac{2c(m-v_0^L)}{3\sigma^2}\right]+\left(\frac{v_0^H}{3}+\frac{\sigma^2}{4c}-\frac{m}{3}\right)^2\left[1/2-\frac{2c(m-v_0^H)}{3\sigma^2}\right]} \in (0,1)
\end{aligned}
$$

We now consider the price. When the above conditions hold, it is optimal to sell to low-type consumers when it is feasible to use a hidden price. In order to sell to low-type consumers, we must have $p_1^* < v_0^L + \sigma^2/4c$ so that low-type consumers will search in the first stage. Because $\Delta p^* < \sigma^2/2c$, which ensures that the consumer may purchase after reaching the checkout page, the optimal total price with a hidden price satisfies $p_1^* + \Delta p^* < v_0^L + \sigma^2/4c + \sigma^2/2c = v_0^L + 3\sigma^2/4c$. The optimal single posted price is:

$$
\begin{aligned}
p_{wo}^* &= \frac{v_0^H}{2}+\frac{\sigma^2}{8c}+\frac{m}{2} \\
&\overset{v_0^H<3\sigma^2/4c+m}{>} \frac{v_0^H}{2}+\frac{\sigma^2}{8c}+\frac{v_0^H-3\sigma^2/4c}{2} \\
&> v_0^H-\frac{\sigma^2}{4c}.
\end{aligned}
$$

Hence, a sufficient condition for $p_{wo}^* > p_1^* + \Delta p^*$ is:

$$
\begin{aligned}
& v_0^H-\frac{\sigma^2}{4c} > v_0^L+\frac{3\sigma^2}{4c} \\
\Leftrightarrow\ & v_0^H - v_0^L > \frac{\sigma^2}{c}.
\end{aligned} \tag{13}
$$

(b) If $-\sigma^2/4c < v_0^L < -m/2$ and $m < \sigma^2/2c$, the optimal price of only selling to low-type consumers is $(p_1, \Delta p) = (0, \sigma^2/4c + m/2)$, and the total price is $p_1 + \Delta p = \sigma^2/4c + m/2$.

The expected profit from the low-type consumer is:

$$
\begin{aligned}
\Pi_2^L &= (1-\rho_v)\cdot \underbrace{(p_1+\Delta p - m)}_{\text{profit per sale}} \cdot \overbrace{(v_0^L - p_1 + \frac{\sigma^2}{4c})\frac{2c}{\sigma^2}}^{\text{probability of reaching the checkout page}} \cdot \underbrace{(1-\frac{2c}{\sigma^2}\Delta p)}_{\text{conditional probability of purchasing}} \\
&= (1-\rho_v)\frac{2c}{\sigma^2}\left(\frac{\sigma^2}{4c}-\frac{m}{2}\right)\left(v_0^L+\frac{\sigma^2}{4c}\right)\left(1/2-\frac{mc}{\sigma^2}\right) \qquad (14)
\end{aligned}
$$

Conditions $v_0^L > -\sigma^2/4c$ and $v_0^H - v_0^L > \sigma^2/c$ imply that $v_0^H = v_0^L + (v_0^H - v_0^L) > 3\sigma^2/4c > -m/2$. So, the expected profit of only selling to high-type consumers is Π_1^H. A sufficient condition for the profit of selling to low-type consumers to be higher than the profit of only selling to high-type consumers is:

$$
\begin{aligned}
\Pi_2^L > \Pi_1^H &= (1-\rho_v)\frac{2c}{\sigma^2}\left(\frac{\sigma^2}{4c}-\frac{m}{2}\right)\left(v_0^L+\frac{\sigma^2}{4c}\right)\left(1/2-\frac{mc}{\sigma^2}\right)] \\
&> \rho_v\frac{2c}{\sigma^2}\left(\frac{v_0^H}{3}+\frac{\sigma^2}{4c}-\frac{m}{3}\right)^2\left[1/2-\frac{2c(m-v_0^H)}{3\sigma^2}\right] \\
\Leftrightarrow \rho_v < \widehat{\rho_v}' &:= \frac{\left(\frac{\sigma^2}{4c}-\frac{m}{2}\right)\left(v_0^L+\frac{\sigma^2}{4c}\right)(1/2-\frac{mc}{\sigma^2})]}{\left(\frac{\sigma^2}{4c}-\frac{m}{2}\right)\left(v_0^L+\frac{\sigma^2}{4c}\right)(1/2-\frac{mc}{\sigma^2})]+\left(\frac{v_0^H}{3}+\frac{\sigma^2}{4c}-\frac{m}{3}\right)^2\left[1/2-\frac{2c(m-v_0^H)}{3\sigma^2}\right]} \in (0,1)
\end{aligned}
$$

We now consider the price. When the above conditions hold, it is optimal to sell to low-type consumers when it is feasible to use a hidden price. Similar to the arguments in part 2a, a sufficient condition for $p_{wo}^* > p_1^* + \Delta p^*$ is condition (13), $v_0^H - v_0^L > \frac{\sigma^2}{c}$.

□

Proof of Proposition 5. Most of the arguments are similar to those in the previous proof. So, we will keep this proof succinct. We first consider the case without a hidden price. When $-\sigma_H^2/4c + m < v_0 \leq -\sigma_L^2/4c + m$, a firm can only sell to high-type consumers without a hidden price. The optimal single posted price is:

$$p_{wo}^* = \frac{v_0}{2} + \frac{\sigma_H^2}{8c} + \frac{m}{2}.$$

The corresponding profit is:

$$\rho_\sigma \cdot (\frac{v_0}{2} + \frac{\sigma_H^2}{8c} + \frac{m}{2} - m) \cdot \frac{c}{\sigma_H^2}(v_0 + \sigma_H^2/4c - m)$$

We now consider the case with a hidden price.

1. The firm only sells to high-type consumers.

   When $v_0 > -m/2$ and $\max\{-\sigma_H^2/4c, -3\sigma_H^2/4c + m\} < v_0 < 3\sigma_H^2/4c + m$, the optimal price is $(p_1, \Delta p) = (2v_0/3 + m/3, \sigma_H^2/4c + (m - v_0)/3)$, and the total price is $p_1 + \Delta p = v_0/3 + \sigma_H^2/4c + 2m/3$. One can verify that $-\sigma_H^2/4c < v_0 - p_1 \leq -\sigma_L^2/4c$ under the conditions of this proposition. So, low-type consumers will directly quit in the first stage, whereas high-type consumers may buy the product. The expected profit is:

$$\Pi^H = \rho_\sigma \frac{2c}{\sigma_H^2} \left(\frac{v_0}{3} + \frac{\sigma_H^2}{4c} - \frac{m}{3} \right)^2 \left[1/2 - \frac{2c(m - v_0)}{3\sigma_H^2} \right] \tag{15}$$

2. The firm sells to low-type consumers.

   To prevent low-type consumers from quitting directly, p_1 must be strictly less than $v_0 + \sigma_L^2/4c$. Instead of directly characterizing the optimal price and profit in this case, we instead examine the optimal profit of *only* considering low-type consumers, which is a lower bound of the optimal profit of selling to low-type consumers.

   When $v_0 > -m/2$, the optimal price of only selling to low-type consumers is $(p_1, \Delta p) = (2v_0/3 + m/3, \sigma_L^2/4c + (m - v_0)/3)$, and the total price is $p_1 + \Delta p = v_0/3 + \sigma_L^2/4c + 2m/3$. The expected profit from the low-type consumers is:

$$\Pi^L = (1 - \rho_\sigma) \frac{2c}{\sigma_L^2} \left(\frac{v_0}{3} + \frac{\sigma_L^2}{4c} - \frac{m}{3} \right)^2 \left[1/2 - \frac{2c(m - v_0)}{3\sigma_L^2} \right] \tag{16}$$

   A sufficient condition for the profit of selling to low-type consumers to be higher than the profit of only selling to high-type consumers is:

$$\Pi^L > \Pi^H = (1 - \rho_\sigma) \frac{2c}{\sigma_L^2} \left(\frac{v_0}{3} + \frac{\sigma_L^2}{4c} - \frac{m}{3} \right)^2 \left[1/2 - \frac{2c(m - v_0)}{3\sigma_L^2} \right]$$

$$> \rho_\sigma \frac{2c}{\sigma_H^2}\left(\frac{v_0}{3}+\frac{\sigma_H^2}{4c}-\frac{m}{3}\right)^2\left[1/2-\frac{2c(m-v_0)}{3\sigma_H^2}\right]$$

$$\Leftrightarrow \rho_\sigma < \widehat{\rho_\sigma} := \frac{\frac{2c}{\sigma_L^2}\left(\frac{v_0}{3}+\frac{\sigma_L^2}{4c}-\frac{m}{3}\right)^2\left[1/2-\frac{2c(m-v_0)}{3\sigma_L^2}\right]}{\frac{2c}{\sigma_L^2}\left(\frac{v_0}{3}+\frac{\sigma_L^2}{4c}-\frac{m}{3}\right)^2\left[1/2-\frac{2c(m-v_0)}{3\sigma_L^2}\right]+\frac{2c}{\sigma_H^2}\left(\frac{v_0}{3}+\frac{\sigma_H^2}{4c}-\frac{m}{3}\right)^2\left[1/2-\frac{2c(m-v_0)}{3\sigma_H^2}\right]} \in (0,1)$$

We now consider the price. When the above conditions hold, it is optimal to sell to low-type consumers when it is feasible to use a hidden price. In order to sell to low-type consumers, we must have $p_1^* < v_0 + \sigma_L^2/4c$ so that low-type consumers will search in the first stage. Because $\Delta p^* < \sigma_L^2/2c$, which ensures that the consumer may purchase after reaching the checkout page, the optimal total price with a hidden price satisfies $p_1^* + \Delta p^* < v_0 + \sigma_L^2/4c + \sigma_L^2/2c = v_0 + 3\sigma_L^2/4c$. The optimal single posted price is:

$$\begin{aligned} p_{wo}^* &= \frac{v_0}{2}+\frac{\sigma_H^2}{8c}+\frac{m}{2} \\ &\overset{v_0<-3\sigma_L^2/4c+m}{>} \frac{v_0}{2}+\frac{\sigma_H^2}{8c}+\frac{v_0+3\sigma_L^2/4c}{2} \\ &= v_0+\frac{\sigma_H^2}{8c}+\frac{3\sigma_L^2}{8c}. \end{aligned}$$

Hence, a sufficient condition for $p_{wo}^* > p_1^* + \Delta p^*$ is:

$$\begin{aligned} v_0+\frac{\sigma_H^2}{8c}+\frac{3\sigma_L^2}{8c} &> v_0+\frac{3\sigma_L^2}{4c} \\ \Leftrightarrow \sigma_H &> \sqrt{3}\sigma_L. \end{aligned} \tag{17}$$

□

Proof of Proposition 6. Consider the parameter range where $\max\{-\sigma^2/4c, -3\sigma^2/4c+m\} < v_0 \leq -\sigma^2/4c+m$. Without a hidden price, the firm cannot sell any product. With a hidden price, the firm can make a positive profit from the consumers who are unaware of the possibility of hidden prices (ρ proportion of consumers). Therefore, the total profit is also positive.

□

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