# Experience Goods and Consumer Search

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**Abstract**. We introduce a search model where products differ in variety and unobserved quality ('experience goods'), and firms can establish quality reputation. We show that the inability of consumers to observe quality before purchase significantly changes how search frictions affect market performance. In equilibrium, higher search costs hinder consumers' search for better-matched variety and increase price, but can boost firms' investment in product quality. Under plausible conditions, both consumer and total welfare initially *increase* in search cost, whereas both would monotonically decrease if quality were observable. We apply the analysis to online markets, where low search costs coexist with low-quality products.

**Keywords**: search friction, search cost, product quality, experience goods, quality observability.

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## 1. INTRODUCTION

Starting from Stigler (1961), economists have devoted considerable effort to the study of markets with consumer search. The literature, focusing on "inspection" goods for which all product and price information can be uncovered before purchase, has shown that search friction is a major source of market power and its reduction generally improves welfare. However, little is known about how search markets work for "experience" goods, the quality of which can be learned only after consumption. This is rather surprising, considering that goods are increasingly bought through the Internet, where product variety is greater but quality is arguably more difficult to assess than in brick-and-mortar stores, and consequently consumers may find a desired product variety through search but not observe its quality before purchase. Despite their high promise for efficiency due to small search cost, online markets are plagued by problems of low-quality sellers and low-quality products.[1] This raises the critical question of whether (further) decreases in search cost could (eventually) restore efficiency or, instead, regulatory policies can enhance market performance even as search friction vanishes.

We present a model in which products are differentiated both horizontally ('variety') and vertically ('quality'), and consumers can observe product variety through search but not quality. Product quality is either high or low, and a consumer's match value from a variety is a random draw from some known distribution. A high-quality product will function properly to deliver its match value to the consumer (her utility from the product), whereas a low-quality product contains a hidden defect that is uncovered only after consumption and diminishes the product's utility.[2] A firm can invest to become a high-quality producer whose

[1] The U.S. General Accounting Office reported in 2018 that 40% of products it purchased in an investigation from independent sellers on five major e-commerce websites, including Amazon and Walmart, were fake or low-quality (GAO 18-216). A recent Wall Street Journal investigation found more than 4,000 items sold by independent sellers on Amazon had safety and other serious quality problems ("Amazon Has Ceded Control of Its Site. The Result: Thousands of Banned, Unsafe or Mislabeled Products." Wall Street Journal, August 23, 2019).

[2] For example, the product could be some furniture or clothing that has many styles (varieties). By

product quality is more likely to be high (so the product has a higher expected quality), and firms differ in investment costs. While consumers cannot observe product quality before purchase, they are in the market at different time periods and the later purchasers can learn about the quality reputation of a firm from its past sales.

This is the first model to introduce experience goods into a search framework, and it yields new insights on how search markets function. In equilibrium, consumers conduct sequential search for their desired variety with a reservation value that reflects search cost and expected product quality, where the latter depends on the portion of high-quality firms. Despite quality uncertainty, we show that equilibrium price can be neatly characterized given average firm quality in the market. An increase in average firm quality leads to more consumer search for variety and more intense price competition, but it can nevertheless raise equilibrium price due to a new demand effect that—as explained later—exists for experience but not for inspection goods. Moreover, while in both cases higher search frictions lead to lower match values and higher price but also to stronger incentive for firms to invest in quality, the welfare impact is strikingly different for experience goods. We show that, under plausible conditions, consumer and total welfare both initially *increase*—though eventually decrease—in search cost, in sharp contrast to the insight from the existing literature on inspection goods.

The mechanism behind our novel result on how search frictions impact welfare for experience goods can be explained in two steps as follows: First, as search cost rises, consumers search less for their desired variety and firms also soften their price competition, resulting in lower match values and higher prices for consumers, both being harmful as in the existing literature. But a higher price raises the return to the reputation for being a high-quality seller and hence the investment incentive,[3] leading to more high-quality firms in the market and a larger probability that consumers will purchase a high-quality product even before

searching a firm, consumers observe the style of its product, but can uncover a defect only after consumption. This provides a new and convenient way of modeling search for experience goods that are differentiated both horizontally and vertically. We shall normalize the utility of a low-quality product to zero.

[3] It has been recognized, in studies without search cost, that reputation can provide firms with incentives to furnish high quality for experience goods (e.g., Choi, 1998; Shapiro, 1983; Wernerfelt, 1988).

firms establish reputation. This generates a beneficial quality effect, because a consumer's match value from a product can be (fully) materialized only if it has high quality.

Second, to understand why the quality effect dominates under low—but not high—search cost, notice that as search cost tends to zero, so does the price markup, and hence the portion of high-quality firms is small because only firms with very small investment cost can profit from investing in quality. A firm will thus have a big boost in sales from establishing a high-quality reputation. Therefore, for the same price increase resulting from a marginal rise in search cost, a firm investing in high quality gains disproportionately more—and hence the quality effect of increasing search cost is much stronger—when search cost is sufficiently low than when it is relatively high.

To clarify the crucial role of quality observability in determining how search friction affects welfare, we also consider the case of inspection goods by assuming instead that product quality is observed before purchase. We show that consumer and total welfare then decrease monotonically when search cost increases, as in the existing literature. Importantly, for inspection goods a higher search cost also motivates more firms to make quality investment by boosting its returns, and higher average firm quality benefits consumers by enabling them to search fewer firms before finding a high-quality product. Why, then, is the relationship between search cost and welfare so different? As our analysis reveals, when product quality is observable, consumers can avoid the utility loss from a low-quality product by not purchasing it, and hence they do not gain as much from increases in firm quality as they would when searching for experience goods. Consequently, the direct effect of a higher search cost to reduce search efficiency dominates its indirect effect of raising search efficiency through the increase in average firm quality. Higher search costs then always harm welfare by decreasing match values and increasing price.

We further show that equilibrium investment for quality is (socially) deficient when search cost is low, which is consistent with the result from the literature on experience goods where—without search frictions—firms typically invest too little in quality (e.g., Riordan, 1986; Shapiro, 1982). However, we also find that quality investment can be excessive when search cost is relatively high, contrary to the conventional wisdom. To understand the latter result, notice that while more high-quality firms in the market can benefit consumers, the higher total investment cost harms industry profit. When search cost is high, consumers have relatively low match values from their chosen varieties. They thus benefit less when an increase in (average) firm quality raises the probability that the match values are materialized, but the private investment incentive is high due to the high profit margin from being a high-quality firm. The negative welfare effect of higher investment cost can thus dominate when search cost is high.

Product differentiation and quality uncertainty are prominent features of search markets. Wolinsky (1986) is an early contribution to the study of consumer search for horizontally differentiated products (for related contributions, see, e.g., Anderson and Renault, 1999; Armstrong et al., 2009; Haan and Moraga-González, 2011; Rhodes, 2011). Recent papers have analyzed consumer search across vertically-differentiated firms (e.g., Athey and Ellison, 2011; Chen and He, 2011), under both horizontal and vertical differentiation (e.g., Eliaz and Spiegler, 2011; Bar-Isaac et al., 2012; Chen and Zhang, 2018), or with investment in product quality (e.g., Fishman and Levy, 2015; Moraga-González and Sun, 2019)[4]. All of these and other studies in the search literature assume that consumers will learn all information about a product through search before making a purchase.

Our model advances the literature in an important new direction, and our results provide new perspectives on how search frictions impact market performance. In the existing literature, reductions in search cost benefit consumers and welfare even when a lower search cost sometimes leads to higher market price (e.g., Chen and Zhang, 2011; Bar-Isaac et al., 2012; Zhou, 2014; Moraga-González, et al., 2017; Choi, et al., 2018), or when it lowers product quality (e.g., Fishman and Levy, 2015; Moraga-González and Sun, 2019). In our model, there are also important consumer and efficiency benefits from reducing search friction, but there can be offsetting factors via the effect on investment in quality. Consequently, for experience goods, decreases in search cost beyond a certain point will actually *reduce* both

[4] Relatedly, Wolinsky (2005) and Moraga-González and Sun (2018) study consumer search models in which sellers exert costly efforts to create service plans.

consumer and total welfare.[5] In fact, in our model the presence of some search friction is *necessary* in order for either consumer or total welfare to be maximized.

One might wonder whether search intermediaries would alleviate the product quality distortions. Previous research has shown that a monopoly search intermediary improves search efficiency when firms offer inspection goods and differ in the probability that their product is of high quality (e.g., Athey and Ellison, 2011; Chen and He, 2011). As in these studies, in our model an intermediary may improve welfare by screening out low-quality sellers. However, we show that it is also possible for the intermediary to exacerbate the distortion, because the fee it charges can reduce the sellers' investment return, resulting in (even) fewer firms who invest in quality.

Digital technology and the Internet have drastically reduced search cost and expanded consumers' reach for product variety. Despite their tremendous benefits to consumers and society, online markets are not without perils. In particular, online markets appear to be especially plagued by the presence of many low-quality sellers. Our results show that reductions in search cost could indeed result in lower average seller quality and product quality in online markets, but they will nevertheless boost consumer and total welfare if consumers can observe product quality before purchase. However, many products sold online can be considered as experience goods, the quality of which is not observed before purchase. Our results suggest that for such products reduced search frictions can actually decrease welfare, and the quality problem is unlikely to disappear by itself even if search cost virtually vanishes. Rather, there can be substantial welfare gains from regulations that, for example, impose minimum quality standards and product liability (as we discuss further in section 6).

The rest of the paper proceeds as follows. In section 2, we present our search model of experience goods, in which there are two periods, a firm's quality is endogenously determined by its private investment at the beginning of the first period, and firms have quality

[5] Taylor (2017) considers a model in which a seller can manipulate the browsing cost (search cost) of potential buyers. He shows that a higher browsing cost, by driving away less serious buyers and increasing the sales effort of the seller, can benefit consumers and increase welfare.

reputation in period 2 from their sales in period 1. The model is readily adaptable to the case of inspection goods, providing a unified framework for studying consumer search under quality uncertainty. In section 3, we analyze sequential consumer search and price competition in a benchmark where the average firm quality in the market is exogenously given. In addition to its intrinsic interest, this analysis provides the basis for the study of our full model under endogenous firm quality and reputation, conducted in section 4, where our main welfare results are established. We extend the model to include a search intermediary in section 5, and conclude in section 6. Proofs are gathered in the appendix.

## 2. THE MODEL

The market contains a unit mass of firms and operates for two periods, 1 and 2. A firm's product quality, $q$, can be either high $(H)$ or low $(L)$, respectively with probability $\beta$ and $1-\beta$, where $\beta \in \{\beta_h, \beta_l\}$ and $0 \leq \beta_l < \beta_h \leq 1$. Thus, $\beta_h$ and $\beta_l$ correspond to a high- and a low-quality firm, respectively.[6] Initially, all firms have $\beta = \beta_l$; but at the beginning of period 1, each firm can privately make a one-time investment that costs $x$ to permanently increase its quality from $\beta_l$ to $\beta_h$, where $x$ is a privately-observed random draw from distribution $G(x)$, with density $g(x) > 0$ on $[0, \bar{x}]$ for some $\bar{x} \in (0, \infty)$. Each firm's quality, $\beta$, is then determined and remains as the firm's private information. Production cost is normalized to zero.

In each period, a distinct unit mass of consumers are present in the market.[7] Each consumer desires to purchase one unit of the product. A consumer's value for an $H$ product is $v$, which is a random draw from cumulative distribution function $F(v)$, and her value

[6] Hence, we draw a distinction between *firm* quality ($\beta$) and *product* quality ($q$). Our model nests the case where a high-quality firm only produces $q = H$ while a low-quality firm only produces $q = L$, with $\beta_h = 1$ and $\beta_l = 0$. We allow more general values of $\beta_h$ and $\beta_l$ so that there can be quality uncertainty for both types of firms.

[7] Each consumer thus purchases only once by assumption. We can extend the analysis to situations where (some) consumers may purchase in both periods, but this would complicate analysis because a consumer's search strategy would then depend on her likelihood of repeat purchases (from the same firm). Our assumption allows us to focus on how the experience nature of goods impacts consumer search.

for an $L$ product is normalized to zero. That is, a consumer's utility from a product is

$$u(q) = \begin{cases} v & if \quad q = H \\ 0 & if \quad q = L \end{cases}.$$

Hence, firms are differentiated both horizontally and vertically, respectively because each consumer's $v$ is independently drawn across firms and because a high-quality firm ($\beta = \beta_h$) is more likely to produce a high-quality product ($q = H$). We assume that $F(v)$ has corresponding density $f(v) > 0$ on $[0, \bar{v}]$, with $0 < \bar{v} < \infty$.

To focus on experience goods, we assume that an $H$ product and an $L$ product from the same firm have the same appearance. By searching a firm, a consumer learns her $v$ for the firm's product and the firm's price. She knows that her utility from the product is $v$ if $q = H$ and 0 if $q = L$; and she can observe $q$ only after purchase.[8] Each search costs the consumer $s > 0$. In each period, firms simultaneously and independently choose prices, after which consumers may conduct sequential search and make purchases. To capture the idea that firms can establish quality reputation, we assume that the period-1 consumers will furnish product reviews about whether $q = H$ or $L$ for each firm's product.[9] In period 2, a new cohort of consumers, who replace the period-1 consumers, can observe these product reviews before conducting search. All values in period 2, when discounted to period 1, have a common discount factor $\delta > 0$.[10]

A firm's strategy specifies its investment decision, based on its investment cost $x$, and its prices $p_1$ and $p_2$ (possibly contingent on its $\beta$) in the two periods. A period-1 consumer's strategy specifies her search and purchase decisions, whereas period-2 consumers may base these decisions also on observed product reviews. At a perfect Bayesian equilibrium, each firm's strategy maximizes its discounted sum of profit, holding beliefs about other firms'

[8] This reflects the *experience* nature of the product. Products from different firms may have different "appearances" or styles that reflect horizontal differentiation. We assume purchase and consumption occur in the same period.

[9] Our results will be the same whether all period-1 consumers or a randomly-drawn portion of them will publicly reveal their product experiences. For ease of exposition, we assume all of them will.

[10] We may consider period 2 as combining all possible future periods after period 1 for which firms have established quality reputation, in which case $\delta$ could be higher than 1.

and consumers' strategies; each consumer's strategy maximizes her surplus (at any point of her sequential decision process), holding beliefs about firms' qualities and prices; and beliefs are consistent with strategies along the equilibrium path.

One desirable feature of our model is that it can be readily adapted to the study of "inspection goods". In fact, if consumers were able to observe product quality ($q$) before purchase by searching the firm, our model would become one of search for inspection goods. In the case of inspection goods, we may interpret $\beta$ as the probability that the firm's product meets each consumer's needs, so that a higher quality firm—whose product has a broader appeal to consumers— has a higher $\beta$, as in Chen and He (2011). Our formulation allows us to compare results for experience and inspection goods in a unified framework, and to uncover how quality observability matters for the functioning of search markets.

We analyze our model in two steps. First, as a benchmark, we study in section 3 consumer search and price competition in a single period of our model in which exogenously given portions of $G$ and $1-G$ firms have $\beta=\beta_h$ and $\beta=\beta_l$, respectively, for $G\in[0,1]$. This analysis has its independent interest, and it will provide the basis for the full analysis of our model in section 4 with two periods and endogenous $G$.

## 3. SEARCH AND PRICE UNDER GIVEN AVERAGE FIRM QUALITY

This section analyzes consumer search and price competition under given average firm quality.

### 3.1 Search Equilibrium for Experience Goods

Consider a single period of our model, in which a given $G\in[0,1]$ portion of firms have $\beta=\beta_h$. The average firm quality in the market is then given as:

$$\gamma=G\beta_h+(1-G)\,\beta_l. \tag{1}$$

For given $\gamma$, we first consider consumers' search strategy. As in search models for inspection goods in which firms are horizontally and vertically differentiated (e.g., Eliaz and

Spiegler, 2011; Chen and Zhang, 2018), we focus on a uniform-price equilibrium where all firms charge the same price $p_\gamma$, and we shall discuss the motivation for this equilibrium when characterizing $p_\gamma$ later. Each consumer's equilibrium search strategy, holding belief $p_\gamma$, solves the following dynamic search problem:

$$V_\gamma = \max_{v_\gamma} \left\{ -s + [1 - F(v_\gamma)] \frac{\int_{v_\gamma}^{\bar{v}} (\gamma v - p_\gamma) f(v)\, dv}{[1 - F(v_\gamma)]} + F(v_\gamma) V_\gamma \right\}, \tag{2}$$

where $V_\gamma$ is a consumer's (maximized) continuation value from searching a randomly-selected firm whose expected quality and price are respectively $\gamma$ and $p_\gamma$. The consumer will sequentially and randomly search sellers, and will purchase when she finds a seller whose product value $v$ reaches her optimal reservation value $v_\gamma$ (provided the seller's price is indeed $p_\gamma$). Each search costs $s$; and under reservation value $v_\gamma$, the search will lead to a purchase with probability $[1 - F(v_\gamma)]$ while the consumer will search again to receive continuation value $V_\gamma$ with probability $F(v_\gamma)$. The consumer's optimal reservation value $v_\gamma$ thus satisfies the first-order condition:

$$-(\gamma v_\gamma - p_\gamma) f(v_\gamma) + f(v_\gamma) V_\gamma = 0.$$

It follows that the consumer's continuation value, which is also the surplus for a consumer to engage in search or to participate in the market, is

$$V_\gamma = \gamma v_\gamma - p_\gamma, \tag{3}$$

and in equilibrium $V_\gamma \geq 0$ to ensure consumers' participation in the market. Combining (2) and (3), we obtain

$$s = -[1 - F(v_\gamma)] V_\gamma + \int_{v_\gamma}^{\bar{v}} (\gamma v - p_\gamma) f(v)\, dv \ ,$$

which can be re-stated as the following condition for the optimal reservation value in search:

$$\gamma \int_{v_\gamma}^{\bar{v}} (v - v_\gamma) f(v)\, dv = s. \tag{4}$$

The left-hand side of equation (4) is the consumer's expected benefit from one more search when she is currently at a seller with $v_\gamma$, which decreases in $v_\gamma$, while $s$ is the marginal cost of the extra search. The condition extends the optimal search rule for horizontally differentiated products (e.g., Wolinsky, 1986), which is a special case of equation (4) when $\gamma = 1$. As we clarify shortly, when $s < \bar{s}$—which we shall assume—for some positive number $\bar{s}$, there exists a unique $v_\gamma \in (0, \bar{v})$ that solves (4) and indeed $V_\gamma > 0$.

Consider next the pricing strategy by firms. At the proposed uniform-price equilibrium, consumers will have reservation value $v_\gamma$ at any firm she searches that charges price $p_\gamma$, holding the equilibrium belief that all firms have expected quality $\gamma$ and price $p_\gamma$. Now suppose that a firm deviates to a price $p$. The consumer's purchase decision at this firm will partly depend on her belief about the firm's $\beta$, as well as on her belief about other firms' prices and qualities following the deviation. The concept of perfect Bayesian equilibrium, which we adopt, does not constrain beliefs off the equilibrium path, potentially resulting in multiple equilibria. To overcome this well-known problem in dynamic games of imperfect information, we assume that consumers hold "passive belief" off the equilibrium path: at the deviating firm with price $p$, each consumer believes that (i) the firm deviating to price $p$ continues to have the expected quality $\gamma$, and (ii) any other firm continues to charge price $p_\gamma$ with expected quality $\gamma$.

Part (ii) above follows from the standard assumption in consumer search for differentiated products (e.g., Wolinsky, 1986), where following the deviation by one firm the other firms are expected to continue with the equilibrium price; and the expected quality of any such firm would then continue to be $\gamma$.[11] Part (i) of the assumption is motivated by the following consideration. In our model, if a price deviation is profitable for one $\beta$ type, it will be equally profitable for the other $\beta$ type. Thus, if the consumer believes the expected quality of the deviating firm to be, say, $B(p, p_\gamma)$, this belief can be consistent with profitable deviation only if $B(p, p_\gamma) = \gamma$. It is thus reasonable to assume that, observing a deviating price $p$, consumers will hold belief $B(p, p_\gamma) = \gamma$. In other words, we require consumers' off-

[11] Janssen and Ke (2020) also assume a passive belief in a consumer search model in which firms may choose to provide a service that other firms can free-ride on. In their model, when observing a firm's deviation on service provision or/and price, consumers continue to believe that other firms maintain their equilibrium decisions

equilibrium belief to be consistent with firms' incentives: $B(p, p_\gamma)$ is equal to the expected quality of firms that can (weakly) benefit from the deviation.[12]

Under passive belief, the consumer, who has arrived at a firm with price $p$ and value $v$, will purchase from the firm if

$$\gamma v - p \geq \gamma v_\gamma - p_\gamma \geq 0.$$

Thus, the demand for the firm with price $p$ from any visiting consumer, given that all other firms charge $p_\gamma$, is

$$D(p, p_\gamma) = 1 - F\left(\frac{\gamma v_\gamma + p - p_\gamma}{\gamma}\right),$$

with $D(p_\gamma, p_\gamma) = 1 - F(v_\gamma)$. The profit for a firm of quality $\beta$ from any visiting consumer, $\pi(p, p_\gamma) = pD(p, p_\gamma)$, is maximized when $p$ satisfies

$$\frac{\partial \pi(p, p_\gamma)}{\partial p} = 1 - F\left(\frac{\gamma v_\gamma + p - p_\gamma}{\gamma}\right) - p\frac{1}{\gamma} f\left(\frac{\gamma v_\gamma + p - p_\gamma}{\gamma}\right) = 0.$$

At the uniform-price equilibrium, $p = p_\gamma$, and

$$p_\gamma = \gamma \frac{1 - F(v_\gamma)}{f(v_\gamma)}. \tag{5}$$

Moreover, if $1 - F(v_\gamma)$ is log-concave, or, equivalently, the inverse hazard rate is (weakly) decreasing:

$$\lambda'(v) \leq 0 \quad \text{for } \lambda(v) \equiv \frac{1 - F(v)}{f(v)}, \tag{6}$$

then $\pi(p, p_\gamma)$ is single-peaked at $p_\gamma$, the uniform-price equilibrium with $p = p_\gamma$ exists uniquely, and $p_\gamma$ is (weakly) lower when consumers search more intensively (i.e., $v_\gamma$ is higher). Moreover, at the unique $p_\gamma$,

$$V_\gamma = \gamma v_\gamma - p_\gamma = \gamma v_\gamma - \gamma \lambda(v_\gamma) = \gamma [v_\gamma - \lambda(v_\gamma)].$$

[12] In the literature on experience goods, firms can sometimes signal their quality through price and other devices (e.g., Choi, 1998; Riordan, 1988; Shapiro, 1983; Wernerfelt, 1988). In our model, given their qualities, firms are symmetric in all other aspects and there exists no signal that could potentially separate them. We will show formally in Proposition 1 below that there can be no "separating" equilibrium in our model for a given $\gamma$.

The highest possible search cost ($\bar{s}$) and its corresponding (lowest possible) reservation value ($v_0$) are defined as

$$\bar{s} \equiv \gamma \int_{v_0}^{\bar{v}} (v - v_0) f(v)\, dv, \qquad \text{where} \qquad v_0 \equiv \frac{1 - F(v_0)}{f(v_0)}. \tag{7}$$

Then, for any $s < \bar{s}$, there is a unique $v_\gamma \in (0, \bar{v})$ that solves (4) and $V_\gamma > 0$, so that consumers will indeed engage in search when average firm quality in the market is $\gamma \in [\beta_l, \beta_h]$. We shall maintain assumptions (6) and $s < \bar{s}$ throughout the paper.

In equilibrium, each firm's profit is

$$\pi_\gamma = \sum_i [F(v_\gamma)]^i p_\gamma D(p_\gamma, p_\gamma) = \gamma \lambda(v_\gamma),$$

where $[F(v_\gamma)]^i$ is the number of consumers for whom the seller is their $i$'s visit. We measure consumer welfare and total welfare respectively by aggregate consumer surplus and total surplus. For a market with a unit measure of consumers and of firms under average firm quality $\gamma$, industry profit, consumer welfare and total welfare are respectively:

$$\Pi_\gamma = \gamma \lambda(v_\gamma); \qquad V_\gamma = \gamma [v_\gamma - \lambda(v_\gamma)]; \qquad W_\gamma = \gamma v_\gamma. \tag{8}$$

The result below summarizes the above discussions, and it further establishes that there can be no "separating equilibrium" under the following extended passive-belief assumption for the case where firms with different $\beta$ charge different prices: At a potential "separating equilibrium" where $\beta_h$ and $\beta_l$ firms respectively charge $p_h \neq p_l$, following a deviating price $p$ in the (small) neighborhoods of $p_h$ or $p_l$, we say that the off-equilibrium belief satisfies the extended passive-belief assumption if consumers believe the deviation to have been made respectively by a $\beta_h$ or $\beta_l$ firm.

**Proposition 1** *There is a unique uniform-price equilibrium in the experience-goods market where average firm quality is $\gamma$. At the equilibrium, consumers search sequentially with reservation value $v_\gamma$ and each firm charges price $p_\gamma$. Moreover, under the extended passive-belief assumption, there can be no equilibrium where $\beta_h$ and $\beta_l$ firms charge different prices.*

A "separating" equilibrium with different prices for different $\beta$ types cannot exist in our model, because there is nothing to enable such separation. Given average firm quality, the equilibrium in our search model of experience goods is essentially unique and is the uniform-price equilibrium.[13]

### 3.2 Impacts of Search Cost and Average Firm Quality

We next consider how the equilibrium may vary with search cost $s$ for given firm quality or with average firm quality $\gamma$ for given $s$. From (4), consumers' reservation value, $v_\gamma$, increases in $\gamma$ and decreases in $s$. Because $p_\gamma = \gamma\lambda(v_\gamma)$ and $\lambda'(\cdot) \leq 0$, it follows from (8) that, given $\gamma$, $p_\gamma$ and $\Pi_\gamma$ increase in $s$ whereas $V_\gamma$ and $W_\gamma$ decrease in $s$. Intuitively, a higher search cost reduces consumer search efficiency, which not only reduces consumers' reservation value in search but also lessens competition and raises price. The higher price and lower search efficiency reduce consumer surplus, and the lower search efficiency also reduces total welfare; whereas higher price boosts profit.

From (8), clearly $V_\gamma$ and $W_\gamma$ increase in $\gamma$, the average quality of firms in the market. The effects of $\gamma$ on price (and profit) are less obvious, as we can see, from (5):

$$\frac{dp_\gamma}{d\gamma} = \lambda(v_\gamma) + \gamma\lambda'(v_\gamma)\frac{\partial v_\gamma}{\partial \gamma},$$

where the first and the second terms on the RHS reflect, respectively, the positive (direct) demand effect and the negative (indirect) search effect on $p_\gamma$ from an increase in $\gamma$. A higher $\gamma$ lowers the price elasticity of demand for given $v_\gamma$[14]:

$$\eta = -\frac{\partial D(p, p_\gamma)}{\partial p}\frac{p}{D}\bigg|_{p=p_\gamma} = \frac{p_\gamma}{\gamma\lambda(v_\gamma)},$$

which positively impact price; but it also increases the search reservation value $v_\gamma$ and

[13] Our no-separating-equilibrium result also holds if, following a deviating price $p$ at the proposed separating equilibrium, consumers believe that the deviating firm has quality $\gamma$. Search models are known to contain an equilibrium where all firms charge very high prices and no consumer engages in search. We do not consider such "uninteresting" equilibrium.

[14] When $\gamma$ is higher, the quality-adjusted price $\frac{p}{\gamma}$ is lower and a marginal change in $p$ is associated with less change in $\frac{p}{\gamma}$ and hence leads to less change in the quantity demanded.

negatively impacts $p_\gamma$ due to $\lambda'(v_\gamma) \leq 0$. Because

$$\frac{\partial v_\gamma}{\partial \gamma} = \frac{\int_{v_\gamma}^{\bar{v}} [1 - F(v)]\, dv}{\gamma [1 - F(v_\gamma)]} < \frac{\bar{v} - v_\gamma}{\gamma},$$

a sufficient—but not necessary—condition for $\frac{\partial p_\gamma}{\partial \gamma} > 0$ is

$$\frac{1}{\bar{v} - v_\gamma} \geq -\frac{\lambda'(v_\gamma)}{\lambda(v_\gamma)}, \tag{9}$$

which holds, for example, if $F(v)$ is a uniform or exponential distribution. The proceeding discussions lead to the following:

**Corollary 1** *In equilibrium: (i) given average firm quality $\gamma$, price and profit increase, while $V_\gamma$ and $W_\gamma$ decrease, in $s$; (ii) given $s$, a higher $\gamma$ leads to higher price and profit if (9) holds, even though $v_\gamma$ is higher and $\lambda(v_\gamma)$ lower; moreover, $V_\gamma$ and $W_\gamma$ increase in $\gamma$.*

With exogenously-given firm quality for experience goods, the effects of search friction on price and welfare are similar to those in search markets for inspection goods.[15] Notably, $p_\gamma$ increases in $\gamma$ under (9), despite increased consumer search and price competition;[16] this is in contrast to the result under search for inspection goods, to which we turn next.

### 3.3 Comparing with Search for Inspection Goods

We now consider inspection goods, also under exogeneously-given firm quality, by assuming that searching a firm enables a consumer to learn whether its $q$ is $H$ or $L$, in addition to uncovering its price and $v$. Everything else is the same as in subsection 3.1. In particular, $\beta \in \{\beta_l, \beta_h\}$ continues to be a firm's quality and remains to be its private information, with $\gamma$ being the average firm quality in the market as defined in (1). We again look for a uniform-price equilibrium, where each firm charges price $p_\gamma^I$. As in subsection 3.1, consumers' optimal search follows a reservation-value strategy, with the optimal reservation

[15] When we return to our full model in section 4, under endogenous firm quality and reputation, search costs have rather surprising welfare effects for experience goods, in contrast to those for inspection goods.

[16] However, as Corollary 1 indicated, despite the higher prices, an increase in $\gamma$ nevertheless results in higher consumer and total welfare.

value $v_\gamma^I$ satisfying

$$\gamma \int_{v_\gamma^I}^{\bar{v}} \left(v - v_\gamma^I\right) f(v)\, dv = s. \tag{10}$$

Interestingly, this condition is identical to condition (4) for experience goods. This is because when arriving at a firm with $v = v_\gamma^I = v_\gamma$, the expected marginal benefit of an additional search is the same under inspection and experience goods.[17] In other words, given $\gamma$ and $s$, $v_\gamma = v_\gamma^I$.

To determine the demand for each firm, suppose a firm deviates with price $p$. The passive belief assumption is now needed only for its part (ii)—other firms' price is still $p_\gamma^I$—because when searching the firm a consumer learns its product quality $q$. A visiting consumer will purchase from the firm if she finds $q = H$ (which occurs with the firm's probability $\beta$) and

$$v - p \geq v_\gamma^I - p_\gamma^I.$$

The firm's demand from any visiting consumer is thus

$$D^I\left(p, p_\gamma^I\right) = \beta\left[1 - F\left(v^I + p - p_1^I\right)\right],$$

and it chooses $p$ to maximize $pD^I\left(p, p_\gamma^I\right)$, which, in equilibrium, leads to

$$p_\gamma^I = \frac{1 - F\left(v_\gamma^I\right)}{f\left(v_\gamma^I\right)} = \lambda\left(v_\gamma^I\right). \tag{11}$$

Since a random visit by a consumer to a firm will on average result in a purchase with probability $\gamma\left[1 - F\left(v^I\right)\right]$, and since all consumers—whose total mass is one—purchase, the equilibrium output of a firm with quality $\beta$ is $\frac{D^I\left(p^I, p_\gamma^I\right)}{\gamma[1-F(v^I)]} = \frac{\beta}{\gamma}$, and hence the firm's equilibrium profit is $\pi^I(\beta) = \frac{\beta}{\gamma}\lambda\left(v_\gamma^I\right)$. Thus, a firm will have a higher profit than an average firm if its quality $\beta$ is higher than the market average, in contrast to the case of experience goods where a firm's equilibrium profit is independent of its $\beta$.

Notice that the price elasticity of demand here is independent of $\gamma$, in contrast to that for experience goods, which explains why $p_\gamma^I$ does not depend on $\gamma$ but $p_\gamma$ does. Therefore,

[17] However, as we shall see shortly, equilibrium consumer and social welfare are both higher for inspection than for experience goods, because for the former consumers can detect and hence avoid the utility loss from consuming a low quality product.

for inspection goods it is always true that

$$\frac{dp_\gamma^I}{d\gamma} = \lambda' \left(v_\gamma^I\right) \frac{\partial v_\gamma^I}{\partial \gamma} \leq 0,$$

in contrast to $\frac{\partial p_\gamma}{\partial \gamma} > 0$ for experience goods under condition (9). However, given $\gamma$, an increase in $s$ reduces match value $(v_\gamma^I)$ and raises price $(p_\gamma^I)$, as for experience goods.

In equilibrium, industry profit, consumer surplus, and total welfare are respectively

$$\Pi_\gamma^I = \lambda \left(v_\gamma^I\right); \qquad V_\gamma^I = v_\gamma^I - \lambda \left(v_\gamma^I\right); \qquad W_\gamma^I = v^I \ . \tag{12}$$

Since $v_\gamma^I = v_\gamma$, comparing $p_\gamma^I$ with $p_\gamma$ and (12) with (8), we see interesting similarities and differences in search equilibrium properties between inspection and experience goods, as follows:

**Proposition 2** *Given $\gamma$, consumers search with the same reservation value for inspection and experience goods, but $V$, $\Pi$, and $W$ are all lower for the latter. A higher $s$ leads to lower match value and higher price in both cases. A higher $\gamma$ leads to higher $p$ for experience goods under condition (9) but to lower $p$ for inspection goods. Moreover, a firm's profit increases in its $\beta$ under inspection goods but is independent of its $\beta$ under experience goods.*

For inspection goods, a higher average firm quality ($\gamma$) in the market implies that consumers will have higher expected benefit from a search, because they are more likely to find an $H$-product. This boosts consumers' search incentive, as reflected by their higher search reservation value, which increases competition and leads to lower equilibrium price. Because consumers can observe product quality before purchase, an increase in $\gamma$ will not affect a consumer's demand for a firm. By contrast, for experience goods, product quality is observed only after consumption, and thus higher $\gamma$ also increases a consumer's expected utility from the product and hence the demand for it. Consequently, while a higher average firm quality similarly exerts a downward pressure on equilibrium price—by raising consumers' search reservation value—as for inspection goods, it has the additional demand effect that, on balance, results in higher equilibrium price under condition (9).

## 4. ENDOGENOUS FIRM QUALITY AND REPUTATION

We now return to our full model with endogenous firm quality and reputation. Notice that if it is profitable for a firm with a higher $x$ to make the quality investment, it must also be profitable for a firm with a lower $x$ to do so. The equilibrium of our model will thus have the property that, for some threshold $t$, a firm will invest $x$ to have $\beta_h$ if $x \leq t$ but will have $\beta_l$ without the investment if $x > t$. We assume that $\bar{x}$ is high enough so that in equilibrium $t < \bar{x}$; i.e., some firms (with sufficiently high realizations of $x$) will not incur $x$.

### 4.1 Market Equilibrium

For a given $t$, the average firm quality ($\beta$) in the market is

$$\gamma = \gamma(t) \equiv G(t)\,\beta_h + [1 - G(t)]\,\beta_l.$$

The first-period equilibrium is then the same as in our preliminary analysis of section 3 with $\gamma = \gamma(t)$, where consumers conduct sequential search with reservation value $v_\gamma$ and all firms charge equilibrium price $p_1^* = p_\gamma$.

In the second period, consumers will observe product reviews from period-1 consumers. For a firm of quality $\beta$, a portion $\beta$ of its period-1 customers experienced quality $H$ for its product. Thus, from the product reviews, period-2 consumers can correctly infer each firm's $\beta$.[18] There will thus effectively be two distinguishable segments of competing firms, one having quality $\beta_h$ and another $\beta_l$. Comparing $V_\gamma$ from (8) for $\gamma = \beta_h$ and $\gamma = \beta_l$, consumers will clearly receive a higher surplus from—and thus only search—the segment of firms with $\beta = \beta_h$. Thus, in equilibrium, consumers will all first search the segment of firms with $\beta = \beta_h$.

It follows that only $\beta_h$ firms will be active sellers in the market in period 2, and consumers will search them with reservation value $v_h \equiv v_h(s)$ that uniquely solves

$$\beta_h \int_{v_h}^{\bar{v}} (v - v_h)\, f(v)\, dv = s. \tag{13}$$

[18] We could allow product reviews to be noisy signals or consumer observations of product reviews in period 2 to be noisy signals as well. Our results will remain valid if the noisy signals are sufficiently accurate.

Moreover, in equilibrium all $\beta_h$ firms charge price

$$p_2^* = \beta_h \lambda(v_h), \tag{14}$$

and each earns profit

$$\pi_2^*(\beta_h) = \frac{\beta_h \lambda(v_h)}{G(t)},$$

where $G(t)$ is the mass of $\beta_h$ firms in the market. Firms with $\beta_l$ earn zero profit in period 2.

We next consider the investment choices of firms and determine the threshold $t$ of investment cost $x$. Given that firms invest $x$ if and only $x \leq t$, if a firm with $x$ acquires $\beta_h$ at the beginning of period 1, it will earn discounted sum of profit

$$\pi_h = \gamma\lambda(v_\gamma) + \delta\frac{\beta_h \lambda(v_h)}{G(t)} - x. \tag{15}$$

By contrast, if the firm chooses to maintain $\beta_l$ without investment, its expected profit is

$$\pi_l = \gamma\lambda(v_\gamma). \tag{16}$$

The equilibrium $t = t^* \equiv t^*(s)$ is determined by the $x$ at which $\pi_h = \pi_l$, or

$$\delta\beta_h\lambda(v_h) = t^* G(t^*). \tag{17}$$

Because average firm quality

$$\gamma \equiv \gamma(t^*) = \beta_h G(t^*) + \beta_l[1 - G(t^*)] \tag{18}$$

is endogenous, we modify the definition of $\bar{s}$ in (7) by re-defining

$$\int_{v_0}^{\bar{v}} (v - v_0) f(v)\, dv = \frac{\bar{s}}{\gamma(t^*(\bar{s}))}, \tag{19}$$

where $v_0 \equiv \lambda(v_0) = \frac{1-F(v_0)}{f(v_0)}$, to ensure consumer participation whenever $s < \bar{s}$.[19] Following the discussions above, we establish the result below by further showing the existence of $t^*$ that solves equation (17).[20]

[19] As we shall discuss shortly, $\frac{s}{\gamma(t^*(s))}$ is likely to be monotonically increasing in $s$. If it is not, there might be multiple $s$ that satisfies (19), in which case we define $\bar{s}$ to be the smallest $s$ among them.

[20] If $\lambda(u)$ is strictly decreasing, then $t^*$ is unique.

**Proposition 3** *Given $s < \bar{s}$, our model has an equilibrium where a firm has $\beta = \beta_h$ if and only if its $x \leq t^* = t^*(s)$, and the average firm quality in period 1 is $\gamma(t^*)$. Consumers search with reservation value $v_\gamma$ and pay price $p_1^*$ in period 1, but search only $\beta_h$ firms with reservation value $v_h$ and pay $p_2^*$ in period 2.*

The second-period industry profit, consumer surplus, and total welfare are respectively

$$\Pi_2^* = \beta_h \lambda(v_h); \qquad V_2^* = \beta_h \phi(v_h); \qquad W_2^* = \gamma v_h,$$

where we define $\phi(v) \equiv [v - \lambda(v)]$, with $\phi(v) > 0$ and $\phi'(v) \geq 1$. Their corresponding discounted sums for the two periods are given by:

$$\Pi^* = \gamma\lambda(v_\gamma) + \delta\beta_h\lambda(v_h) - \int_0^{t^*} x dG(x); \tag{20}$$

$$V^* = \gamma\phi(v_\gamma) + \delta\beta_h\phi(v_h); \tag{21}$$

$$W^* = \gamma v_\gamma + \delta\beta_h v_h - \int_0^{t^*} x dG(x). \tag{22}$$

In equilibrium, each consumer receives positive (expected) surplus from market participation and all firms receive positive profits, while the more efficient firms (with $x < t^*$) receive higher profits.

## 4.2 Impacts of Search Cost

We now consider the impacts of search cost. Utilizing $\frac{\partial v_h}{\partial s} = -\frac{1}{\beta_h[1-F(v_h)]}$ from (13),

$$\frac{\partial p_2^*}{\partial s} = \beta_h \lambda'(v_h) \frac{\partial v_h}{\partial s} = -\frac{\lambda'(v_h)}{[1 - F(v_h)]} \geq 0.$$

Thus, as expected, a higher search cost leads to a higher price in period 2. Since

$$\frac{\partial t^*}{\partial s} = \frac{\delta\beta_H\lambda'(v_h)\frac{\partial v_h}{\partial s}}{G(t) + tg(t)} = \frac{-\delta\lambda'(v_h)}{G(t) + tg(t)} \frac{1}{[1 - F(v_h)]} \geq 0, \tag{23}$$

and $\frac{\partial\gamma(t^*)}{\partial t^*} = G'(t^*)(\beta_h - \beta_l) > 0$, we have

$$\frac{\partial\gamma(t^*)}{\partial s} = \frac{\partial\gamma(t^*)}{\partial t^*}\frac{\partial t^*}{\partial s} \geq 0.$$

Therefore, increases in search cost raise average firm quality.[21] Intuitively, when $s$ is higher, price is higher, and a firm has higher profit in period 2 for being a $\beta_h$ firm. That is, the return to the reputation of being a high-quality firm is higher. This motivates more firms to invest in $\beta_h$, so that $t^*$ becomes higher, which boosts $\gamma$ in period 1.

When $\gamma$ is given exogenously, a higher $s$ leads to a lower $v_\gamma$, which in turn results in higher price and profit. With endogenous $\gamma$, changes in $s$ also affect $\gamma = \gamma(t^*)$. While a higher $s$ directly impacts $v_\gamma$ negatively, it indirectly impacts $v_\gamma$ positively through a higher $\gamma$. We expect the direct effect of $s$ to outweigh its indirect effect through $\gamma$, so that $\frac{s}{\gamma}$ is higher with a higher $s$. Define the elasticity of average seller quality, $\gamma$, with respect to search cost as $\varepsilon = \frac{s}{\gamma}\frac{\partial\gamma}{\partial s} = \frac{s}{\gamma}\frac{\partial\gamma}{\partial t^*}\frac{\partial t^*}{\partial s} \geq 0$. Then

$$\frac{d\left(\frac{s}{\gamma}\right)}{ds} = \frac{\gamma - s\frac{\partial\gamma}{\partial s}}{\gamma^2} \geq 0 \quad \Longleftrightarrow \quad \varepsilon \equiv \frac{\partial\gamma}{\partial s}\frac{s}{\gamma} \leq 1.$$

Thus, if $\varepsilon \leq 1$, then

$$\frac{\partial v_\gamma}{\partial s} = \frac{\partial v_\gamma}{\partial(s/\gamma)}\frac{\partial(s/\gamma)}{\partial s} = \frac{\varepsilon - 1}{\gamma[1 - F(v_\gamma)]} \leq 0, \tag{24}$$

$\frac{\partial p_\gamma}{\partial s} = \gamma\lambda'(v_\gamma)\frac{\partial v_\gamma}{\partial s} \geq 0$, and since $\delta\beta_h\lambda'(v_h)\frac{\partial v_h}{\partial s} = [t^*g(t^*) + G(t^*)]\frac{\partial t^*}{\partial s}$ from totally differentiating the two sides of (17), we have

$$\frac{\partial\Pi^*}{\partial s} = \frac{\partial p_\gamma}{\partial s} + \delta\beta_h\lambda'(v_h)\frac{\partial v_h}{\partial s} - t^*g(t^*)\frac{\partial t^*}{\partial s} = \frac{\partial p_\gamma}{\partial s} + G(t^*)\frac{\partial t^*}{\partial s} \geq 0.$$

The discussions above lead to:

**Remark 1** *$\gamma(t^*)$ and $p_2^*$ increase in $s$, and so do $p_1^*$ and $\Pi^*$, provided $\lambda'(v) < 0$ and $\varepsilon \leq 1$.*

Thus, with endogenous firm quality and reputation, search cost continues to be a key indicator of competition intensity, with increases in $s$ leading to less competition and high prices in both periods. However, as we show next, search cost now has unconventional effects on consumer surplus and welfare. The result below refers to assumption:

$$\text{There exists some number } N > 0 \text{ such that } -N < \lambda'(v) < 0 \text{ for all } v \in [0, \bar{v}], \tag{25}$$

[21] Notice that if $\lambda'(v) = 0$, then $\partial t^*/\partial s = 0$, and hence $\partial\gamma(t^*)/\partial s = 0$. Thus $\lambda'(v) < 0$ is needed in order for average firm quality to (strictly) increase with $s$.

which strengthens condition (6). Condition (25) is satisfied, for instance, if $F(v)$ is a uniform distribution.

**Proposition 4** *(i) Under condition (25), both $V^*$ and $W^*$ increase in $s$ when $s$ is sufficiently small. (ii) Suppose $\varepsilon \leq 1$. Then, when $s \to \bar{s}$, $V^*$ decreases in $s$, and so does $W^*$ if $v_0(\beta_h - \beta_l) \leq \bar{t}$.*

Therefore, higher search frictions can improve market performance for experience goods, with both $V^*$ and $W^*$ initially increasing and eventually decreasing in $s$ under plausible conditions. To understand this striking result, notice that the effect of a marginal increase in $s$ on consumer surplus can be decomposed as follows under conditions (25) and $\varepsilon \leq 1$:

$$\frac{\partial V^*}{\partial s} = \underbrace{\frac{\partial \gamma}{\partial s}\phi(v_\gamma)}_{\text{average firm quality effect } >0} + \underbrace{\gamma\phi'(v_\gamma)\frac{\partial v_\gamma}{\partial s}}_{\text{search efficiency effect in period 1 } \leq 0} + \underbrace{\delta\beta_h\phi'(v_h)\frac{\partial v_h}{\partial s}}_{\text{search efficiency effect in period 2 } <0}.$$

An increase in $s$ raises the profit from being a $\beta_h$ firm, motivating more firms to invest in quality and hence average firm quality $\gamma$ is higher in period 1. On the other hand, a higher $s$ reduces $v_h$ and, when $\varepsilon \leq 1$, also reduces $v_\gamma$; that is, a higher search cost reduces search efficiency in both periods, which negatively impacts consumer surplus.

When search cost is low, price is low. Thus consumer surplus from an $H$ product, $\phi(v_\gamma)$, is high, and the number of high quality firms (that incur $x$) is small. In such situations, although a marginal increase in $s$ only raises prices slightly, the profit increase from becoming a high quality firm is large because of a big boost to its sales in period 2. Hence, a marginal increase in $s$ leads to a large increase in the number of high-quality firms and in $\gamma$ (i.e., $\frac{\partial \gamma}{\partial s}$ is high), which means that $\frac{\partial \gamma}{\partial s}\phi(v_\gamma)$ is high, whereas the effect on search efficiency is more moderate. Thus the (average firm) quality effect dominates when $s$ is small. On the other hand, when $s$ is large, price is high. Thus $\frac{\partial \gamma}{\partial s}$ and $\phi(v_\gamma)$ are relatively low, so that the negative search efficiency effect dominates.

We can similarly decompose the effect of search cost on total welfare as follows:

$$\frac{\partial W^*}{\partial s} = \underbrace{\frac{\partial \gamma}{\partial s}v_\gamma}_{\text{average firm quality effect } > 0} + \underbrace{\gamma\frac{\partial v_\gamma}{\partial s} + \delta\beta_h\frac{\partial v_h}{\partial s}}_{\text{search efficiency effect } < 0} + \underbrace{- t^* g(t^*)\frac{\partial t^*}{\partial s}}_{\text{investment cost effect } < 0}.$$

In addition to the average firm quality and search efficiency effects, as in the case of consumer surplus, for $W^*$ there is the additional effect of investment cost: a higher search cost increases the total investment cost for $\beta_h$, because the higher profit from being a high-quality firm from an increase in $s$ leads to more firms to invest in $\beta_h$. But when $s \to 0$, $t^* \to 0$, and thus the additional effect of investment cost vanishes so that $W^*$ increases in $s$, similarly as for $V^*$. On the other hand, when $s \to \bar{s}$, the highest possible value of search cost, $t^* \to \bar{t}$ and $v_\gamma \to v_0$. If $v_0 (\beta_h - \beta_l) < \bar{t}$, then the investment cost effect (alone) dominates the average firm quality effect, and hence $W^*$ decreases in $s$, similarly as for $V^*$.

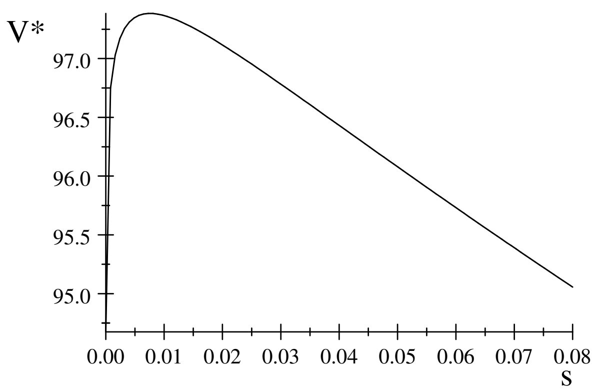


Figure 1A

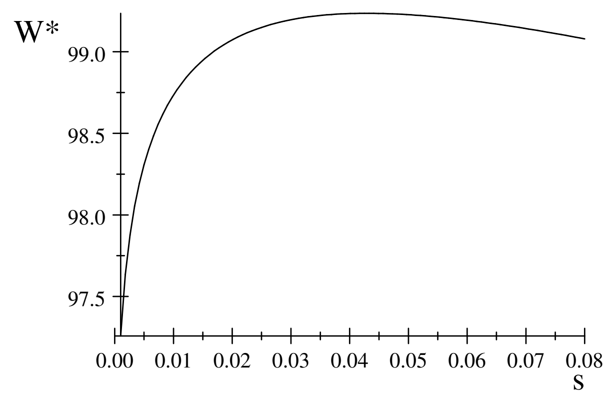


Figure 1B

The conclusions in Proposition 4 can be strengthened if we impose additional assumptions. For example, both $V^*$ and $W^*$ exhibit an inverted-U shape as $s$ increases when $F(v)$ and $G(x)$ are uniform distributions under plausible parameter values, as illustrated in Figures 1A and 1B, where $F(v) = \frac{v}{100}$, $G(x) = \frac{x}{50}$, $\beta_h = 0.8$, $\beta_l = 0.3$, and $\delta = 0.8$.

The welfare effects of search frictions in our model is in sharp contrast to the result in the existing search literature, where consumer and total welfare monotonically decrease as search cost increases. Both endogenous firm quality and the experience nature of goods are important for the non-monotonic result in our model. If average firm quality in the market ($\gamma$) is exogenously given, higher search costs would only have the negative effect of reducing search efficiency. In our model, an increase in search cost has the additional effect of inducing a higher $\gamma$, which positively impacts consumer and total welfare, and it is the dominant force when search cost is sufficiently low. However, for inspection goods, even with endogenous product quality, both consumer and total welfare would decrease with search cost, as we show next.

### 4.3 Comparing to Welfare for Inspection Goods

For inspection goods, same as in the case of experience goods, for a given $t$ the average firm quality in the market is

$$\gamma = \gamma(t) = G(t)\beta_h + [1 - G(t)]\beta_l.$$

The first-period equilibrium is then the same as in subsection 3.3, with consumers conducting sequential search under reservation value $v^I_\gamma = v_\gamma$ and all firms charging $p^I_1 = p^I_\gamma$. Notice that a firm of quality $\beta$ earns profit $\frac{\beta}{\gamma}\lambda\left(v^I_\gamma\right)$ in period 1.

Suppose also that, as for experience goods, in period 2 consumers can observe first-period consumers' product reviews, which reveal each firm's $\beta$.[22] Then, in period 2, consumers will also only search $\beta_h$ firms, with reservation value $v_h$. Moreover, from subsection 3.3, $\beta_h$ sellers will charge $p^I_2 = \lambda(v_h)$, each earning profit $\frac{1}{G(t)}\lambda(v_h)$ in period 2 if the number of $\beta_h$ firms is $G(t)$. Thus, a $\beta_h$ seller earns higher profits in both periods.

In equilibrium, a firm will invest in $\beta_h$ if and only if $x \leq \tau$, where the cutoff value $\tau$ is determined by

$$\frac{\beta_h}{\gamma}\lambda\left(v^I_\gamma\right) + \delta\frac{1}{G(\tau)}\lambda(v_h) - \tau = \frac{\beta_l}{\gamma}\lambda\left(v^I_\gamma\right),$$

or

$$\tau = \frac{\beta_h - \beta_l}{\gamma(\tau)}\lambda(v_\gamma) + \delta\frac{1}{G(\tau)}\lambda(v_h). \tag{26}$$

Thus, similarly as for experience goods, a higher $s$, which increases $\lambda(v_\gamma)$ and $\lambda(v_h)$, will raise average firm quality $\gamma(\tau)$. Industry profit, consumer surplus, and total welfare for the

[22] Since consumers observe $q \in \{H, L\}$ when searching a firm, they will only purchase if $q = H$. A consumer's review in this case is still about whether a firm's product quality $q$ is $H$ or $L$; if $q = L$, even though she can avoid to purchase the product, the consumer has wasted a costly search.

two periods together are respectively

$$\Pi^I = \lambda(v_\gamma) + \delta\lambda(v_h) - \int_0^\tau x dG(x); \qquad V^I = \phi(v_\gamma) + \delta\phi(v_h); \qquad W^I = v_\gamma + \delta v_h - \int_0^\tau x dG(x),$$

where recall $\phi(v) = v - \lambda(v)$.

The impact of search cost on consumer welfare under inspection goods is always negative (provided $\varepsilon \leq 1$ so that $d\left(\frac{s}{\gamma}\right)/ds \geq 0$), because the positive average firm quality effect for experience goods is absent:

$$\frac{\partial V^I}{\partial s} = \underbrace{\phi'(v_\gamma)\frac{\partial v_\gamma}{\partial s}}_{\text{search efficiency effect in period 1 } \leq 0} + \underbrace{\delta\phi'(v_h)\frac{\partial v_h}{\partial s}}_{\text{search efficiency effect in period 2 } <0} < 0.$$

Similarly,

$$\frac{\partial W^I}{\partial s} = \underbrace{\gamma\frac{\partial v_\gamma}{\partial s} + \delta\beta_h\frac{\partial v_h}{\partial s}}_{\text{search efficiency effect } <0} \underbrace{-\tau g(\tau)\frac{\partial \tau}{\partial s}}_{\text{investment cost effect } <0} < 0.$$

We thus have:

**Remark 2** *For inspection goods, consumer and total welfare monotonically decrease in search cost, in contrast to the result for experience goods.*

For both inspection and experience goods, an increase in search cost leads to higher price and hence to higher returns for investment in quality because only $\beta_h$ firms make sales in period 2. However, consumers can avoid the loss from a low-quality product for inspection goods but not for experience goods. Thus, the marginal benefit from increasing firm quality ($\gamma$) in period 1 due to a higher $s$ is lower for inspection goods. This explains why a higher $s$ can be beneficial to consumers and total welfare for experience but not for inspection goods.

### 4.4 Equilibrium vs. Efficient Quality Investment

We further investigate how the equilibrium quality investment compares with the social optimum, by comparing the cutoff values for quality investment ($t$) in these two cases. The result below shows that the equilibrium cutoff ($t^*$) can be higher or lower than the efficient value ($t^o$) when search cost is sufficiently high or low, respectively.

**Proposition 5** *Given $s \in (0, \bar{s})$, there exists $t^o > 0$ that maximizes total welfare. Moreover, provided $t^o < \bar{t}$, there exists a unique $\sigma > 0$ such that $t^* \leq t^o$ if $s \leq \sigma$ but $t^* > t^o$ if $\sigma < s \leq \bar{s}$.*

An increase in $t$ results in a higher proportion of firms that invest. This leads to a higher expected quality of sellers and hence higher welfare in the first period, as reflected by a higher $\gamma v_\gamma$. On the other hand, investment is costly, and a higher $t$ leads to higher investment cost $\int_0^t x dG(x)$. A socially optimal $t^o$ balances these two opposing forces, with the marginal benefit from a higher $\gamma$ being equal to the marginal cost of increasing $t$. From the definition of $\bar{t}$ in (38), we note that $\bar{t} > 0$ is independent of $\beta_l$ whereas $t^o \to 0$ if $\beta_l \to \beta_h$. Thus $t^o < \bar{t}$ when $(\beta_h - \beta_l)$ is relatively small so that the benefit from high quality $(\beta_h)$ is more limited.

When a firm chooses to invest in quality (to incur $x$), it internalizes neither the positive impact on consumers nor the negative impact on other firms' profits from a higher $\gamma$. When $s$ is low, consumers have strong search incentives and $v_\gamma - p_\gamma$ is high, so that a higher average firm quality $\gamma$ (i.e. a higher $t$) has a large impact on $\gamma(v_\gamma - p_\gamma)$ and the positive consumer externality dominates. Therefore $t^* < t^o$ when $s$ is low. On the other hand, when $s$ is high, $v_\gamma - p_\gamma$ is low and welfare gain from increasing $\gamma$ is relatively small (so $t^o$ is relatively low), whereas price is high and the negative "profit shifting" effect tends to dominate, so that $t^*$ tends to exceed $t^o$.

In the literature on experience goods (without consumer search), product quality is usually inefficiently low because the market often creates other distortions (such as inefficiently high price) in order to induce firms to improve quality. This is consistent with our result that equilibrium product quality is deficient ($t^* \leq t^o$) when search cost $s$ is sufficiently small. However, our result also shows that there can be socially excessive quality investment in the presence of (substantial) search frictions.

It can be verified that a result similar to Proposition 5 also holds for inspection goods. Thus, quality provision is socially deficient when $s$ is low but possibly excessive when $s$ is high, for both experience and inspection goods in search markets. One notable difference is that the profit-shifting effect of a firm's quality investment arises only in period 2 for experience goods, whereas it also arises in period 1 for inspection goods, because consumers' purchases in period 1 are affected by product quality only for the latter. This suggests that equilibrium product quality is more likely to be deficient for experience than for inspection goods.

## 5. EFFECTS OF AN INTERMEDIARY

In many markets, consumers search their products through an intermediary that serves as a search platform, such as Amazon.com and booking.com. We now extend our model to include such an intermediary.[23] A profit-maximizing intermediary can affect market outcomes by charging sellers fees for being on its platform, which may in turn affect the (average) quality of sellers on the marketplace, search efficiency, and market price.[24] We shall show that the intermediary can improve welfare by screening out low-quality sellers, especially when it can commit to a relatively small listing space on the platform, but it may lower welfare when lacking such commitment ability.

Suppose that a monopoly intermediary, $M$, can charge each seller $(k,\ \mu)$, where $k \geq 0$ is a fixed fee and $\mu \geq 0$ a percentage of the transaction price. Sellers that pay the fees will have access to consumers associated with $M$. We further assume that there is a minimum platform size $\Omega \in (0, 1]$—number of sellers to be listed on the platform—that $M$ can commit to.[25]

The timing of the extended model is as follows. $M$ first chooses $(k,\ \mu)$. In period 1, after

[23] Athey and Ellison (2011) and Chen and He (2011) study position auctions by a monopoly search engine, emphasizing their beneficial role as information intermediary. Bagwell and Ramey (1996) pioneered the study of coordination economies in retail market search. Others have shown that search intermediaries need not (optimally) improve search efficiency (e.g. Eliaz and Spiegler, 2011; White, 2013; de Cornière and Taylor, 2014). None of the above analyze experience goods.

[24] In addition to providing a search platform, the intermediary may publish product reviews by customers. The intermediary can thus be a reputation carrier, enabling firms to establish quality reputation when product reviews are otherwise unavailable.

[25] A similar assumption is adopted by, for example, Eliaz and Spiegler (2011) under a continuum of sellers, or Athey and Ellison (2011) and Chen and He (2011) under a finite number of sellers.

its realization of $x$, each seller chooses whether to pay the fees to sell on the platform and decides whether to invest $x$ to become a seller with $\beta_h$. Sellers on the platform then set prices, consumers sequentially search sellers on the platform, and transactions are made. In period 2, consumer reviews from previous period are available to the current cohort of consumers. Sellers on the platform set prices, and consumers again sequentially search sellers on the platform and possibly make purchases. Everything else about the model is the same as in section 2.[26] Notice that sellers not on the platform are not active in either period.

Given the average firm quality on the platform, $\gamma$, which is endogenously determined by the firms on the platform who will invest in $\beta_h$, the firms' pricing and consumers' search strategies are the same as in section 4, unaffected by the values of $k$ and $\mu$. In particular, at a uniform-price equilibrium, the optimal consumer search rule is again given by (19), whereas a seller will choose $p$ to maximize $(1-\mu)\, pD\,(p, p^*)$, the solution of which does not depend on $\mu$.

There are two possible types of equilibria for a given $\Omega$, depending on its value: (1) a separating equilibrium in which all sellers on the platform are of high quality ($\beta_h$), and (2) a pooling equilibrium in which both high and low quality sellers are present on the platform.

First, at a separating equilibrium, $M$ charges high fees such that only high quality sellers will be able to earn positive profit. Suppose that in equilibrium, there is a cutoff value $t_k$ such that only sellers with $x \leq t_k$ choose to invest in $\beta_h$ and pay to be listed on the platform while other sellers are off the platform and inactive. In this case, in equilibrium $M$ solves the following problem (P1):

$$\max_{(k,\mu)} \; \Psi = kG\,(t_k) + \mu\beta_h\lambda\,(v_h)\,(1+\delta)\,,$$

subject to

$$(1-\mu)\,\frac{1}{G\,(t_k)}\beta_h\lambda\,(v_h) - k < 0, \tag{27}$$

$$(1-\mu)\,\frac{1}{G\,(t_k)}\beta_h\lambda\,(v_h)\,(1+\delta) - k - x \geq 0 \quad \text{for} \quad x \leq t_k, \tag{28}$$

[26] For convenience, we assume that each search still costs $s$. The analysis can be easily extended to situations where $s$ becomes lower when consumers search on the platform.

where the first constraint ensures that a seller with $\beta_l$ has no incentive to be on the platform (being able to sell only in period 1) and the second constraint ensures that sellers with low $x$ find it profitable to acquire $\beta_h$ and sell on the platform for two periods.

Define $t_\Omega$ and $\hat{t}$ respectively as

$$G(t_\Omega) = \Omega; \qquad \hat{t} = \frac{1}{G(\hat{t})}\beta_h \lambda(v_h)(1+\delta), \tag{29}$$

and, for $\bar{t}$ defined in (38), we assume $\max\{t_\Omega, \hat{t}\} < \bar{t} < \bar{x}$. Then, exactly $\Omega$ firms will be listed on the platform if and only if all firms with $x \leq t_\Omega$ pay $(k, \mu)$ and invest $x$, whereas $G(\hat{t})$ is the mass of firms who will acquire $\beta_h$ and be on the platform if $k = \mu = 0$ and $\gamma = \beta_h$.

**Lemma 1** *Suppose $t_\Omega \leq \hat{t}$. There is a separating equilibrium in which $M$ optimally sets $\mu^* = 0$ and*

$$k^* = \frac{1}{G(t_\Omega)}\beta_h \lambda(v_h)(1+\delta) - t_\Omega; \tag{30}$$

*whereas only firms with $x \leq t_\Omega$ choose to acquire $\beta_h$ and sell on the platform. Moreover, the presence of the intermediary improves welfare if $t_\Omega \leq t^*$, with $t^*$ defined in (17) and $t^* < \hat{t}$ .*

Given (relatively small) $\Omega$ so that $\hat{t} \geq t_\Omega$, $M$ can screen out low quality firms by charging high fees and thus organize a platform that contains only high quality sellers. At this equilibrium, search efficiency is higher in period 1 (and is unchanged in period 2) as compared to the market equilibrium without $M$; if additionally $t_\Omega \leq t^*$, then the total investment cost on quality is also (weakly) lower—and hence total welfare must be higher—at the separating equilibrium.

We next consider an alternative possible equilibrium, a pooling equilibrium, which arises when $t_\Omega > \hat{t}$. In this equilibrium, there is a cutoff value $t_k$ such that only firms with $x \leq t_k$ choose to acquire $\beta_h$, but all firms will pay to be on the platform. $M$ solves the following maximization problem (P2):

$$\max_{k,\mu} \ \Psi = k + \mu\left[\gamma(t_k)\lambda(v_\gamma) + \delta\beta_h\lambda(v_h)\right],$$

subject to

$$(1-\mu)\,\gamma\,(t_k)\,\lambda\,(v_\gamma)-k\geq 0, \tag{31}$$

$$(1-\mu)\,\delta\frac{1}{G\,(t_k)}\beta_h\lambda\,(v_h)-x\geq 0 \quad \text{for} \quad x\leq t_k, \tag{32}$$

where the two constraints ensure respectively that firms with $\beta_l$ are willing to pay $(k,\mu)$ and that firms with $x\leq t_k$ will additionally choose to acquire $\beta_h$. The result below refers to condition

$$\left(\lambda\,(v_\gamma)-\lambda'\,(v_\gamma)\,\frac{s}{\gamma}\frac{1}{1-F\,(v_\gamma)}\right)(\beta_h-\beta_l)\leq t^* \tag{33}$$

for $\gamma=\gamma\,(t^*)$, which holds if $(\beta_h-\beta_l)$ is not too large.

**Lemma 2** *Suppose $t_\Omega>\hat{t}$ and (33) holds. Then, there exists a pooling equilibrium with $t_k^*\in(0,t^*)$. $M$ optimally chooses*

$$k^*=(1-\mu^*)\,\gamma\,(t_k^*)\,\lambda\,(v_\gamma)\,;\qquad \mu^*=1-t_k^*G\,(t_k^*)\,\frac{1}{\delta\beta_h}\lambda\,(v_h)\,;$$

*and all firms choose to be on the platform. However, only firms with $x\leq t_k^*$ choose to acquire $\beta_h$.*

When the minimum platform size $\Omega$ is relatively large and $(\beta_h-\beta_l)$ relatively small, there is a pooling equilibrium in which $M$ finds optimal to accommodate both high and low quality firms, with positive $k$ and $\mu$. Due to $\mu^*>0$, however, $t_k^*<t^*$ and the average firm quality in period 1 is lower than when $M$ is absent. The intermediary can thus lower welfare if it leads to a pooling equilibrium, because the market provision of quality may be already too low without $M$.

Combining Lemma 1 and Lemma 2, noting $t^*<\hat{t}$ and recalling from Proposition 5 that $t^*<t^o$ if $s<\sigma$, we have

**Proposition 6** *For the extended model with $M$, assume* $\max\left\{t_\Omega,\hat{t}\right\}<\bar{t}$. *(i) If $t_\Omega<\hat{t}$, then it is an equilibrium that only firms with $x\leq t_\Omega$ acquire $\beta_h$ and list on $M$, with $M$ improving total welfare. (ii) If $t_\Omega>\hat{t}$, then it is an equilibrium for all firms to list on $M$ but only* *those with $x \leq t_k^* < t^*$ to acquire $\beta_h$; and if $s < \sigma$, then $t_k^* < t^* < t^o$, so that the market provision of quality is further below the social optimum.*[27]

The presence of a profit-maximizing search intermediary can thus either increase or decrease welfare.[28] Notice that $t_\Omega < t^*$ is more likely to hold if $s$ is relatively large, while $t_\Omega > \hat{t}$ and $s < \sigma$ are more likely to hold if $s$ is relatively small. Therefore, the presence of the intermediary is more likely to increase welfare when it can commit to a relatively small minimum listing size or under relatively large search cost; but the intermediary can reduce welfare when the minimum listing space on the search platform is relatively large and search cost is relatively low.[29]

## 6. CONCLUSION

The standard view in economics has been that decreases in search friction increase welfare in consumer markets. This paper shows that the impact of search friction on market performance is more nuanced, depending on the observability of product quality before purchase. In our setting, while for inspection goods a reduction in search cost is indeed always beneficial, for experience goods it will decrease both consumer and total welfare if search cost is already low. We also find that the market provision of product quality is deficient when search cost is low but can be excessive when it is high. Moreover, a search intermediary can improve welfare by committing to a sufficiently limited space for displaying sellers, but it may reduce welfare if it is unable to do so.

[27] In this case, total welfare, same as $W^*$ from (22), is likely—but not necessarily—lower under $t_k^*$ than under $t^*$. If $W^*$ is monotonically increasing in $t$ for $t < t^o$, which for example is true when $F(\cdot)$ and $G(\cdot)$ are uniform distributions, then $W^*$ is unambiguously lower under $t_k^*$ than under $t^*$ if $t_k^* < t^* < t^o$.

[28] As discussed in subsection 4.3, for inspection goods a firm's profit is higher when it has higher quality. Thus, with $M$ it is likely that a separating equilibrium prevails, with only the high-quality firms being present on the search platform in both periods. The intermediary will then improve welfare, as in Chen and He (2011) and Athey and Ellison (2011). To focus on our main interest, we have not analyzed this case.

[29] We have verified numerically that, for example, if $F(v)$ and $G(x)$ are both uniform distributions, then there are plausible parameter values under which $\max\{t_\Omega, \hat{t}\} < \bar{t}$ and the intermediary increases welfare when $\Omega$ is small but decreases welfare when $\Omega$ is relatively large.

The analytical results of our model are especially relevant in the contemporary economy, where transactions are increasingly conducted through online markets where search cost is low and product quality may be difficult to observe before purchase. Online markets are thus more susceptible to low-quality sellers and low-quality products than traditional markets. Our results suggest that further diminishing search cost and increasing competition need not improve the performance of these markets. Rather, regulatory policies can play important roles in protecting consumers and increase welfare. One such policy is to impose minimum quality standards, when feasible, to prohibit the sale of low-quality products. Another possibility is to provide stronger consumer rights for product return and other remedies to low quality. Product return is often costly to consumers for the time and efforts involved, and it is not always feasible because a quality problem may not be detected promptly after purchase. But when it is feasible, product return can effectively change the nature of a product from an experience to an inspection good, improving efficiency. A related issue is how to design product liability to provide efficient incentives to invest in product quality, both for producers and for intermediaries that can screen out low-quality sellers. We believe that these are important issues for future research.

## APPENDIX

The appendix contains proofs for Propositions 1, 3, 4, 5 and for Lemmas 1 and 2.

**Proof of Proposition 1.** It suffices to show that there can be no equilibrium where $\beta_h$ and $\beta_l$ firms charge different prices. Suppose, to the contrary, that there is an equilibrium where $\beta_h$ and $\beta_l$ firms charge $p_h \neq p_l$. Then the equilibrium profit for the two types of firms must be equal, $\pi_h = \pi_l$, because otherwise a firm of the type with a lower profit, say, $\beta_l$, can deviate to $p_h$ and increase its profit. So suppose $p_h \neq p_l$ but $\pi_h = \pi_l$. We show that this leads to a contradiction.

Let each consumer's reservation values be $v_h$ and $v_l$ at a $\beta_h$ and a $\beta_l$ firm, respectively. Then, since the consumer has the same continuation value at both types of firms, we have

$$\beta_h v_h - p_h = \beta_l v_l - p_l. \tag{34}$$

Moreover, reservation values $v_h$ and $v_l$ satisfy the following equation

$$G\int_{v_h}^{\bar{v}}\beta_h(v-v_h)f(v)\,dv+(1-G)\int_{v_l}^{\bar{v}}\beta_l(v-v_l)f(v)\,dv=s, \tag{35}$$

in which the LHS is the expected gain from one more search: When the consumer is currently at a $\beta_h$ firm (having $v_h$ and $p_h$), with probability $G$ she will encounter another $\beta_h$ firm with gain $(\beta_h v-p_h)-(\beta_h v_h-p_h)=\beta_h(v-v_h)$, conditional on her $v>v_h$ from the new firm searched, while with probability $(1-G)$ the consumer will encounter a $\beta_l$ firm with gain $(\beta_l v-p_l)-(\beta_h v_h-p_h)$, which equals $\beta_l(v-v_l)$ from (34), conditional on $v>v_l$. The argument is similar when the consumer is currently at a $\beta_l$ firm (having $v_l$ and $p_l$).

Next, given consumers' search behavior and the pricing strategies of other firms, if a $\beta_h$ firm deviates with price $p$ in the neighborhoods of $p_h$, under our extended passive-belief assumption consumers will believe that the deviation is made by the $\beta_h$ firm. Hence, at the deviating price $p$, a consumer with value $v$ at the $\beta_h$ firm will purchase if $\beta_h v-p\geq(G)[\beta_h v_h-p_h]+(1-G)[\beta_l v_l-p_l]=\beta_h v_h-p_h$. The firm's demand from any visiting consumer is thus $1-F\left(v_h+\frac{p-p_h}{\beta_h}\right)$. Solving $\max_p p\left[1-F\left(v_h+\frac{p-p_h}{\beta_h}\right)\right]$, with $p=p_h$ in equilibrium, we obtain $p_h=\beta_h\lambda(v_h)$. Similarly, $p_l=\beta_l\lambda(v_l)$. Therefore

$$\beta_h v_h-p_h=\beta_h[v_h-\lambda(v_h)];\qquad \beta_l v_l-p_l=\beta_l[v_l-\lambda(v_l)],$$

and from (34) we obtain

$$\beta_h[v_h-\lambda(v_h)]=\beta_l[v_l-\lambda(v_l)]. \tag{36}$$

Furthermore:

$$\pi_h=\frac{p_h[1-F(v_h)]}{1-(G)F(v_h)-(1-G)F(v_l)},\qquad \pi_l=\frac{p_l[1-F(v_l)]}{1-(G)F(v_h)-(1-G)F(v_l)}. \tag{37}$$

If $p_h>p_l$, then $\pi_h=\pi_l$ implies $v_h>v_l$, which further implies $\beta_h[v_h-\lambda(v_h)]>\beta_l[v_l-\lambda(v_l)]$ since $\lambda'(\cdot)\leq 0$. This contradicts (36). If $p_h=\beta_h\lambda(v_h)<p_l=\beta_l\lambda(v_l)$, then from $\beta_h>\beta_l$ and $\lambda'(\cdot)\leq 0$ we have $v_h\geq v_l$ and hence

$$\beta_h v_h-\beta_h\lambda(v_h)>\beta_l v_l-\beta_l\lambda(v_l),$$

again contradicting (36). ■

**Proof of Proposition 3.** The RHS of equation (17) increases in $t^*$, whereas the LHS of equation (17) is larger than the RHS when $t^* \to 0$. Moreover, define $\bar{t}$ as

$$\delta \beta_h \lambda \left( v_h \left( \bar{s} \right) \right) = \bar{t} G \left( \bar{t} \right). \tag{38}$$

Since $\lambda \left( v_h \right)$ weakly increases in $s$, we have $\delta \beta_h \lambda \left( v_h \left( s \right) \right) \leq \bar{t} G \left( \bar{t} \right)$ for all $s \in \left( 0, \bar{s} \right)$. Thus, the LHS of equation (17) is no higher than the RHS when $t^* \to \bar{t}$. Therefore, there exists $t^* \in \left( t, \bar{t} \right)$ that solves equation (17). ■

**Proof of Proposition 4.** (i) First, from (21),

$$\frac{\partial V^*}{\partial s} = \frac{\partial \gamma}{\partial s} \phi \left( v_\gamma \right) + \ \gamma \phi' \left( v_\gamma \right) \frac{\partial v_\gamma}{\partial s} + \ \delta \beta_h \phi' \left( v_h \right) \frac{\partial v_h}{\partial s}.$$

Since $\frac{\partial v_\gamma}{\partial (s/\gamma)} = -\frac{1}{[1 - F(v_\gamma)]}$ from (4) and from (23):

$$\frac{\partial \gamma}{\partial s} = \frac{\partial \gamma}{\partial t^*} \frac{\partial t^*}{\partial s} = \left( \beta_h - \beta_l \right) g \left( t^* \right) \frac{-\delta \lambda' \left( v_h \right)}{G \left( t^* \right) + t^* g \left( t^* \right)} \frac{1}{\left[ 1 - F \left( v_h \right) \right]}.$$

With $\frac{\partial v_\gamma}{\partial s} = \frac{\varepsilon - 1}{\gamma [1 - F(v_\gamma)]}$ from (24) and $\frac{\partial (s/\gamma)}{\partial s} = \frac{1 - \varepsilon}{\gamma}$, we then have

$$\begin{aligned} \frac{\partial V^*}{\partial s} &= \left( \beta_h - \beta_l \right) g \left( t^* \right) \frac{-\delta \lambda' \left( v_h \right)}{G \left( t^* \right) + t^* g \left( t^* \right)} \frac{\phi \left( v_\gamma \right)}{\left[ 1 - F \left( v_h \right) \right]} + \frac{\phi' \left( v_\gamma \right) \left( \varepsilon - 1 \right)}{\left[ 1 - F \left( v_\gamma \right) \right]} - \delta \frac{\phi' \left( v_h \right)}{\left[ 1 - F \left( v_h \right) \right]} \\ &\geq \frac{1}{\left[ 1 - F \left( v_h \right) \right]} \left[ \left( \beta_h - \beta_l \right) \frac{-\delta \lambda' \left( v_h \right) \phi \left( v_\gamma \right)}{\frac{G(t^*)}{g(t^*)} + t^*} - \phi' \left( v_\gamma \right) - \delta \phi' \left( v_h \right) \right], \end{aligned} \tag{39}$$

where the inequality holds because $\varepsilon \geq 0$ and $\left[ 1 - F \left( v_\gamma \right) \right] \geq \left[ 1 - F \left( v_h \right) \right]$. When $s \to 0$: $\frac{G(t^*)}{g(t^*)} \to 0$, $v_h \to \bar{v}$, $v_\gamma \to \bar{v}$; $\lambda' \left( \bar{v} \right) < 0$, $\phi \left( v_\gamma \right) \to \bar{v}$; and $\left( \beta_h - \beta_l \right) \frac{-\delta \lambda'(v_h) \phi(v_\gamma)}{\frac{G(t)}{g(t)} + t} \to \infty$. Thus, since $\phi' \left( v \right) = 1 - \lambda' \left( v \right)$ is bounded for any $v$, we have $\frac{\partial V^*}{\partial s} > 0 \quad \text{as} \quad s \to 0$.

Next, from (22),

$$\begin{aligned} \frac{\partial W^*}{\partial s} &= \frac{\partial \gamma}{\partial s} v_\gamma + \gamma \frac{\partial v_\gamma}{\partial s} + \delta \beta_h \frac{\partial v_h}{\partial s} - t^* g \left( t^* \right) \frac{\partial t^*}{\partial s} \\ &= \left[ v_\gamma \left( \beta_h - \beta_l \right) - t \right] g \left( t \right) \frac{\partial t}{\partial s} + \left( \varepsilon - 1 \right) \frac{1}{1 - F \left( v_\gamma \right)} - \delta \frac{1}{1 - F \left( v_h \right)} \\ &= \left[ v_\gamma \left( \beta_h - \beta_l \right) - t^* \right] \frac{-\delta \lambda' \left( v_h \right)}{t^* + \frac{G(t^*)}{g(t^*)}} \frac{1}{1 - F \left( v_h \right)} + \left( \varepsilon - 1 \right) \frac{1}{1 - F \left( v_\gamma \right)} - \delta \frac{1}{1 - F \left( v_h \right)} \\ &> \frac{1}{1 - F \left( v_h \right)} \left\{ \left[ v_\gamma \left( \beta_h - \beta_l \right) - t^* \right] \frac{-\delta \lambda' \left( v_h \right)}{t^* + \frac{G(t^*)}{g(t^*)}} - 1 - \delta \right\}, \end{aligned}$$

where the last inequality is due to $\varepsilon \geq 0$ and $v_\gamma \leq v_h$. When $s \to 0$, $t^* \to 0$, $\frac{G(t^*)}{g(t^*)} \to 0$, $v_\gamma \to \bar{v}$, and hence $[v_\gamma (\beta_h - \beta_l) - t^*] \frac{-\delta\lambda'(v_h)}{t^* + \frac{G(t^*)}{g(t^*)}} \to \infty$. Thus $\frac{\partial W^*}{\partial s} > 0 \quad$ as $\quad s \to 0$.

(ii) First, $\frac{\partial v_h}{\partial s} < 0$, $\lambda'(v) \leq 0$, $\frac{\partial v_\gamma}{\partial s} \leq 0$ if $\varepsilon \leq 1$; and, when $s \to \bar{s}$, $\phi(v_\gamma) = [v_\gamma - \lambda(v_\gamma)] \to 0$. Hence, from (39), if $\varepsilon \leq 1$, $\frac{\partial V^*}{\partial s} < 0 \quad$ as $\quad s \to \bar{s}$.

Next, when $s \to \bar{s}$, $v_\gamma \to v_0$, $t^* \to \bar{t}$, and hence $\frac{\partial W^*}{\partial s} < 0$ if $\bar{t} \geq v_0 (\beta_h - \beta_l)$ and $\varepsilon \leq 1$. ■

**Proof of Proposition 5.** Recall $\frac{\partial \gamma}{\partial t} = (\beta_h - \beta_l) g(t)$ and $\frac{\partial v_\gamma}{\partial \gamma} = \frac{s}{\gamma^2} \frac{1}{1-F(v_\gamma)}$. Thus,

$$\begin{aligned} \frac{\partial W^*}{\partial t} &= \frac{\partial (\gamma v_\gamma)}{\partial \gamma} \frac{\partial \gamma}{\partial t} - t g(t) \\ &= \left[ \left( v_\gamma + \frac{s}{\gamma} \frac{1}{1 - F(v_\gamma)} \right) (\beta_h - \beta_l) - t \right] g(t). \end{aligned} \tag{40}$$

Clearly $\frac{\partial W^*}{\partial t}|_{t=0} > 0$. Moreover, for given $s > 0$, $v_\gamma$ is bounded away from $\bar{v}$. Thus, $\frac{\partial W^*}{\partial t} < 0$ if $t$ is sufficiently high. Hence, there exists $t^o \in (0, \bar{x})$ such that $W^*$ is maximized at $t^o$. Moreover, from (17), $t^*$ increases in $s$ and $t^* \to \bar{t}$ if $s \to \bar{s}$. Therefore, if $t^o < \bar{t}$, there exists a unique $\sigma$ such that $t^* \leq t^o$ when $s \leq \sigma$, and $t^* > t^o$ when $\sigma < s \leq \bar{s}$. ■

**Proof of Lemma 1.** In equilibrium, constraint (28) is binding when $x = t_k$ and thus

$$(1 - \mu) \frac{1}{G(t_k)} \beta_h \lambda(v_h)(1 + \delta) = k + t_k.$$

Hence,

$$\Psi = \beta_h \lambda(v_h)(1 + \delta) - t_k G(t_k),$$

which decreases in $t_k$. Thus, the intermediary optimally sets $(k^*, \tau^*)$ such that the firm with $x = t_\Omega$ is indifferent between being on and off the platform:

$$k^* = (1 - \mu^*) \frac{1}{G(t_\Omega)} \beta_h \frac{1 - F(v_h)}{f(v_h)} (1 + \delta) - t_\Omega.$$

Moreover, substituting $k^*$ into constraint (27), we have

$$\mu^* < t_\Omega G(t_\Omega) \frac{1}{\delta \beta_h} \frac{f(v_h)}{1 - F(v_h)}.$$

Therefore, $\mu^* = 0$ and $k^*$ solve problem (P1) and induce the separating equilibrium, which improves search efficiency in period 1. If additionally $t_\Omega \leq t^*$, then the total investment cost on quality is not higher in the separating equilibrium than in the equilibrium without the intermediary, and hence total welfare must be higher in the former. ■

**Proof of Lemma 2.** Constraint (32) is binding when $x = t_k$, with

$$t_k = (1-\mu)\,\delta \frac{1}{G(t_k)} \beta_h \lambda(v_h)\,. \tag{41}$$

Since RHS of (41) decreases in $t_k$ and $\mu$, it follows that $t_k$ decreases in $\mu$. In equilibrium, (31) is binding. Moreover, from (41),

$$t_k G(t_k) = (1-\mu)\,\delta \beta_h \lambda(v_h)\,.$$

Thus, the intermediary's objective function becomes, for $\gamma = \gamma(t_k)$,

$$\Psi = \gamma(t_k)\,\lambda(v_\gamma) - t_k G(t_k) + \delta \beta_h \lambda(v_h)\,. \tag{42}$$

Since $\frac{\partial v_\gamma}{\partial \gamma} = \frac{1}{[1-F(v_\gamma)]}\frac{s}{\gamma^2}$ and $\frac{\partial \gamma}{\partial t_k} = (\beta_h - \beta_l)\,g(t_k)$, we have

$$\begin{aligned}
\frac{\partial \Psi}{\partial t_k} &= \left(\lambda(v_\gamma) + \gamma \lambda'(v_\gamma)\frac{\partial v_\gamma}{\partial \gamma}\right)\frac{\partial \gamma}{\partial t_k} - G(t_k) - t_k g(t_k) \\
&= \left(\lambda(v_\gamma) - \lambda'(v_\gamma)\frac{s}{\gamma}\frac{1}{1-F(v_\gamma)}\right)(\beta_h - \beta_l)\,g(t_k) - G(t_k) - t_k g(t_k) \\
&= \left[\left(\lambda(v_\gamma) - \lambda'(v_\gamma)\frac{s}{\gamma}\frac{1}{1-F(v_\gamma)}\right)(\beta_h - \beta_l) - t_k\right] g(t_k) - G(t_k)\,.
\end{aligned} \tag{43}$$

Since $\lambda'(v_\gamma) \leq 0$, we have $\frac{\partial \Psi}{\partial t_k}|_{t_k \to 0} > 0$. Also, under (33), $\frac{\partial \Psi}{\partial t_k}|_{t_k \to t^*} < 0$. Therefore, there exists $t_k^* < t^*$ that maximizes $\Psi$, with $\mu^* > 0$. ■

## REFERENCES


Anderson, S. and Renault, R. (1999). “Pricing, Product Diversity, and Search Costs: A Bertrand-Chamberlin-Diamond Model.” *RAND Journal of Economics,* Vol. 30 , pp. 719–735.

Armstrong, M., Vickers, J., and Zhou, J. (2009). "Prominence and Consumer Search." *RAND Journal of Economics*, Vol. 40, No. 2, pp. 209–233.

Athey, S. and Ellison, G. (2011). “Position Auctions with Consumer Search.” *Quarterly Journal of Economics*, Vol. 126, pp. 1213–1270.

Bagwell, K., and G. Ramey (1994): “Coordination Economies, Advertising, and Search Behavior in Retail Markets,” *American Economic Review*, 84(3), 498–517.

Bar-Isaac, H, Caruana, G., and Cuñat, V. (2012). “Search, Design, and Market Structure.” *American Economic Review*, Vol. 102(2), pp. 1140-1160.

Chen, Y. and He, C. (2011). “Paid Placement: Advertising and Search on the Internet.” *Economic Journal,* Vol.121, pp. F309-28.

Chen, Y. and T. Zhang (2011). “Equilibrium Price Dispersion with Heterogeneous Searchers.” *International Journal of Industrial Organization*, Vol. 29, pp. 645-654.

Chen, Y. and T. Zhang (2018). “Entry and Welfare in Search Markets.” *Economic Journal,* Vol. 128 (608), 55-88.

Choi, J.P. (1998). “Brand Extension as Informational Leverage.” *Review of Economic Studies*, Vol. 65 (4), pp. 655-669.

Choi, M., Y. Dai and K. Kim (2018). “Consumer Search and Price Competition.” *Econometrica*, Vol. 86 (4), pp. 1257–1281.

de Cornière, A. and Taylor, G. (2014) “Integration and Search Engine Bias.” *RAND Journal of Economics*, Vol. 45, pp. 576–597.

Eliaz, K. and Spiegler, R. (2011). “A Simple Model of Search Engine Pricing.” *Economic Journal,* Vol.121, pp F329-39.

Fishman, A. and N. Levy (2015). “Search costs and investment in quality.” *Journal of Industrial Economics*, Vol. 63 (4), pp. 625-641.

Grossman, S. and J. Stiglitz (1980). “On the impossibility of Informationally Efficienct Markets.” *American Economic Review*, 70 (3), pp. 393-408.

Haan, M. A. and Moraga-González, J. L. (2011). “Advertising for Attention in a Consumer Search Model.” *Economic Journal,* Vol. 121, pp. 552–579.

Janssen, M. and T. Ke (2020). “Searching for service.” *American Economic Journal: Microeconomics,* 12 (1), pp. 188–219.

Moraga-González, J. L, and Y. Sun (2018). “Consumer Search Costs and the Provision of Service Quality.” working paper.

Moraga-González, J. L, and Y. Sun (2019). “Product Quality and Consumer Search.” working paper.

Moraga-González, J. L, Z. Sandor, and M. Wildenbeest (2017). “Prices and Heterogeneous Search Costs.” *RAND Journal of Economics,* Vol. 48, pp. 125-146.

Rhodes, A. (2011). "Can Prominence Matter Even in an Almost Frictionless Market?," *Economic Journal*, 121: F297–F308.

Riordan, M. H. (1986). "Monopolistic Competition with Experience Goods." *Quarterly Journal of Economics*, 101(2): pp. 265–279.

Shapiro, C. (1982). "Consumer Information, Product Quality, and Seller Reputation." *Bell Journal of Economics*, Vol. 13, pp. 20–35.

Shapiro, C. (1983). "Premiums for High Quality Products as Returns to Reputations." *Quarterly Journal of Economics*, 98: 659-680.

Stigler, G. (1961). "The Economics of Information." *Journal of Political Economy*, Vol. 69, pp. 213-225.

Taylor, G. (2017). "Raising Search Costs to Deter Window Shopping Can Increase Profits and Welfare." *RAND Journal of Economics,* Vol. 48, pp. 387-408.

Wernerfelt, B., (1988), "Umbrella Branding as a Signal of New Product Quality: An Example of Signaling by Posting a Bond", *RAND Journal of Economics*, 19: 458-66.

White, A. (2013). "Search Engines: Left Side Quality Versus Right Side Profits." *International Journal of Industrial Organization*, 31: 690-701.

Wolinsky, A. (1986). "True Monopolistic Competition as a Result of Imperfect Information." *Quarterly Journal of Economics,* Vol. 101(3), pp. 493–511.

Wolinsky, A. (2005). "Procurement via Sequential Search." *Journal of Political Economy,* Vol. 113(4), pp. 785–810.

Zhou, J. (2014). "Multiproduct search and the joint search effect." *American Economic Review*, 104: 2918-39.