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# Communicating Attribute Importance Under Competition

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**Abstract.** When consumers encounter unfamiliar products, they often face difficulty in understanding which attributes are crucial, leading to challenges in product comparison and potential diminished interest in the category. This study examines how firms strategically communicate the importance of product attributes in a competitive environment. Despite consumer awareness of attributes and their levels, uncertainty regarding their relative importance remains. We analyze a situation where two firms each receive a noisy signal about the true importance of the attribute and communicate to consumers through cheap-talk messages. Following these communications, consumers decide whether to incur a cost to explore the category by visiting stores. Our findings reveal a truthful equilibrium in which firms report their received signals honestly. In this equilibrium, firms can credibly convey information about the most important attribute if their messages align, thus encouraging store visits and purchases. Interestingly, firms may still find it advantageous to truthfully highlight an attribute, even if it does not align with their competitive advantage. Moreover, we show that without competition (i.e., a single firm communicating), this truthful equilibrium does not exist. Thus, the presence of competition enables the credible communication of information about attribute importance, benefiting both firms by enhancing consumer engagement with the product category.

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## 1. Introduction

In today's market, consumers often find it overwhelming to choose from the extensive selection of products available. The challenge lies not just in the sheer number of options but also in the complexity of comparing these products, each with its unique set of distinct attributes. The complexity of comparing these diverse products makes it hard for consumers to easily identify which product best suits their needs. The advent of digital technologies and online platforms has particularly alleviated this challenge by providing consumers with access to details about product attributes. However, choosing between products where no single option clearly outperforms the others remains a challenge. This complexity in the process of comparing products can cause decision fatigue (Ursu et al. 2023), where the search cost, in terms of time and cognitive load, becomes so high that some consumers choose to disengage from the purchasing process altogether, ultimately opting out of the product category. The situation is compounded in categories featuring new or advanced technologies. Novice consumers, especially those unfamiliar with the category, struggle to understand which attribute is more essential in the product category (Dzyabura and Hauser 2019).

Consider Alex, a first-time buyer in the electric vehicle (EV) category. Alex is initially thrilled at the prospect of buying an electric vehicle but becomes increasingly frustrated after visiting two dealerships. The first Lucid dealer emphasizes its superior battery range and its luxury comfort, whereas the second dealer for Hyundai IONIQ 5 insists that fast charging capabilities are what truly matter.[1] This conflicting advice leaves Alex so confused and overwhelmed that they start to question the practicality of switching to an EV at all. Concerned about making the wrong choice, Alex decides to postpone the purchase indefinitely, sticking with the manufacturers' gas-powered vehicle while lamenting the complexity of the EV market. A similar situation occurs for Jordan, who is a homeowner interested in upgrading to smart home technology. He decided to visit a local Best Buy store to explore the available options firsthand. There, a Google Nest representative highlighted device compatibility, whereas an Asus ZenWiFi representative focused on superior security features. The contrasting pitches left Jordan unsure which feature was more crucial—compatibility or security.[2] Despite the initial excitement and the visit to gather information, the conflicting advice led to skepticism about the true benefits of smart home technology. Overwhelmed by the complexity and perceived tradeoffs, Jordan's skepticism leads to a decision to avoid investing in smart home devices altogether, as Jordan perceives the category as too complicated and fraught with tradeoffs.

Without understanding which attributes are most critical and how much weight to allocate across different attributes, detailed attribute information about the products in the category may not be sufficient for making comparisons and, ultimately, purchasing decisions. This highlights the need for firms to streamline the decision-making process by clearly communicating the importance of key product attributes. To prevent consumers from disengaging from the product category, it is in the common interest of the firms in the category to provide consumers with guidance on the significance of key attributes, helping to simplify decision making and potentially increasing the total demand for the product category.

In practice, we have seen several examples where a specific product attribute becomes a focal point in a category, especially new and advanced technologies that are often unfamiliar to them, significantly influencing consumer behavior. For example, in the early era of personal desktop computers, more than 2,700 PC makers all singled out their microprocessors among other components in their advertising campaigns, notably beginning with the Intel Inside campaign in 1991. This collective emphasis enabled consumers to anchor their decision-making process on the microprocessor, significantly contributing to the substantial growth of the PC market (Moon and Darwall 2002). Similarly, certain attributes gain prominence when multiple firms collectively emphasize their importance. For instance, outdoor apparel brands like The North Face and Patagonia highlight waterproof and breathable fabrics, such as Gore-Tex, guiding consumers to prioritize fabric technology in their decision making. Additionally, wearable technology companies, including Fitbit and Apple, accentuate health monitoring capabilities. These strategies simplify consumer choices by emphasizing a single crucial attribute, thereby assisting consumers in navigating their purchasing decisions.

However, not all companies or sales agents will highlight the same feature because of their unique competitive advantages. Taking real estate as an instance, agents significantly influence buyer decisions. When parents search for a new home, prioritizing aspects like school districts and outdoor spaces, agents might direct their attention to the luxurious aspects of a property not located in a preferred school zone, such as a modern kitchen or lavish bathrooms. This demonstrates how sales strategies can influence on defining what attributes are considered more important, potentially shifting the buyers' focus from their initial priorities. In the auto industry, car dealers might highlight a car's safety features over its battery efficiency, influencing buyers' perceptions of what is truly important. In consumer electronics, a retailer may promote a phone's camera quality while downplaying its short battery life, potentially obscuring drawbacks that are important for the consumer.

The question of credibility in firm communication arises naturally in these interactions, especially when the importance and prioritization of product attributes are not clearly understood. Simply providing detailed information on product features may be insufficient for consumers to make effective comparisons and informed decisions. Companies or salespeople might strategically highlight certain features to present their products favorably. Despite these incentives and potential for mixed messages because of these different focuses, truthful communication can prevail when firms collectively emphasize certain key attributes. This consensus helps consumers, particularly those new to the category, identify and prioritize the most significant attributes in the category, thus facilitating more informed shopping decisions.

This study examines how strategic communication by firms in competitive markets can credibly inform consumers about the importance of product attributes and influence their decision making. We identify the conditions under which an attribute becomes prominent, even in markets where competing firms have advantages in different attributes. We use a two-sender cheap-talk game, where firms send messages highlighting one of two attributes based on a noisy signal about which attribute is likely more important. A representative consumer, initially uncertain about the attribute's importance, receives these messages, which may either align or conflict on the attribute's importance, and forms beliefs about the relative importance of the attributes. Each firm, having a competitive advantage in a distinct attribute, aims to persuade consumers of the importance of the attribute it highlights. The consumer, with rational expectations about the firms' strategies in equilibrium, decides whether to further engage with the product category by paying a cost to acquire more information about both products or to disengage at no cost. If the consumer chooses to engage by paying the cost, the consumer learns more about the unique value of each product beyond the main attributes, reducing uncertainty about their true match values. After partially resolving the consumer's uncertainty about the attribute importance, the consumer makes an informed decision on whether and which product to buy.

We show that the consumer's uncertainty about the relative importance of attributes can be a critical barrier hindering the consumer's further engagement with a product category. Firms can benefit from effectively conveying credible information about attribute importance. Moreover, we identify a truthful equilibrium in which firms, despite their self-interest, truthfully convey the noisy signal about attribute importance, even when it may not align with their competitive advantage (i.e., a firm has a competitive disadvantage in that attribute). In this equilibrium, when both firms' messages align, their collective messages can credibly convey information about the more important attribute, thereby encouraging store visits and purchase. Interestingly, firms may still find it profitable to truthfully emphasize an attribute, even if it does not align with their competitive edge.

Should firms diverge in their communications, highlighting only their own superior attributes, consumers are likely to encounter conflicting messages. This inconsistency fails to resolve consumer uncertainty about the relative importance of attributes, leading to consumer confusion. This confusion could prompt consumers to decide against investing time and resources to further explore the products, choosing instead to disengage with the category entirely. Such a scenario is detrimental to both firms, as it prevents them from capitalizing on potential consumer interest and demand, negatively impacting the overall demand within the category.

The impact of competition on communication strategies between firms and consumers is critical, especially regarding attribute importance. Contrary to the lay belief that competition might incentivize firms to highlight only their strongest attributes at the expense of truthful reporting, our analysis reveals that a monopoly on communication actually undermines credibility. Specifically, in situations where only one firm communicates with consumers, the absence of competition undermines the credibility of communication message, eliminating the possibility of establishing a truthful equilibrium, leading to a breakdown in the credible communication of attribute importance. By contrast, competition encourages credible communication, thereby enhancing consumer engagement by reliably informing consumers about product attributes. This demonstrates that competition facilitates rather than impedes effective firm-consumer communication, ultimately benefiting all parties involved by enhancing consumer engagement within the product category. We further show that these results are robust to settings with endogenous pricing and different communication structures (simultaneous versus sequential). Under sequential communication, where the second firm observes the first firm's signal before sending its own message, truthful equilibrium unravels because the observability of rivals' signals generates strong incentives for firms to coordinate rather than report truthfully. Therefore, it is precisely the unobservability of rivals' private signals under simultaneous communication that sustains truthful reporting. The robustness of our findings reinforces the generality of competition as a mechanism to maintain credible firm-to-consumer communication.

The remainder of the paper is organized as follows. Section 2 reviews related literature. Section 3 introduces the model, including firm strategies and equilibrium definitions. Section 4 presents equilibrium analysis and key findings. Section 5 tests the robustness of our main results by incorporating endogenous pricing, sequential firm communications, and sequential consumer search. Section 6 concludes. Technical proofs are in the appendix and the Online Appendix.

## 2. Related Literature

This paper relates to several streams of research in marketing and economics. First, it contributes to the literature on coopetition (see Meena et al. (2023) for a review) and the strategic coexistence of competition and cooperation among firms (Brandenburger and Nalebuff 1996). Prior research examines coopetition in strategic alliances (Amaldoss et al. 2000, Luo et al. 2007), licensing (Inkpen 1998), and innovation sharing (Lu and Shin 2018), highlighting how joint communication about products can reduce consumer search costs. Our contribution lies in showing how competing firms achieve credibility in communication through mutual discipline, despite the cheap-talk nature of their messages (Farrell and Rabin 1996).

Thus, our work naturally extends the literature on strategic cheap-talk communication (Crawford and Sobel 1982) to firm–consumer interactions. Previous studies identified mechanisms for message credibility in single-sender scenarios, such as selling costs disciplining price claims (Shin 2005) and seller-cost announcements guiding buyer search (Guo 2022). Other work has examined credibility of nonprice attributes through selective emphasis (Chakraborty and Harbaugh 2014), targeted communication (Gardete 2013), limited sender information (Gardete and Bart 2018), prepurchase consumer learning (Gardete and Guo 2021), and incentive-compatible contracts, such as revenue sharing (Li 2005). In contrast, our duopoly setting emphasizes how interactions among multiple communicators discipline strategic communication without resorting to imposed off-equilibrium beliefs, contributing directly to multisender cheap-talk literature (Krishna and Morgan 2001, Battaglini 2002, Ambrus and Takahashi 2008). Our mechanism also complements research on reputational effects in strategic communication. Wernerfelt (1994) shows reputational concerns can sustain honest sales communication, even for a monopolist, in repeated interactions. By contrast, our analysis considers a one-shot setting where reputation effects (Kreps and Wilson 1982, Jullien and Park 2014) are absent, and truth-telling does not naturally arise. Instead, credibility emerges from competition, as firms discipline each other's messages. This scenario aligns closely with real-world settings characterized by infrequent interactions or one-time consumer engagements, limiting the influence of reputational concerns.

Additionally, our study complements research on attribute salience and consumer decision making. Prior work highlights how attribute prominence influences consumer utility and attention (Bordalo et al. 2013, Zhu and Dukes 2017), whereas correlated uncertainties guide consumer search (Ke and Lin 2020). Our analysis differs by explicitly modeling how attribute importance emerges endogenously from strategic firm communication, offering a microfoundation for attribute salience. This approach is particularly relevant to the literature on consumer information overload, where excessive choices or information can lead to decision avoidance and dissatisfaction (Jacoby 1984, Iyengar and Lepper 2000, Kuksov and Villas-Boas 2010, Branco et al. 2016). Previous studies examine firm responses to overload through pricing and assortment strategies (Wathieu and Bertini 2007, Guo and Zhang 2012, Li et al. 2019, Shin and Wang 2024). We add to this literature by demonstrating how credible attribute-focused communication helps consumers navigate information overload, thereby enhancing category engagement.

Finally, our analysis links to the broader literature on the competitive foundations of credibility and firm profitability. Prior studies identify competition as beneficial for alleviating double marginalization (Harutyunyan and Jiang 2019), reducing communication costs (Lu and Shin 2018), and softening price competition (Shin 2007). We highlight a complementary mechanism: Competition sustains truthful strategic communication. Specifically, we demonstrate that monopolizing the communication channel undermines credibility because a sole communicator cannot credibly commit to truthfulness, reflecting dynamics seen in asymmetric equilibria. Thus, competition plays a critical disciplinary role, ensuring credibility in strategic firm disclosure.

## 3. Model

We consider a market with two firms, 1 and 2, and a single representative consumer. Each firm offers a product at an exogenous symmetric price $p$, which is common knowledge to the firms and consumer. In Section 5.1, we analyze a model where the firms set their prices endogenously. The consumer has a choice of purchasing one of the products or none at all, where the utility of no purchase is normalized to zero. The total consumption value derived from purchasing product $i$ can be expressed as

$$V_i = U_i + \nu_i - p, \tag{1}$$

where $U_i$ denotes the main utility from the product's primary attributes. This utility component is influenced by the product's essential features, such as battery range and fast charging capabilities in EVs or device compatibility and security coverage in smart home technologies. These attributes are crucial for the consumer's overall evaluation of each product and final purchasing decision. On the other hand, $\nu_i$ represents the idiosyncratic value component of the total consumption value, stemming from secondary attributes like design aesthetics. This element reflects the consumer's unique and personal preferences beyond the primary attributes.

The main utility component $U_i$ for product $i$ is defined as a function of the attribute importance weight $\omega$ as follows:

$$U_i(\omega) = \omega \cdot \alpha_i + (1 - \omega) \cdot \beta_i, \tag{2}$$

where $\alpha_i, \beta_i \in \{u_L, u_H\}$ represent the vertical levels of two key attributes, with $u_H > u_L > 0$. For instance, in the context of EVs, the $\alpha$-attribute could relate to battery range, available as long ($u_H$) or short ($u_L$), whereas the $\beta$-attribute might refer to charging speed, categorized as fast ($u_H$) or slow ($u_L$). The importance weight $\omega$ determines the true relative significance of the first attribute in the product category. Here, we assume a market-wide consensus on the weight $\omega$.[3]

The model posits two possible states for the attribute importance weight: high ($\omega_H$) or low ($\omega_L$), with $0 \le \omega_L < 1/2 < \omega_H \le 1$. Here, $\omega$ indicates the importance of the first attribute ($\alpha$). The state can be high ($\omega = \omega_H$), making the first attribute more important, or low ($\omega = \omega_L$), indicating the second attribute is more important. The true state of $\omega$ is drawn from a prior distribution such that $\Pr(\omega = \omega_H) = \mu_0 \in (0, 1)$. Moreover, without loss of generality, we designate firm 1 as having its strength in the first attribute ($\alpha_1 = u_H$) and a weakness in the second attribute ($\beta_1 = u_L$). This means that for a given price $p$, firm 1 offers higher utility to consumers when $\omega = \omega_H$ compared with when $\omega_L$: $U_1(\omega_H) > U_1(\omega_L)$. On the other hand, firm 2 possesses its competitive advantage in the attribute where firm 1 is weaker such that $\alpha_2 = u_L$ and $\beta_2 = u_H$. Thus, for a given $p_2$, firm 2 offers higher utility in the state $\omega_L$ than in the state $\omega_H$: $U_2(\omega_L) > U_2(\omega_H)$.

Additionally, we assume that the sum of the attribute importance weights equates to unity, $\omega_H + \omega_L = 1$. This ensures parity in the utility values each firm delivers in their favorable states, making $U_1(\omega_H) = U_2(\omega_L)$ and $U_1(\omega_L) = U_2(\omega_H)$.[4] Such an arrangement posits that, although firms 1 and 2 exhibit distinct competitive edges, primarily in the first and second attributes, respectively, their offerings are perceived equally by consumers when evaluating the products in their optimal states. Consequently, this setup allows us to focus on the symmetric competition between two differentiated firms. Therefore, we will employ the following notation:

$$\begin{aligned}\overline{U} &:= U_1(\omega_H) = U_2(\omega_L) = \omega_H \cdot u_H + \omega_L \cdot u_L \\ \underline{U} &:= U_1(\omega_L) = U_2(\omega_H) = \omega_L \cdot u_H + \omega_H \cdot u_L.\end{aligned} \quad (3)$$

Each firm independently receives a noisy signal $s_i \in \{H, L\}$ about the true state of $\omega$, where the level of noisiness is captured by $\gamma \in (0, 1/2)$ such that $\Pr(s_i = H|\omega = \omega_H) = \Pr(s_i = L|\omega = \omega_L) = 1 - \gamma$.[5] Although the two firms might receive different signals about the true state of $\omega$, the condition $\gamma < 1/2$ ensures that these signals are positively correlated. However, despite the correlation, conditional on the true state of $\omega$, the signals $s_1$ and $s_2$ are independent events.

Upon receiving their respective noisy signals $s_i \in \{H, L\}$, each firm communicates a message $m_i$ to the consumer, emphasizing one of the two attributes. Messaging about the first attribute corresponds to reporting that $\omega = \omega_H$, whereas emphasizing the second attribute corresponds to reporting that $\omega = \omega_L$. Consequently, without loss of generality, the firm's message space can be represented by $m_i \in \{h, l\}$, employing lowercase letters for messages ($m_i$) to differentiate them from the uppercase letters used for signals ($s_i$). The consumer only knows the prior distribution from which $\omega$ is drawn, and the consumer makes inferences about $\omega$ after receiving messages from the two firms. The noisy signals that the firms receive about the true state introduce information asymmetry between the firms and the consumer about the true state $\omega$. This initial information asymmetry reflects the potential advantage firms have because of their market research efforts, including product testing, which can reveal deeper insights into product attributes and their market valuation (Dzyabura and Hauser 2019, Shin and Yu 2021).

The information asymmetry also highlights the consumer's challenge in determining the true relative importance of product attributes without direct experience. For instance, a buyer of an EV may only realize the significance of battery range versus fast charging capabilities after experiencing the practical implications of each during their daily use. Similarly, a consumer investing in smart home technology might only understand the relative importance of device compatibility versus security features after encountering various scenarios in their home usage. These scenarios underscore the gap between the attributes marketed by the firms and the consumer's eventual realization of the importance of attributes through usage.

The additional term $\nu_i$ represents an idiosyncratic shock to the consumer's utility from product $i$ capturing the utility from factors beyond the main attributes described by $U_i$, such as vehicle design, color options for an EV, or the size of a smart home device to fit in a specific space in the house. This term follows a uniform distribution $U[-1, 1]$, which is common knowledge to all market participants. Initially, the consumer is unaware of the exact values of $\nu_i$s but can discover these by visiting a retailer that showcases both products, which requires a search cost $c > 0$.[6] Thus, this idiosyncratic preference can be fully resolved if the consumer visits the store incurring this cost. Although such a visit can reveal specific details such as the exact fit of a smart home device or the color options available for an EV, they do not clarify the consumer's uncertainty about the importance of the attribute $\omega$ as understanding its importance typically comes from the postpurchase experience. Moreover, without incurring the search cost $c > 0$, the consumer cannot engage further with the product category.[7] As a result, the consumer leaves the market with an outside option value set to zero.

Because the consumer must incur a positive search cost to visit a retailer for additional product information, reducing the consumer's uncertainty about the attribute importance ($\omega$) through the firms' announcements becomes crucial. If this uncertainty remains, the consumer is less likely to visit the retailer, as the cost may not be worth it just to learn about the $\nu_i$'s alone.[8]

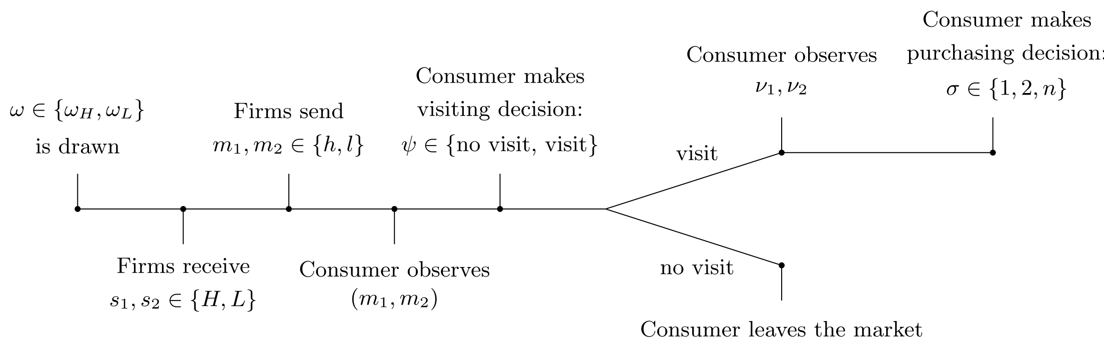
The timeline of the game is as follows: The relative importance parameter $\omega \in \{\omega_H, \omega_L\}$ is drawn from the prior distribution. Each firm privately receives an independent noisy signal $s_i \in \{H, L\}$ about the true state $\omega$. The firms simultaneously send a message $m_1, m_2 \in \{h, l\}$ to the consumer. Then, the consumer observes $(m_1, m_2)$ and decides whether to pay the cost $c$ to observe $(\nu_1, \nu_2)$. Finally, the consumer decides whether to purchase either product 1 or 2 or neither. The sequence of events is depicted in Figure 1.

### 3.1. Strategies, Beliefs, and Equilibria

The firm $i$'s payoff is $p$ if the consumer purchases product $i$ and zero otherwise. Each firm's (pure) strategy is a mapping from the firm's private signal about $\omega$ to the message of its choice, $m_i : \{H, L\} \to \{h, l\}$. Upon receiving the messages $m_1$ and $m_2$, the consumer updates the consumer's beliefs about the true state $\omega$. Specifically, the consumer assigns a probability that $\omega = \omega_H$, denoted by $\hat{\mu}(m_1, m_2) = \Pr(\omega = \omega_H|m_1, m_2)$, indicating the consumer's updated belief that the first attribute, $\alpha$, is more important after considering the messages from both firms.[9]

Based on these beliefs, the consumer decides whether to incur the cost $c > 0$ and observe both $\nu_i$s. The consumer's strategy is thus a mapping from her beliefs to her visit decision $\psi : [0, 1] \to \{\text{visit}, \text{no visit}\}$. If the consumer chooses "visit," the consumer incurs the cost to learn about $(\nu_1, \nu_2)$; if the consumer chooses "no visit,"

**Figure 1.** Timeline




the consumer avoids the cost but remains unaware of $(\nu_1, \nu_2)$. The consumer's purchasing strategy after observing $(\nu_1, \nu_2)$ is a function, $\sigma : [0,1] \times [0,1] \times [0,1] \to \{1, 2, n\}$, denoted by $\sigma(\hat{\mu}, \nu_1, \nu_2)$, where 1 and 2 indicate purchasing product 1 or 2, respectively, and $n$ means that the consumer does not purchase any product. Our solution concept is the perfect Bayesian equilibrium (PBE), which we define more formally below.

**Definition 1** (Perfect Bayesian Equilibrium). A PBE is a triplet consisting of firms' strategy $(m_1^*, m_2^*)$, a consumer's strategy $(\psi^*, \sigma^*)$, and a consumer's belief $\hat{\mu}^*(m_1^*, m_2^*)$ satisfying

1. Firms choose $m_i^*(\omega)$ for each $\omega \in \{\omega_H, \omega_L\}$, to maximize firm $i$'s expected payoff given $m_j^*$, $\psi^*$, $\sigma^*$, and $\hat{\mu}^*$;
2. The consumer chooses $\psi^*(\hat{\mu}^*)$ and $\sigma^*(\hat{\mu}^*, \nu_1, \nu_2)$ to maximize the consumer's expected utility, given $m_1^*$, $m_2^*$, $\sigma^*$, and $\hat{\mu}^*$, and given $m_1^*$, $m_2^*$, $\psi^*$, and $\hat{\mu}^*$, respectively; and
3. The belief $\hat{\mu}^*(m_1, m_2)$ follows Bayes' rule for each $m_1, m_2 \in \{h, l\}$, whenever applicable.

Moreover, we focus on the truthful equilibrium in which both firms truthfully announce the noisy signals they received. In this equilibrium, the true state can be communicated to the consumer through the firms' messages. Also, we strict our focus on equilibrium where the consumer makes a purchase with a positive probability. Given the level of noisiness $\gamma > 0$, firms may receive a signal different from the true state $\omega$, implying that consumers are unable to detect any firm's deviation from the equilibrium strategy. Consequently, there is no off-the equilibrium path. The truthful equilibrium is defined as follows.

**Definition 2** (Truthful Equilibrium). A truthful equilibrium is a PBE, where

1. Firms report their received noisy signal truthfully, that is, $m_i(s_i) = s_i$, and
2. The consumer purchases either product 1 or product 2 with a strictly positive probability for each $s_i \in \{H, L\}$.

The truthful equilibrium is a separating equilibrium because each firm conveys distinct messages based on their signal $s_i$. As a result, one can expect the most information transmission in the truthful equilibrium.[10] However, other types of equilibria, such as pooling equilibria (in which each firm adopts a pooling strategy of sending the same message regardless of its private signal) or an asymmetric equilibrium (in which one firm pooling and the other separating), may exist. Section 4.3 analyzes these equilibria, and Section 5.2 the mixed equilibria.

## 4. Analysis

### 4.1. Consumer Decisions

**4.1.1. Consumer's Purchasing Decision.** We solve the game backward to analyze consumer behavior. Consider a consumer who has visited the stores and observed the idiosyncratic values $(\nu_1, \nu_2)$ of both products. The consumer's posterior beliefs about the attribute importance given the firms' messages $(m_1, m_2)$ are $\hat{\mu} = \Pr[\omega = \omega_H | (m_1, m_2)]$. The consumer's expected total value from product $i$ is

$$\mathbb{E}[V_i] = \mathbb{E}U_i(\hat{\mu}) + \nu_i - p, \tag{4}$$

where $\mathbb{E}U_i(\hat{\mu})$ represents the expected utility from the primary attributes and $\nu_i$:

$$\mathbb{E}U_1(\hat{\mu}) := \hat{\mu} \cdot \overline{U} + (1 - \hat{\mu}) \cdot \underline{U},$$
$$\mathbb{E}U_2(\hat{\mu}) := \hat{\mu} \cdot \underline{U} + (1 - \hat{\mu}) \cdot \overline{U}. \tag{5}$$

The consumer's purchasing decision is based on this expected utility from the main attributes, adjusted by their belief $\hat{\mu}$. After visiting the retailer and observing the idiosyncratic values $(\nu_1, \nu_2)$, the consumer weighs these values against the expected utility from the primary attributes, taking into account the product's price. Specifically, the consumer buys product 1 if the expected value $\mathbb{E}[V_1(\nu_1; \hat{\mu})] = \mathbb{E}U_1(\hat{\mu}) + \nu_1 - p$ is greater than both the outside option (value at zero) and the expected value of product 2: $\mathbb{E}[V_2(\nu_2; \hat{\mu})] = \mathbb{E}U_2(\hat{\mu}) + \nu_2 - p$. That is,

$$\mathbb{E}[V_1(\nu_1; \hat{\mu})] > \max\{0, \mathbb{E}[V_2(\nu_2; \hat{\mu})]\}. \tag{6}$$

Similarly, the consumer buys product 2 if $\mathbb{E}[V_2(\nu_2; \hat{\mu})] > \max\{0, \mathbb{E}[V_1(\nu_1; \hat{\mu})]\}$. If $0 > \max\{\mathbb{E}[V_1(\nu_1; \hat{\mu})], \mathbb{E}[V_2$

$(\nu_2;\hat{\mu})]\}$, the consumer chooses not to purchase, represented by the "$n$" region in Figure 2.

Figure 2 shows the consumer's purchase regions based on $\hat{\mu}$. When $\hat{\mu}$ is higher, indicating greater expected utility from product 1's primary attributes, the area where the consumer prefers product 1 expands (Figure 2(a)). Conversely, a lower $\hat{\mu}$, suggesting a preference for product 2's primary attributes, increases the purchase area for product 2 (Figure 2(b)). Figure 2 illustrates how updated consumer beliefs, $\hat{\mu}$, influence purchasing decisions. Firm communication plays a crucial role in how consumers update these beliefs, ultimately impacting whether a product is adopted or avoided in the market.

**4.1.2. Consumer's Search Decision.** Anticipating the aforementioned purchasing rules, the consumer decides whether to visit the stores given the prior beliefs about the $\nu_i$s. The consumer's expected gain from visiting the store (i.e., $\psi(\hat{\mu})$ = visit) with a cost $c$ is

$$W(\hat{\mu}) := \frac{1}{4}\int_{-1}^{1}\int_{-1}^{1}\max\{\mathbb{E}U_1(\hat{\mu}) + \nu_1 - p, \mathbb{E}U_2(\hat{\mu}) + \nu_2 - p, 0\}d\nu_1 d\nu_2, \tag{7}$$

where the factor of 1/4 is because of the probability density function (or, pdf) 1/2, of the uniform distribution from which each $\nu_i$ is drawn.

The consumer chooses to incur a cost $c$ in order to further engage with the product category by visiting the stores if and only if $W(\hat{\mu}) - c$ is greater than the consumer's expected payoff from not visiting the stores, which is zero, that is, $W(\hat{\mu}) - c > 0$.[11] Thus, the expected gain from visiting, $W(\hat{\mu})$, determines the consumer's decision to either engage further with the product category by incurring cost $c$, or opt out.

Before we establish an important property of $W(\hat{\mu})$ relative to the consumer's posterior beliefs about the attribute importance, we restrict the range of price so that the consumer's visit decision is nontrivial. That is, the subsequent analysis assumes that

$$\underline{U} - 1 < p < \underline{U} + 1, \qquad \overline{U} - 1 < p < \overline{U} + 1. \tag{8}$$

Note that Assumption (8) implies that $\overline{U} - \underline{U} < 2$.

If the price is so high that $p > \overline{U} + 1$, the consumer would never visit the stores because even the maximum $\nu_i = 1$ would not be sufficient to convince the consumer to buy the product. On the other hand, if the price is so low that $p$ falls below $\underline{U} - 1$, the consumer would purchase a product regardless of a store visit, because even the lowest $\nu_i = -1$ would not prevent the consumer from making a purchase. Thus, we focus on scenarios where the price is in the intermediate range such that the consumer's visit decision is not trivial.

Under this assumption, we characterize the consumer's value function $W(\hat{\mu})$ with the following lemma that reveals its simple yet robust characteristics.

**Lemma 1.** *The consumer's expected payoff from visiting the stores* $W(\cdot)$ *is symmetric about* $\hat{\mu} = 1/2$. *Specifically,* $W(\cdot)$ *strictly decreases within the range* $0 \le \hat{\mu} < 1/2$ *and strictly increases within* $1/2 < \hat{\mu} \le 1$.

The symmetry of $W(\cdot)$ around $\hat{\mu} = 1/2$ is because of the symmetry between the two firms, as illustrated in Figure 3. A more general result is that $W(\cdot)$ has a $U$-shaped curve, which is because the two firms have distinct competitive advantages, leading to a negative correlation between the consumer's utilities from the two firms on the primary attributes.[12] This implies that the consumer's expected value from visiting the store decreases when there is greater uncertainty about the true state (i.e., $\hat{\mu}$ is in an intermediate range). Also, as the consumer's uncertainty decreases (that is, $\hat{\mu}$ moves to either end of the interval [0, 1]), the expected value from visiting increases. Essentially, the more informed the consumer is about the importance of the attribute $\omega$, the greater the benefit of evaluating the idiosyncratic values $\nu_i$s during a store visit. If the uncertainty about $\omega$

**Figure 2.** Consumer Purchasing Decision

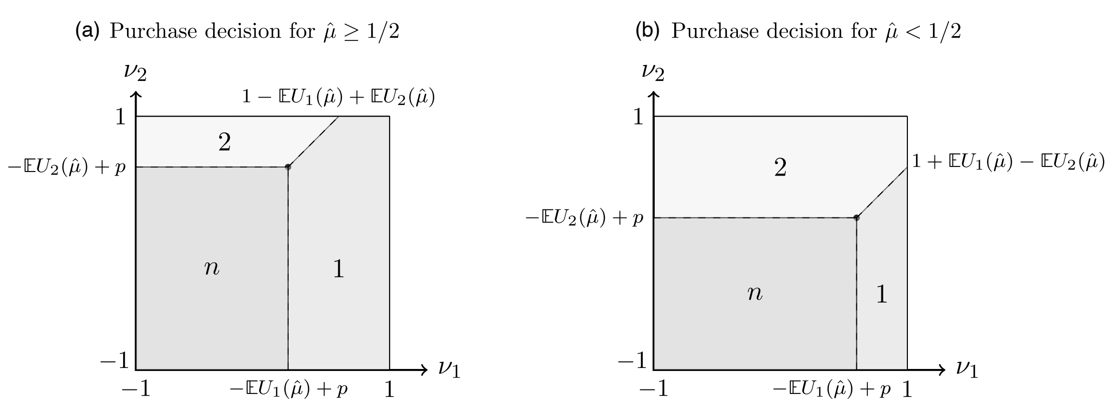
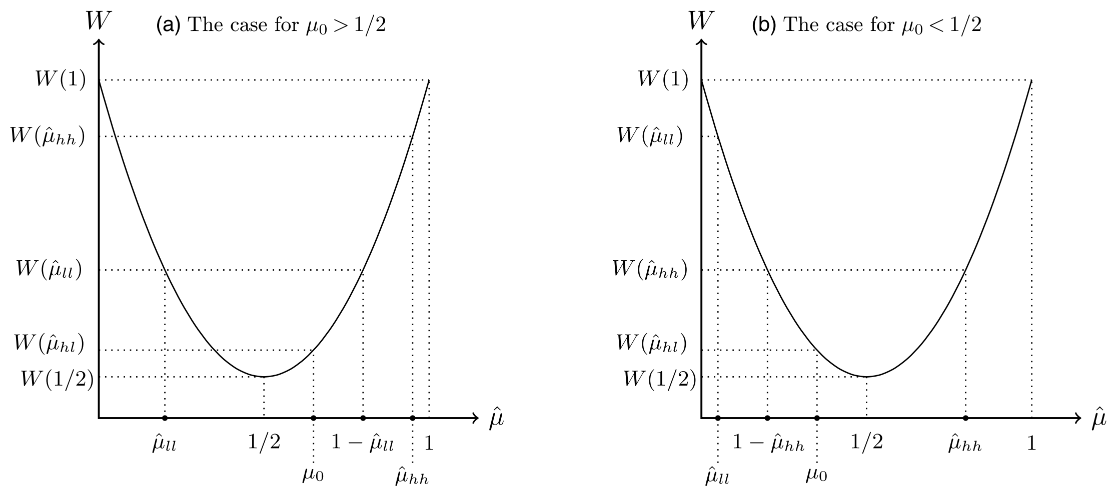


**Figure 3.** Expected Gain for Visiting the Stores: $W(\hat{\mu})$




persists after observing the $v_i$s, the consumer has to make a purchasing decision with considerable uncertainty about $\omega$. Consequently, the consumer's posterior belief about $\omega$ significantly influences the willingness to further explore the product category.

**4.1.3. Belief Updating.** Upon observing the firms' messages $(m_1, m_2)$, the consumer updates beliefs using Bayes' rule. The consumer encounters four possible message combinations, namely $(m_1, m_2) \in \{h, l\} \times \{h, l\}$. The consumer's posterior beliefs, $\Pr(\omega = \omega_H | (m_1, m_2)) = \hat{\mu}_{m_1 m_2}$, are determined by the consumer's prior belief, signal noisiness, and the communication strategy of each firm. More specifically,

$$\hat{\mu}_{m_1 m_2} = \frac{\Pr[(m_1, m_2)|\omega_H] \cdot \Pr[\omega = \omega_H]}{\Pr[(m_1, m_2)|\omega_H] \cdot \Pr[\omega = \omega_H] + \Pr[(m_1, m_2)|\omega_L] \cdot \Pr[\omega = \omega_L]}, \tag{9}$$

where $\Pr[\omega = \omega_H] = \mu_0$, $\Pr[\omega = \omega_L] = 1 - \mu_0$, and $\Pr[(m_1, m_2)|\omega]$ depends on the signal generation structure and the firms' communication strategy.[13] In a truthful equilibrium scenario, the consumer's posterior beliefs are

$$\hat{\mu}_{hh} = \frac{(1-\gamma)^2 \mu_0}{(1-\gamma)^2 \mu_0 + \gamma^2 (1-\mu_0)},$$
$$\hat{\mu}_{ll} = \frac{\gamma^2 \mu_0}{\gamma^2 \mu_0 + (1-\gamma)^2 (1-\mu_0)},$$
$$\hat{\mu}_{hl} = \hat{\mu}_{lh} = \mu_0. \tag{10}$$

The evaluation of the consumer's value function, given the four possible messages the consumer might receive, depends on the level of uncertainty, assessed by how significantly the posterior beliefs diverge from the center point of belief, 1/2, which represents the state of maximal uncertainty for the consumer. This divergence is influenced by the consumer's initial belief $\mu_0$ and the level of noisiness $\gamma$ present in each firm's signal. We focus on the truthful equilibrium, where the consumer's uncertainty is significantly reduced upon receiving consistent messages rather than conflicting ones, denoted by the conditions $|1/2 - \hat{\mu}_{ll}| > |1/2 - \mu_0|$ and $|1/2 - \hat{\mu}_{hh}| > |1/2 - \mu_0|$. We ensure this condition by setting[14]

$$\gamma < \min\{\mu_0, 1 - \mu_0\}. \tag{11}$$

The following lemma maps the consumer's posterior beliefs onto the consumer's value functions and enables us to characterize conditions under which the consumer decides to visit the stores in the truthful equilibrium.

**Lemma 2.** *The relationship among the posterior beliefs is as follows: $\hat{\mu}_{ll} < \hat{\mu}_{lh} = \hat{\mu}_{hl} = \mu_0 < \hat{\mu}_{hh}$. Given that $\gamma < \min\{\mu_0, 1 - \mu_0\}$, we also find that*

1. *For $\mu_0 \geq 1/2$, we have $\hat{\mu}_{hh} - 1/2 \geq 1/2 - \hat{\mu}_{ll} > \hat{\mu}_{hl} - 1/2$, leading to $W(\hat{\mu}_{hh}) > W(\hat{\mu}_{ll}) > W(\hat{\mu}_{hl})$.*
2. *For $\mu_0 < 1/2$, we have $1/2 - \hat{\mu}_{ll} > \hat{\mu}_{hh} - 1/2 > 1/2 - \hat{\mu}_{hl}$, thus $W(\hat{\mu}_{ll}) > W(\hat{\mu}_{hh}) > W(\hat{\mu}_{hl})$.*

Figure 3 illustrates $W(\hat{\mu}_{m_1 m_2})$ for $\gamma < \min\{\mu_0, 1 - \mu_0\}$. The left panel (Figure 3(a)) is for $\mu_0 > 1/2$, reflecting a situation where the consumer's default belief is that the first attribute ($\alpha$) is likely to be more significant. Receiving a consistent message $(h, h)$ reinforces the consumer's confidence in the $\alpha$-attribute's importance. However, a $(l, l)$ message makes the consumer adjust beliefs more negatively toward the state being $\omega_L$, although with less conviction than after an $(h, h)$ message. In scenarios where consistent messages $(h, h)$ or $(l, l)$ are received, the consumer's level of uncertainty is reduced compared with when conflicting messages $(l, h)$ or $(h, l)$ are encountered. The reduction in uncertainty with consistent messages—whether $(h, h)$ or $(l, l)$—contrasts against the uncertainty stemming from conflicting messages $(l, h)$ or $(h, l)$ and convinces the consumer with enhanced clarity, thus potentially increasing the expected value derived from visiting the stores.

However, the feasibility of such store visits is tied to the cost $c$. The following lemma establishes a basic relationship between the cost of visiting stores and the consumer's engagement decision with the product category.

**Lemma 3.** *The consumer's optimal decision to visit stores is as follows:*

1. *If* $c \geq \max\{W(\hat{\mu}_{hh}), W(\hat{\mu}_{ll})\}$, *the cost outweighs the benefits of visiting for all possible messages communicated to the consumer. Thus, the consumer never visits the firms and leaves the product category.*
2. *If* $c < W(\mu_0)$, *the expected benefits of visiting the stores exceed its cost for all possible messages that the consumer receives. Thus, the consumer chooses to visit the firms regardless of the messages received.*

The lemma illustrates the thresholds at which the search cost becomes a barrier or an incentive to seeking additional information by visiting stores. When the cost $c$ is prohibitively high, specifically $c \geq \max\{W(\hat{\mu}_{hh}), W(\hat{\mu}_{ll})\}$, then the consumer never finds it optimal to pay the cost and visit the stores. Consequently, a truthful equilibrium, as outlined in Definition 2, fails to emerge because the likelihood of the consumer making a purchase converges to zero. On the other hand, if $c < W(\mu_0) = W(\hat{\mu}_{hl}) = W(\hat{\mu}_{lh})$, the consumer finds it optimal to visit the stores across all scenarios, irrespective of receiving consistent or conflicting messages from the firms. In such cases, rather than conveying their private signal about the true state honestly, firms are incentivized to announce messages that highlight their competitive strengths—firm 1 favoring $m_1 = h$ and firm 2 leaning toward $m_2 = l$, independent of their actual signals $s_i \in \{H, L\}$. This scenario, nevertheless, prompts the consumer to consistently engage with the product category, driven not by a resolution of uncertainty regarding the true state but by the relatively minimal cost of exploration.

## 4.2. Equilibrium Results

Building on the results from the previous section, which illustrates how the cost of store visits influences consumer behavior and the firms' strategic messaging, we derive the core equilibrium results of our analysis. Lemma 3 sets a basic condition for the existence of a truthful equilibrium. Specifically, for a truthful equilibrium to exist, $c$ must be in an intermediate range, namely $W(\mu_0) \leq c < \max\{W(\hat{\mu}_{hh}), W(\hat{\mu}_{ll})\}$. This condition is crucial; outside this range, consumers either refrain from searching because of prohibitive costs or indiscriminately purchase based on highest $\nu$, as firms are motivated to emphasize their competitive advantages through strategic messaging.

Here, we analyze the firms' expected profits and incentives. Let $\Pi_i^*(s_i)$ denote firm $i$'s expected profit when it receives a noisy signal $s_i \in \{H, L\}$ in the truthful equilibrium. As the price is exogenous, each firm decides whether to report its signal honestly or dishonestly to maximize its expected demand. Given the symmetry of the two firms, it suffices to analyze firm 1's equilibrium conditions.

Consumer purchasing decisions are based on their beliefs about the true state $\omega$, formed by the messages they receive from both firms. To calculate its expected profit, a firm must compute the conditional probability of the other firm's signal based on its own signal as follows:

$$\begin{aligned} \Pr(s_2 = H | s_1 = H) &= \frac{\mu_0 \cdot (1-\gamma)^2 + (1-\mu_0) \cdot \gamma^2}{\mu_0 \cdot (1-\gamma) + (1-\mu_0) \cdot \gamma}, \\ \Pr(s_2 = L | s_1 = L) &= \frac{\mu_0 \cdot \gamma^2 + (1-\mu_0) \cdot (1-\gamma)^2}{\mu_0 \cdot \gamma + (1-\mu_0) \cdot (1-\gamma)}. \end{aligned} \tag{12}$$

Based on these probabilities, the firm predicts consumer responses to the messages $(m_1, m_2)$, which determines its demand and profit. If the firms send conflicting messages, the expected profit is zero. Conversely, if the messages align, the firm anticipates positive demand and profit, which is calculated based on consumer evaluations of the competing offers:

$$\begin{aligned} \pi_1^*(h,h) &= p \cdot \Pr(\mathbb{E}[V_1(\nu_1; \hat{\mu}_{hh})] > \max\{\mathbb{E}[V_2(\nu_2; \hat{\mu}_{hh})], 0\}), \\ \pi_1^*(l,l) &= p \cdot \Pr(\mathbb{E}[V_1(\nu_1; \hat{\mu}_{ll})] > \max\{\mathbb{E}[V_2(\nu_2; \hat{\mu}_{ll})], 0\}), \end{aligned} \tag{13}$$

where $\pi_i^*(m_1, m_2)$ is the firm's expected profit conditional on the consumer observing the messages $(m_1, m_2)$. Note that its expected demand here corresponds to the area labeled "1" in Figure 2(a) (in case the consumer observes messages $(h, h)$) and in Figure 2(b) (for messages $(l, l)$).

If firm 1 receives a private signal $s_1$, its expected profit in the truthful equilibrium is

$$\begin{aligned} \Pi_1^*(H) &= \Pr(s_2 = H | s_1 = H) \cdot \pi_1^*(h, h), \text{ and} \\ \Pi_1^*(L) &= \Pr(s_2 = L | s_1 = L) \cdot \pi_1^*(l, l). \end{aligned} \tag{14}$$

However, if firm 1 misreports its signal, it will only make a positive profit if firm 2 coincidentally sends a matching message:

$$\begin{aligned} \hat{\Pi}_1(H) &= \Pr(s_2 = L | s_1 = H) \cdot \pi_1^*(l, l), \text{ and} \\ \hat{\Pi}_1(L) &= \Pr(s_2 = H | s_1 = L) \cdot \pi_1^*(h, h). \end{aligned} \tag{15}$$

Here, $\hat{\Pi}_1(H)$ is the expected profit when firm 1 deviates by misreporting the message $m_i = l$ despite receiving $s_i = H$. Likewise, $\hat{\Pi}_1(L)$ is the expected profit when firm

1 deviates by misreporting the message $m_i = h$ after receiving $s_i = L$.

Intuitively, when firm 1 receives the favorable signal $s_i = H$, it has no incentive to mislead the consumer. However, if firm 1 receives the less favorable signal $s_i = L$, it might consider deviating from the truthful strategy to persuade the consumer that the $\alpha$ attribute is more significant, potentially gaining an advantage from this deception. To ensure the truthful equilibrium, we must demonstrate that

$$\Pi_1^*(L) = \Pr(s_2 = L | s_1 = L) \cdot \pi_1^*(l,l) > \hat{\Pi}_1(L) = \Pr(s_2 = H | s_1 = L) \cdot \pi_1^*(h,h). \quad (16)$$

The following proposition specifies the necessary and sufficient condition for the existence of a truthful equilibrium in this context.

**Proposition 1.** *There is a threshold $\overline{\gamma} > 0$ such that for $\gamma < \overline{\gamma}$, a truthful equilibrium exists if and only if $c$ falls within the interval $[\underline{c}, \overline{c})$, where $\underline{c} = W(\mu_0)$ and $\overline{c} = \min\{W(\hat{\mu}_{hh}), W(\hat{\mu}_{ll})\}$. Moreover, the expected profits of both firms are positive in this equilibrium: $\mathbb{E}\Pi_1^* > 0$, $\mathbb{E}\Pi_2^* > 0$.*

This proposition demonstrates that the specified range for $c$ and the threshold $\overline{\gamma}$ collectively determine the feasibility of achieving a truthful equilibrium where consumers make informed decisions based on accurate firm disclosures. For $c$ in an intermediate range, the consumer will visit the stores if and only if the firms' messages are consistent, that is, $(m_1, m_2) = (h,h)$ or $(l,l)$. To have the consumer visit their stores, the firms find it optimal to announce their signals honestly because doing so allows the firms to coordinate on their announced messages. This is because their signals are positively correlated through the true state. This coordination between firms through honest announcement strategies partly resolves the consumer's uncertainty about the true state, thus inducing the consumer's visit to the stores and making both firms better off compared with the alternative case where the consumer does not visit.

However, we cannot assume that firms will always follow the equilibrium strategy and communicate truthfully. Specifically, there exists a potential incentive for each firm to deviate from the equilibrium strategy and strategically misrepresent information, highlighting an attribute (or state) where it perceives a competitive edge, regardless of the accuracy of its signal. For example, even when firm 2 communicates its signal truthfully ($m_2 = s_2$), firm 1 might always announce $m_1 = h$. This deviation could be profitable, especially if signal noisiness ($\gamma$) is high enough. This is because, in situations where the actual state is $\omega = \omega_L$, there is a nonnegligible chance that firm 2 erroneously receives a signal $s_2 = H$. Under such circumstances, firm 1's dishonest deviation could lead to a successful coordination on firm 1's preferred message, leveraging the noise in the signals for strategic advantage. To prevent such deviations, the signals must not be excessively noisy, that is, $\gamma \le \overline{\gamma}$. This restriction ensures that firms are disciplined to announce its message truthfully, even when it involves acknowledging a competitive shortcoming. With lower noise levels ($\gamma \le \overline{\gamma}$), even if the firm receives an unfavorable signal (for example, $s_1 = L$), it is still better off to report truthfully because both firms are likely to receive the same signals, reducing the incentives to deviate by reporting dishonestly. Even in less favorable scenarios, firms can still attract consumers with high enough idiosyncratic values. Thus, the honest reporting can still lead to purchases under these conditions as shown in $\Pr(\mathbb{E}[V_1(\nu_1; \hat{\mu}_{ll})] > \max\{\mathbb{E}[V_2(\nu_2; \hat{\mu}_{ll})], 0\})$. Therefore, under this condition, truthful communication becomes the optimal choice for firms, and their collective messages can credibly convey information about the attribute importance, thereby encouraging store visits and purchase.

Finally, we can calculate the overall expected profit for a firm in the truthful equilibrium prior to receiving any signal as follows:

$$\begin{aligned}\mathbb{E}\Pi_1^* &= \Pr(s_1 = H) \cdot \Pi_1^*(H) + \Pr(s_1 = L) \cdot \Pi_1^*(L) \\ &= (\mu_0 \cdot (1-\gamma)^2 + (1-\mu_0) \cdot \gamma^2) \cdot \pi_1(h,h) \\ &\quad + (\mu_0 \cdot \gamma^2 + (1-\mu_0) \cdot (1-\gamma)^2) \cdot \pi_1(l,l), \quad (17)\end{aligned}$$

confirming that expected profit is positive.

Although it may seem counterintuitive, firms often promote features where they lack a competitive edge. In the EV market, for example, Tesla has superior battery range, but competitors like Nissan with the Leaf and Chevrolet with the Bolt EV still focus on range in their marketing. Even if their vehicles do not match Tesla's performance, these companies highlight battery range to signal its importance in the consumer's decision-making process for EVs. This strategy educates consumers about key attributes, reduces buyer uncertainty, and increases engagement (Moon and Darwall 2002). Ultimately, by emphasizing these features, all firms help expand the overall market (Lu and Shin 2018).

Our mechanism is most relevant when consumers confront a new or unfamiliar product category and lack clear guidance on which attributes to prioritize. In such contexts, the challenge is not only product differentiation but also generating primary demand for the category. Credible communication about attribute importance plays a central role in facilitating consumer engagement and can benefit all firms by expanding the overall market.

We now examine how the accuracy of information, $\gamma$, affects the firms' equilibrium profits. This analysis will clarify the conditions under which the truthful equilibrium is applicable and effective.

**Proposition 2.** *Suppose that $\gamma < \overline{\gamma}$ and $c \in [\underline{c}, \overline{c})$.*

1. *Conditional on both firms' sending congruent messages, each firm's equilibrium profit changes in $\gamma$ as follows:*

b. *When messages are congruent and favorable to the firm, profits decrease as $\gamma$ increases: $\partial\pi_1^*(h,h)/\partial\gamma$, $\partial\pi_2^*(l,l)/\partial\gamma \le 0$.*

c. *When messages are congruent and unfavorable to the firm, profits increase as $\gamma$ increases: $\partial\pi_2^*(h,h)/\partial\gamma$, $\partial\pi_1^*(l,l)/\partial\gamma \ge 0$.*

4. *The firm's expected profit prior to observing its signal, $\mathbb{E}\Pi_i^*$, decreases in $\gamma$ for $\mu_0$ sufficiently close to $0, 1/2$, or $1$.*

The first part of the proposition explains how a firm's profits are affected by the noisiness (or accuracy) of the information they provide about an important attribute. Specifically, when both firms send the same message—either $(h,h)$, suggesting that $\alpha$ is important, or $(l,l)$, suggesting it is less important—the impact on profits depends on whether the message is favorable or unfavorable to the firm.

If the message is $(h,h)$, which favors firm 1, firm 1′ profits decrease as messages become noisier (that is, as $\gamma$ increases). Thus, we have $\partial\pi_1^*(h,h)/\partial\gamma \le 0$. On the other hand, the same message $(h,h)$ is unfavorable to the firm 2, so its profit increases as the message becomes noisier, as shown by $\partial\pi_2^*(h,h)/\partial\gamma \ge 0$. Similarly, when the firms send the message pair $(l,l)$, the effect on profits follows the same logic but in reverse, depending on whether the message is favorable or unfavorable for the respective firm.

The second part of the proposition shows that the firm's ex ante expected profit, $\mathbb{E}\Pi_i^*$, can decrease in $\gamma$ for different values of $\mu_0$. This decline is mainly because of the effect of $\gamma$ on the correlation between the signals from the two firms. Specifically, a lower $\gamma$ means the firms are more likely to receive the same signal (either $s_1 = s_2 = H$ or $s_1 = s_2 = L$), which increases the chances of congruent signaling and potential profit increase.[15] If the signals conflict, the consumer typically does not respond, resulting in zero profit ($\pi_i^*(h,l) = \pi_i^*(l,h) = 0$). Although $\pi_i^*(l,l)$ increases with $\gamma$ as previously noted, this benefit does not offset the negative impacts on the other components of $\mathbb{E}\Pi_i^*$, leading to an overall decrease in the expected profit. Because of the analytical complexity, the result is only shown for specific values of $\mu_0 = 0$, 1/2, and 1; Figure 4 illustrates a numerical example where $\mathbb{E}\Pi_1/\partial\gamma$ and $\partial\mathbb{E}\Pi_2/\partial\gamma$ are both negative, and thus the result is robust for the entire space of $\mu_0 \in [0,1]$.

**4.2.1. Comparative Statics.** To deepen our understanding, this section examines how changes in key model parameters affect the conditions for a truthful equilibrium. Specifically, the proposition below analyzes how the interval $[\underline{c}, \overline{c})$, the range of the truthful equilibrium, shifts in response to changes in the parameters $\gamma$, $p$, and $u_H$.

**Proposition 3.** *The range of the truthful equilibrium, defined by the length of the interval $(\underline{c}, \overline{c}]$, responds as follows: The length of the interval decreases with increases in $\gamma$ and $p$ (i.e., $\partial(\overline{c} - \underline{c})/\partial\gamma \le 0$ and $\partial(\overline{c} - \underline{c})/\partial p \le 0$) and increases with an increase in $u_H$ ($\partial(\overline{c} - \underline{c})/\partial u_H \ge 0$).*

Recall that the lower bound $\underline{c} = W(\mu_0) = W(\mu_{lh})$ represents the consumer's expected utility from searching based on the prior beliefs. The upper bound $\overline{c} = \min\{W(\mu_{hh}), W(\mu_{ll})\}$ represents the expected utility of visiting the stores when the firms send consistent messages. Thus, the difference $\overline{c} - \underline{c}$, which defines the interval where a truthful equilibrium exists, represents *the marginal value of information* about the attribute importance beyond the prior, communicated through consistent messages from both firms. When $\gamma$ increases (i.e., signals become noisier), the upper bound $\overline{c}$ decreases because of greater uncertainty, whereas the lower bound $\underline{c}$ remains unchanged. Therefore, the difference $\overline{c} - \underline{c}$ decreases in $\gamma$, suggesting that less information about the true state $\omega$ is communicated, making the consumer less likely to engage in search.

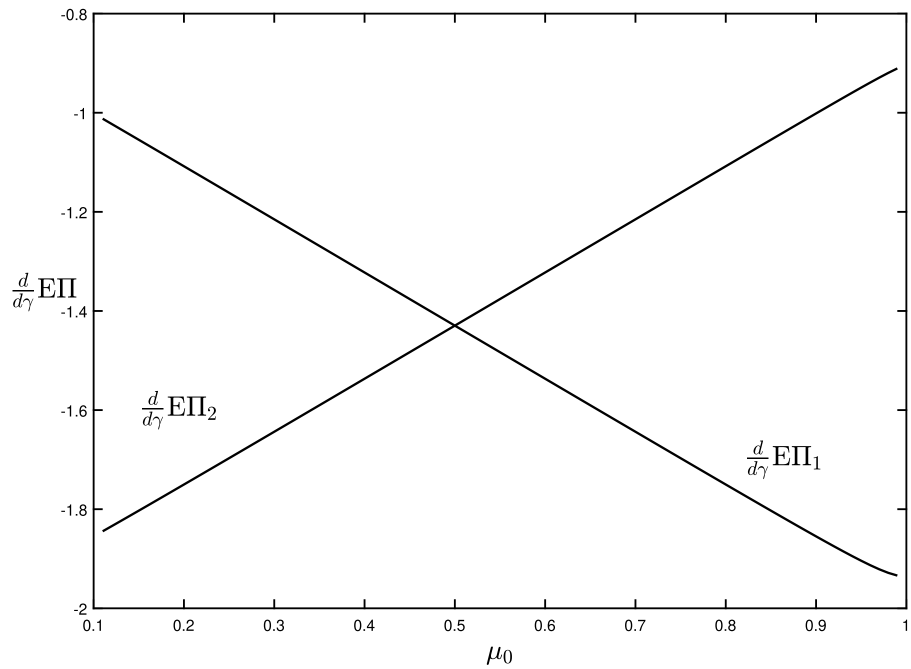
If the level of the strongest attribute of each firm, $u_H$, increases (while keeping everything else constant), the expected utility $W(\hat{\mu})$ would also increase for any $\hat{\mu}$.[16] Thus, both $\overline{c}$ and $\underline{c}$ increase in $u_H$. Furthermore, the difference $\overline{c} - \underline{c}$ also increases in $u_H$ because the value of information about the attribute importance becomes more critical to the consumer. For example, if $\omega = \omega_H$, the consumer would prefer to buy from firm 1, as the attribute $\alpha$ is more important in this state, and firm 1 offers higher quality in that attribute (i.e., $\alpha_1 = \alpha_H > \alpha_2 = \alpha_L$). These incentives would amplify when the level of the stronger attribute $\alpha_H$ were higher.

The cutoffs $\overline{c}$ and $\underline{c}$ both decrease in $p$. This reflects the reduced benefit of searching when consumers face higher prices, irrespective of their beliefs $\hat{\mu}$. Similarly, the difference $\overline{c} - \underline{c}$ also decreases in price $p$. This is because the higher prices reduce the net benefit of making a purchase, reducing the consumer's incentives to visit stores. This direct effect of price dominates any indirect effects where higher prices might otherwise motivate consumers to become more informed about the attribute importance to identify the better product.

### 4.3. Other Equilibria

Although our analysis has primarily focused on a truthful equilibrium, we also identify other types of pure strategy equilibria. First, there exists a *pooling equilibrium*, where each firm consistently sends the same message, regardless of the actual signal (e.g., firm 1 *always* sends $h$ and firm 2 *always* sends $l$). Second, there also exists an *asymmetric equilibrium*, where one firm adopts

**Figure 4.** Plot of $\partial\mathbb{E}\Pi_1/\partial\gamma$ and $\partial\mathbb{E}\Pi_2/\partial\gamma$ for $\gamma = 0.1, \omega_H = 6/7, u_H = 1.6, u_L = 1, p = 1$




a pooling strategy and the other firm adopts a truthful (separating) strategy.

**Proposition 4.** *Equilibria other than the truthful separating equilibrium may exist:*

1. *A pooling equilibrium always exists. However, the consumer does not visit the stores and, thus, does not buy any product if $c \geq \underline{c}$.*
2. *An asymmetric equilibrium exists only when $\mu_0 = 1/2$.*

In a pooling equilibrium, each firm sends the same message regardless of its private signal $s_i$, thereby failing to convey any additional information about the true state $\omega$ to the consumer. Although this equilibrium exists under all parameter values, consumers never purchase if $c \geq \underline{c}$, as the uncertainty is too great to justify the cost $c$ of further engagement, resulting in no transaction and zero profit for the firms.

There is also the possibility of an asymmetric equilibrium, but it is rare and only exists when $\mu_0$ is exactly 1/2. In this case, one firm's message is completely uninformative, so the consumer relies solely on the other firm's message, which adopts the separating strategy. However, the firm with the informative message has no incentive to coordinate with its competitor and is thus tempted to deviate by highlighting its stronger attribute. This deviation is profitable, thus eliminating the asymmetric equilibrium except when $\mu_0 = 1/2$. Therefore, the separating equilibrium, where information about the attribute is effectively communicated, is the only equilibrium for all $\mu_0 \neq 1/2$, and it is also the only equilibrium in which the transaction occurs with a positive probability.

### 4.4. Impact of Competition on Credibility of Communication and Profits

One may posit that the presence of competing firms with different strengths, each eager to highlight opposing attributes, limits their ability to choose messages, ultimately leaving both firms worse off. To address this concern, we analyze a monopoly setting where without loss of generality firm 1 is the unique firm in the market. We first analyze equilibria of this game and compare the best feasible profit of firm 1 across two models: a monopoly and duopoly setting.

**Proposition 5** (Equilibrium of a Monopoly Firm Game). *In the game with a monopoly firm,*

1. *Separating equilibrium does not exist, and*
2. *Pooling equilibria in which the firm always sends message $m(s) = h$ or always message $m(s) = l$ exist.*

*If $c < \bar{c}_M = W_M(\mu_0)$, the firm obtains a maximum expected profit of $\pi^*_M(\mu_0) = p(1 - p + \mathbb{E}U_M(\mu_0))/2$. However, if $c \geq \bar{c}_M$, the highest feasible expected profit of the firm is zero.*

In a monopoly market, only pooling equilibria exist, and no credible communication about attribute importance occurs.[17] In this setting, the consumer relies on the monopoly firm as the only source of information. Thus, under the assumption that the consumer believes the firm to communicate honestly (or uses any separating strategy such that the consumer can correctly infer the firm's private signal), the firm has a profitable deviation to talk about its stronger attribute regardless of its private signal. Thus, the truthful equilibrium does not exist.[18]

In a pooling equilibrium, the firm's communication does not resolve the consumer's uncertainty. Thus, the consumer finds it optimal to visit the monopoly firm if and only if $c < \bar{c}_M = W_M(\mu_0)$, which denotes the consumer's expected value from visiting the monopoly firm given the consumer's posterior belief $\mu_0$:

$$W_M(\mu) = 1/2\int_{-1}^{1}\max\{\overline{U}_M(\mu) + v - p, 0\}\,dv = \frac{1}{4}(\mathbb{E}U_M(\mu) + 1 - p)^2, \quad (18)$$

where $\mathbb{E}U_M(\mu) = \mu\overline{U} + (1-\mu)\underline{U}$. Upon visiting the store, the consumer realizes $v$ from a uniform distribution on $[-1,1]$ and buys the product if and only if $\mathbb{E}U_M(\mu) + v - p \geq 0$, that is, $v \geq p - \mathbb{E}U_M(\mu)$. Thus, the firm's expected profit in this region for $c$ is

$$\pi^*_M(\mu) = p\cdot(1 - p + \mathbb{E}U_M(\mu))/2. \quad (19)$$

Next, we compare the firm's profit under the monopoly and duopoly setting.

**Proposition 6** (Profit Comparison: Monopoly Versus Duopoly Firm). *If $c \geq \bar{c}$, the firm is indifferent between being in a duopoly market and a monopoly market. If $\bar{c}_M \leq c < \bar{c}$, the firm prefers to be in a duopoly market. Otherwise, if $c < \bar{c}_M$, the firm is better off in a monopoly market.*

## 5. Extensions

### 5.1. Endogenous Pricing

In this section, we analyze an extension game in which each firm chooses their prices endogenously prior to receiving its private signal about the true state.[19] Through the analysis, we seek to establish robustness of our main result that a truthful equilibrium exists where both firms communicate their private signals truthfully to the consumer because doing so enables credible communication about attribute importance. One might posit that the equilibrium may not exist if the firms were allowed to set their prices optimally because a firm (or both firms) may find it beneficial to lie to the consumer and charge a very low price in order to incentivize the consumer to visit the stores despite the consumer's unresolved uncertainty.

The exact timeline of the game is the same as Figure 1, except that each firm chooses price $p_i$ after the true state $\omega$ is realized and before the firm receives its private signal $s_i$. Also, now the consumer observes $(p_1, m_1)$ and $(p_2, m_2)$, where only the messages affect the consumer's posterior beliefs about the true state.

We also assume $\gamma = 0$ for tractability such that both firms always accurately learn the true state, that is, $s_i = s = H$ if $\omega = \omega_H$ and $s_i = s = L$ if $\omega = \omega_L$.[20] Note that in this model, each firm cannot observe the price and message of the other firm when choosing its own price and message.

In this model, each firm must choose both its price and message, with the latter being determined based on the chosen price and the observed $s$. In other words, firm $i$'s strategy is $(p_i, m_i(p_i, s))$, where $m_i : (0,\infty) \times \{H, L\} \to \{h, l\}$. Now consider the following strategy: Firm $i$'s pricing strategy is $p_i = p^*$, where

$$-1 < \overline{U} - p^* < 1, \quad -1 < \underline{U} - p^* < 1. \quad (20)$$

Firm $i$'s messaging strategy is $m^*_i(p, H) = h$, $m^*_i(p, L) = l$ for any $p$. Thus, this strategy involves firms setting the same price and sending truthful messages on the equilibrium path. The following proposition identifies sufficient conditions under which the above strategy constitutes a symmetric equilibrium for $\mu_0 = 1/2$.

**Proposition 7.** *Suppose that $\mu_0 = 1/2$. Then, there exists a nonempty set $S$ such that, for each pair $(u_H, u_L, \omega_H) \in S$, there exist thresholds $\bar{c}$, $\underline{c}$ such that the above strategy constitutes an equilibrium for $\underline{c} \leq c < \bar{c}$. Moreover, $p^*$ is uniquely determined for each pair $(u_H, u_L, \omega_H) \in S$.*

In this equilibrium, the optimal symmetric price uniquely exists. This analysis addresses the concern that a firm might deviate from truth-telling to shift the consumer's posterior beliefs more favorable the firm and at the same time slashing its price to induce the consumer's visit. However, we show that such a deviation leads to inconsistent messages and pessimistic consumer beliefs. Inducing visits under such beliefs would require deep price cuts that significantly erode the firm's margins, making the deviation unprofitable. Hence, even when prices are endogenous, a truthful equilibrium can persist.

### 5.2. Sequential Communications

Previously, we analyzed a game in which the two firms communicate with the consumer simultaneously. In this section, we explore an alternative version of the game in which the two firms send their messages to the consumer sequentially. Therefore, after reaching its private signal $s_i \in \{H, L\}$ about the true state $\omega$, without loss of generality, firm 1 first sends a message $m_1 \in \{h, l\}$. Firm 2 observes this message and sends its message $m_2 \in \{h, l\}$ to the consumer. The consumer then updates beliefs about the state and decides whether to exert a costly effort and observe $v_i$s.

We are interested in understanding to what extent information about attribute importance can be credibly transmitted to the consumer. The equilibrium analysis of the main model where the two firms send messages simultaneously established that truthful equilibrium is the only equilibrium in which credible communication occurs (except in a parameter region of measure zero). One might expect that a sequential game, facilitating better coordination opportunities, would naturally support the emergence of a truthful equilibrium. However, our findings indicate that the dynamics of sequential communication significantly alter this expectation. Specifically, a pure stategy truthful equilibrium does not exist, and credible communication fails to materialize in pure strategies. Nevertheless, we identify an asymmetric equilibrium in mixed-strategies where credible communication still occurs, albeit only partially. In this hybrid equilibrium, firm 1 uses a pooling strategy and firm 2 a partially mixed strategy.

Firm 1's strategy, $\sigma_1(s_1) = \Pr(m_1 = h|s_1) \in \{0,1\}$, is a mapping from its noisy signal $s_1$ to the message $m_1 \in \{h, l\}$. Firm 2's message is a mapping from both its noisy signal $s_2$ and firm 1's message $m_1$ to firm 2's choice of message $m_2$. It is denoted by $\sigma_2(m_1, s_2) = \Pr(m_2 = h|m_1, s_2) \in \{0,1\}$. This setup allows firm 2 to condition its message on both the signal it observes and the message received from firm 1.

The next proposition establishes that, unlike in the simultaneous game, no pure strategy equilibrium allows truthful communication in this sequential setup.

**Proposition 8** (Sequential Communication and Pure Strategy Equilibria). *If the firms announce their messages sequentially, in pure strategies, only pooling equilibria exist. No other forms of equilibria yielding a positive expected payoff, except in a parameter region of measure zero. As a result, credible communication does not occur. Moreover, for any $c \geq W(\mu_0)$, the consumer does not visit the stores, leading both firms' equilibrium profit to be zero.*

In the simultaneous communication game, firms could use truthful strategy as a coordination device, allowing consumers to resolve uncertainty and encouraging store visits. In the sequential communication game, firms still coordinate on their messages, but this alignment is no longer trustworthy. Upon observing firm 1's announcement, firm 2 profitably deviates from truth-telling by simply replicating the message. Anticipating this incentive, firm 1 also forgoes truthful communication and consistently highlights its own comparative advantage. Consequently, messages do not impart any information to consumers.

It is important to note that the truthful equilibrium unravels in this extension because firm 2 can observe firm 1's signal prior to announcing its own message. This observability allows firm 2 to condition its message on firm 1's signal, creating strong incentives to coordinate rather than to report truthfully. Even under simultaneous communication, if firms observe each other's informative signals, their incentive to coordinate dominates any incentive to report truthfully. Suppose, for contradiction, that a truthful equilibrium exists in this setting where firms first observe each other's private signals and then simultaneously announce their messages. In such a setting, each firm must find it optimal to communicate truthfully, regardless of the rival's signal. In equilibrium, the consumer expects both firms to report truthfully and decides to visit the stores if and only if both firms send the same message, following the same logic as in Lemma 3 of our main analysis. However, when the firms observe mismatched signals, each has an incentive to deviate from truth-telling and instead conform to the rival's signal to ensure coordination. This situation is akin to a classic "battle of the sexes" game, where the strategic incentive to coordinate dominates any preference for honesty.[21] As a result, the equilibrium outcome is governed not by the truth but by focal points for coordination, and thus, truthful communication breaks down.

Therefore, the unobservability of the rival's signal is critical for sustaining truthful communication as an equilibrium. When signals are observable—as is naturally the case in sequential games where earlier actions are observable to later movers—the strategic incentive to coordinate outweighs the incentive to be truthful. Thus, it is precisely the unobservability of the rival's signal that introduces stochasticity into firms' inferences and sustains honest reporting through correlated beliefs. When firms cannot observe each other's signals, and their private information is positively correlated, truthful reporting becomes a dominant strategy.[22]

Next, we turn to the possibility of recovering at least partial credible communication in mixed strategies. Specifically, without loss of generality, firm 1 adopts a pooling strategy, whereas firm 2 employs a partially mixed strategy. That is, $\sigma_1(H) = \sigma_1(L) = 1$, $\sigma_2(m_1 = l, L) = 0$, $\sigma_2(m_1 = h, H) = \delta \in (0,1)$. We define the equilibrium with these strategies as *asymmetric equilibrium in mixed strategies*. In addition, in a monopolistic market, we define the equilibrium with the partially mixed strategy (i.e., $\sigma(H) = 1$, $\sigma(L) \in (0,1)$) as *semiseparating equilibrium*.

We consider both cases where $c$ can be constant or stochastic, randomly drawn from a distribution.

**Proposition 9** (The Asymmetric Equilibrium in Mixed Strategy)

*In a duopoly market, an asymmetric equilibrium in mixed strategies*

1. *Exists if the consumer's search cost $c$ is stochastic, regardless of whether firms communicate with the consumer simultaneously or sequentially; or*
2. *Does not exist if $c$ is a constant.*

*In a monopoly market, the semiseparating equilibrium does not exist, regardless of whether $c$ is stochastic or deterministic.*

Firm 2's semiseparating strategy reflects a tradeoff; Being truthful improves the informativeness of its message, which reduces consumer uncertainty and encourages more store visits (increasing the total market size). However, truth-telling also makes firm 2 less attractive relative to firm 1 (shrinking its market share). Conversely, by misrepresenting its signal, firm 2 can bolster its relative appeal, but only at the cost of lower overall market participation.

Given this, first, if $c$ is stochastic, this tradeoff varies across consumers. Consumers with low $c$ will visit regardless, whereas others require certainty to justify search. This dispersion enables the indifference condition necessary for firm 2 to mix; truth-telling helps attract the marginal consumer to stores, whereas lying helps retain competitive positioning. Importantly, this logic holds under both simultaneous and sequential communication because firm 1's pooling strategy renders its message uninformative. Moreover, firm 2's decision does not depend on the timing or observability of firm 1's message.

Second, if $c$ is a constant, this heterogeneity vanishes. There is no smooth tradeoff to balance—either all consumers visit or no consumers do, depending on whether expected utility crosses the constant $c$. As a result, firm 2 always has a strict preference either to tell the truth or to lie, breaking the delicate indifference required for mixing.

We also analyze whether the semiseparating equilibrium exists in the monopoly case. Here, the tradeoff mentioned above breaks down entirely. The firm has a profitable deviation to feature its own stronger attribute, regardless of the truth. Highlighting its weaker attribute honestly may reduce the uncertainty of the consumer, but it does not lead to greater market participation because the only firm has been revealed to be unappealing.

Our findings confirm that this asymmetric equilibrium exists, and thus credible communication occurs partially, only if (i) the search cost is stochastic, and (ii) the market is competitive. Even with random $c$, the equilibrium does arise in a monopoly setting. Moreover, credible communication requires not just the presence of a competing firm but a genuine conflict of interests between competing firms. In a duopoly setting, this conflict prevents either firm from dictating the information flow, anchoring the truthful equilibrium. In contrast, credible communication is impossible in a monopolistic market or when the incentives of the two firms are perfectly aligned. A monopolist would never acknowledge its own weakness, because doing so would only deter visits.[23] A firm in a duopoly market is willing to do so precisely because an unfavorable message about itself can still draw consumers to the market through more positive expectations about the other firm.

### 5.3. Sequential Search

In the main model, the consumer decides whether to visit both firms' stores by paying the search cost once. In this section, we analyze an extension model in which the consumer pays the search cost to visit each firm sequentially. In this model, the consumer decides whether to visit the first firm and pay the search cost $c$. If the consumer visits, then the consumer observes the consumer's matching value from the firm. Next, the consumer can decide whether to continue searching for the other firm, which requires another search cost $c$. The analysis focuses on the existence of the truthful equilibrium in which both firms always announce their messages honestly, and the consumer initiates a search process only when the firms announce the same messages.[24]

We consider two approaches to the consumer's search process. First, the consumer searches endogenously, and second, the consumer visits an anonymous firm randomly. In the former, if the consumer chooses to initiate a search process, the consumer will visit a preferred firm first (according to the consumer's posterior beliefs about the true state $\omega$). Subsequently, the consumer decides whether to visit the less preferred firm. In the latter, the consumer who initiates a search visits one firm randomly without knowing which of the two firms it is. The consumer then realizes whether it was firm 1 and 2 (i.e., whether it was the preferred or less preferred firm) and subsequently decides whether to visit the other firm.

**Proposition 10.** *If the consumer can choose the sequence for the search process, the truthful equilibrium does not exist. However, if the consumer's search process is random, the truthful equilibrium exists for $\gamma$ sufficiently small and c in an intermediate range.*

Thus, the mode of consumer search process, whether in an endogenous or random order, plays an important role for the incentives of the two firms to coordinate through truthful communications. Coordination through truthful communication is sustained only when each firm expects a positive chance of being visited first, which is ensured under random search but not under endogenous ordering. Intuitively, if consumers can optimally choose to visit the more promising firm first, the firm with the less favorable signal has no incentive to be truthful because it would not be visited at all; the consumer will never knowingly incur an additional search cost to visit the less appealing firm.

## 6. Conclusion

This study has shown how strategic communication between competing firms can significantly shape consumer beliefs and influence their decisions in the marketplace. We consider the scenario where firms communicate nonverifiable information about product attributes under competition. Each firm inherently seeks to emphasize its distinct competitive advantage in a particular attribute. Despite these competitive pressures, we find that firms may sometimes cooperate by truthfully communicating their information. Truthful messages increase the likelihood of consistent consumer messages, clarifying attribute importance and enhancing consumer beliefs. This encourages consumers to engage more deeply with the product category, which they might otherwise avoid, making both firms better off. Conversely, if a firm misrepresents its competitive attribute, it may likely lead to inconsistent messages between firms, creating consumer confusion about which attributes are important. This misalignment can deter consumer interaction with the product category, ultimately harming both firms.

Interestingly, our findings suggest that firms benefit from competition because it disciplines their communication strategies. As the sole communicator or monopolist in the product market, the firm can send any message without worrying about what the competitor might say. Without any mechanism to restrict or verify its communication, the firm's message loses its credibility completely. Therefore, in the absence of a competing firm (or, a competing firm's communication), no information can be conveyed to the consumer, often resulting in no transactions within a wide range of parameters. Therefore, competition serves as a commitment device that enables firms to credibly communicate the importance of product attributes. It is also crucial to recognize that effective competition requires conflicting interests; a competing firm with aligned incentives does not enhance the credibility of communications. In essence, the presence of competition not only enhances the credibility of the information provided but also ensures that firms discipline each other. This finding underscores the beneficial role of competition in markets where firms might otherwise monopolize communication and potentially mislead consumers.

Our analysis has several limitations, which open several interesting avenues for future research. First, although we endogenize prices, we restrict the signaling role of prices and focus on symmetric pricing equilibrium. Relaxing this assumption could illuminate how asymmetric pricing interacts with credible communication of information about attribute importance, but would require a significantly richer model. Second, the signal-noisiness parameter $\gamma$ is currently treated as exogenous; endogenizing it would reveal how firms decide how much to learn about the attribute importance and how that choice affects communication strategies, offering insights into the firm's incentives to manage uncertainty. Third, we assume all consumers assign the same weight $\omega$ to the focal attribute, whereas in reality, consumers may prioritize different attributes. Incorporating heterogeneous $\omega$ would deepen the analysis but add substantial complexity. Finally, our framework presumes that consumers know attribute levels and are uncertain only about their importance. Extending the model to cases where consumers are also uncertain about the attribute levels themselves would better capture many real-world settings and pose new challenges for credible communication. Exploring these directions would greatly enrich our understanding of firms' strategic communication of information under competition.

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## Appendix
### A.1. Proof of Lemma 1
First, it is clear that $W(\hat{\mu}) = W(1-\hat{\mu})$ because $\mathbb{E}U_1(\hat{\mu}) = \mathbb{E}U_2(1-\hat{\mu})$ and $\mathbb{E}U_2(\hat{\mu}) = \mathbb{E}U_1(1-\hat{\mu})$. Thus, $W(\hat{\mu})$ is symmetric about $\hat{\mu} = 1/2$. Next, we show that it is convex, that is, $W''(\hat{\mu}) > 0$. The function $W(\cdot)$ can be rewritten as $W(\hat{\mu};p) = f(\mathbb{E}U_1(\hat{\mu}) - p, \mathbb{E}U_2(\hat{\mu}) - p)$, where

$$f(x,y) := \frac{1}{4}\int_{-1}^{1}\int_{-1}^{1} \max\{x+v_1, y+v_2, 0\} dv_1 dv_2, \quad \text{for } x,y \in (-1,1). \tag{A.1}$$

Note that for $\hat{\mu} \le 1/2$, $\mathbb{E}U_1(\hat{\mu}) - p \le \mathbb{E}U_2(\hat{\mu}) - p$, and otherwise, for $\hat{\mu} > 1/2$, $\mathbb{E}U_1(\hat{\mu}) - p > \mathbb{E}U_2(\hat{\mu}) - p$. The exact expression of $f(x,y)$ depends on the comparison between $x$ and $y$ because it changes the shape of the domain of integration. If $x \le y$, which corresponds to the case where $\hat{\mu} \le 1/2$,

$$\begin{aligned} f(x,y) &= \frac{1}{4}\iint_{x+v_1 \ge y+v_2,\ 0} (x+v_1) dv_1 dv_2 \\ &\quad + \frac{1}{4}\iint_{y+v_2 \ge x+v_1,\ 0} (y+v_2) dv_1 dv_2 \\ &= \frac{1}{4}\Bigg(\int_{-x}^{1}\int_{-1}^{x-y+v_1} (x+v_1) dv_2 dv_1 \\ &\quad + \int_{-y}^{1+x-y}\int_{-1}^{-x+y+v_2} (y+v_2) dv_1 dv_2 \\ &\quad + \int_{1+x-y}^{1}\int_{-1}^{1} (y+v_2) dv_1 dv_2\Bigg) \\ &= \frac{1}{24}(x^3 - 3x^2y + 6x^2 - 6xy + 9x + 6y^2 + 9y + 10). \end{aligned} \tag{A.2}$$

Similarly, for $x > y$, which corresponds to the case where $\hat{\mu} > 1/2$, we have $f(x,y) = \frac{1}{24}(y^3 - 3xy^2 + 6y^2 - 6xy + 9y + 6x^2 + 9x + 10) > 0$. Note that it is obtained by switching $x$ and $y$ in the function $f(x,y)$ for the case $x \le y$.

For $\hat{\mu} > 1/2$, we have

$$\begin{aligned} W'(\hat{\mu}) &= \frac{\partial}{\partial \hat{\mu}} f(\mathbb{E}U_1(\hat{\mu}) - p, \mathbb{E}U_2(\hat{\mu}) - p) \\ &= -\frac{1}{4}(\overline{U} - \underline{U})^2 (2\hat{\mu} - 1)((\overline{U} - \underline{U})\hat{\mu} - (\overline{U} - p + 3)), \end{aligned} \tag{A.3}$$

$$W''(\hat{\mu}) = -\frac{1}{4}(\overline{U} - \underline{U})^2(4(\overline{U} - \underline{U})\hat{\mu} - (3\overline{U} - \underline{U} - 2p + 6)). \tag{A.4}$$

Because $p - 1 < \overline{U}$, $\underline{U} < p + 1$, we have $W''(1/2) = \frac{1}{4}\cdot(\overline{U} - \underline{U})^2 \cdot (\overline{U} + \underline{U} - 2p + 6) > 0$, and $W''(1) = \frac{1}{4}\cdot(\overline{U} - \underline{U})^2 \cdot (-(\overline{U} - p) + 3(\underline{U} - p) + 6) > 0$. The linearity of $W''(\cdot)$ confirms that $W'' > 0$ for all $\hat{\mu} \in [1/2, 1]$.

Similarly, for $\hat{\mu} \le 1/2$, $W(\hat{\mu}) = W(1 - \hat{\mu})$ because $W$ is symmetric about $\hat{\mu} = 1/2$. Differentiating both sides with respect to $\hat{\mu}$, we have $W''(\hat{\mu}) = W''(1 - \hat{\mu})$, which is positive because $W''(1 - \hat{\mu}) > 0$ and $1 - \hat{\mu} > 1/2$. This shows that $W(\cdot)$ is convex on the interval $(0, 1)$. □

### A.2. Proof of Lemma 2

Note that $\mu_0 < \hat{\mu}_{hh} \Leftrightarrow \mu_0 < \frac{(1-\gamma)^2\mu_0}{(1-\gamma)^2\mu_0 + \gamma^2(1-\mu_0)} \Leftrightarrow \gamma < 1/2$. Similarly, we have $\hat{\mu}_{ll} < \mu_0 \Leftrightarrow \gamma < 1/2$. Because $\gamma < 1/2$, so we have $\hat{\mu}_{ll} < \mu_0 < \hat{\mu}_{hh}$.

For the case $\mu_0 \ge 1/2$, note that $1 - \hat{\mu}_{ll} \le \hat{\mu}_{hh} \Leftrightarrow \frac{(1-\gamma)^2(1-\mu_0)}{\gamma^2\mu_0 + (1-\gamma)^2(1-\mu_0)} \le \frac{(1-\gamma)^2\mu_0}{(1-\gamma)^2\mu_0 + \gamma^2(1-\mu_0)} \Leftrightarrow \mu_0 \ge 1/2$. Also, $\hat{\mu}_{hl} < 1 - \hat{\mu}_{ll} \Leftrightarrow \mu_0 < \frac{(1-\gamma)^2(1-\mu_0)}{\gamma^2\mu_0 + (1-\gamma)^2(1-\mu_0)} \Leftrightarrow \gamma < 1 - \mu_0$.

For the case $\mu_0 < 1/2$, similar to the previous case with $\mu_0 \ge 1/2$ (which yields $1 - \hat{\mu}_{ll} > \hat{\mu}_{hh}$), we have $\hat{\mu}_{hh} > \hat{\mu}_{hl}$ if and only if $\gamma < \mu_0$. □

### A.3. Proof of Lemma 3

The proof of Lemma 3 is straightforward and follows directly from the argument presented in the main text; hence, we omit a formal proof.

### A.4. Proof of Proposition 1

Lemma 3 establishes a necessary condition for the existence of a truthful equilibrium and shows that outside the range $W(\mu_0) \le c < \max\{W(\hat{\mu}_{hh}), W(\hat{\mu}_{ll})\}$, such an equilibrium cannot exist.

First, we consider the case $\min\{W(\hat{\mu}_{ll}), W(\hat{\mu}_{hh})\} \le c < \max\{W(\hat{\mu}_{ll}), W(\hat{\mu}_{hh})\}$. Without loss of generality, we assume that $W(\hat{\mu}_{ll}) < W(\hat{\mu}_{hh})$, leading to $W(\hat{\mu}_{ll}) \le c < W(\hat{\mu}_{hh})$. If firm 1, observing $s_1 = L$, sends $l$, then the consumer, because of observational error, will receive either $(l, l)$ or $(l, h)$. In both cases, the consumer will leave the market because $W(\hat{\mu}_{lh}) < W(\hat{\mu}_{ll}) \le c$, yielding zero expected payoff for firm 1. However, if firm 1 sends $h$, the consumer receives $(h, h)$ with nonzero probability, and purchase product 1 with strictly positive probability because $c < W(\hat{\mu}_{hh})$. Therefore, firm 1 will deviate from $l$ to $h$, destroying the truthful equilibrium.

Second, consider the case $W(\mu_0) \le c < \min\{W(\hat{\mu}_{ll}), W(\hat{\mu}_{hh})\}$. Without loss of generality, we assume that $\mu_0 \ge 1/2$. We will show that the truthful equilibrium can exist in this range. We first establish a useful result in the next lemma for further analysis (the detailed but straightforward proof is provided in the Online Appendix).

**Lemma A.1.** *If the consumer visits the store, as the consumer's posterior belief $\hat{\mu}$ increases, the probability of purchasing from firm 1 increases whereas that of purchasing from firm 2 decreases.* □

**Proof.** See the Online Appendix.

Using this lemma, we can first establish the equilibrium conditions for both firms.

1. Firm 1: (1) Suppose that firm 1 observes $s_1 = H$. Because $\hat{\mu}_{hh} > \hat{\mu}_{ll}$, according to Lemma A.1, the consumer is more likely to buy product 1 after receiving $(h, h)$ than $(l, l)$. That is, $\pi_1(h, h) > \pi_1(l, l)$. The expected payoffs for firm 1 for sending messages $h$ and $l$ are

$$\Pi_1^*(H) = \underbrace{\frac{\mu_0(1-\gamma)^2 + (1-\mu_0)\gamma^2}{\mu_0(1-\gamma) + (1-\mu_0)\gamma}}_{\Pr(s_2=H|s_1=H)} \cdot \pi_1(h, h),$$
$$\hat{\Pi}_1(H) = \underbrace{\frac{\gamma(1-\gamma)}{\mu_0(1-\gamma) + (1-\mu_0)\gamma}}_{\Pr(s_2=L|s_1=H)} \cdot \pi_1(l, l), \tag{A.5}$$

where the terms inside the underbraces represent the conditional probabilities that firm 2 observes $s_2 = H$ or $s_2 = L$, respectively, given firm 1 observes $s_1 = H$. We can derive the condition under which the expected payoff for sending $m_1 = h$ exceeds that for $m_1 = l$, which occurs when

$$\mu_0(1-\gamma)^2 + (1-\mu_0)\gamma^2 > \gamma(1-\gamma) \Leftrightarrow (\mu_0 - \gamma)(1 - 2\gamma) > 0. \tag{A.6}$$

This condition implies that for $\gamma < \min\{\mu_0, 1/2\}$, the weighted probability of the successful outcome with $m_1 = h$ (i.e., receiving and benefiting from $(h, h)$) exceeds that of $m_1 = l$, leading firm 1 to prefer sending $m_1 = h$ over $m_1 = l$. Therefore, in this setting, firm 1 does not find it beneficial to deviate to $m_1 = l$, confirming the equilibrium condition.

(2) Suppose that firm 1 observes $s_1 = L$. Similar to (1), the firm 1's expected payoff for sending messages $m_1 = h$ and $l$ are

$$\hat{\Pi}_1(L) = \underbrace{\frac{\gamma(1-\gamma)}{(1-\mu_0)(1-\gamma) + \mu_0\gamma}}_{\Pr(s_2=H|s_1=L)} \cdot \pi_1(h, h),$$

$$\Pi_1^*(L) = \underbrace{\frac{(1-\mu_0)(1-\gamma)^2 + \mu_0\gamma^2}{(1-\mu_0)(1-\gamma) + \mu_0\gamma}}_{\Pr(s_2=L|s_1=L)} \cdot \pi_1(l, l). \tag{A.7}$$

Given that $\pi_1(h, h) > \pi_1(l, l)$, firm 1 will not to deviate if $\Pr(s_2 = H|s_1 = L)$ is sufficiently smaller than $\Pr(s_2 = L|s_1 = L)$.

As $\gamma$ decreases, $\Pr(s_2 = H|s_1 = L)$ converges to zero and $\Pr(s_2 = L|s_1 = L)$ converges to one. Concurrently, $\hat{\mu}_{hh}$ approaches one and $\hat{\mu}_{ll}$ nears zero, implying that $\pi_1(h, h)$ and $\pi_1(l, l)$ each converge to a positive constant (according to the condition in Equation (8), when the belief is zero or one, the probabilities of the consumer purchasing product 1 and product 2 remain positive, as can be observed in Figure 2). Therefore, for a sufficiently small $\gamma$, the large second term ensures firm 1 does not deviate to $h$. Specifically, there exists a $\overline{\gamma}_1 > 0$ such that for $\gamma < \overline{\gamma}_1$, firm 1 does not deviate from the truthful equilibrium strategy.

2. For firm 2: Employing a similar logic for firm 1, we show that when a sufficiently small $\gamma < \min\{1 - \mu_0, 1/2\}$, firm 2 remains committed to the truthful messaging, and does not deviate. Specifically, there exists a threshold $\overline{\gamma}_2 > 0$ such that for $\gamma < \overline{\gamma}_2$, firm 2 adheres to the truthful equilibrium strategy. The complete proof is detailed in the Online Appendix.

Now, let $\overline{\gamma} = \min\{\overline{\gamma}_1, \overline{\gamma}_2\}$. Then, for $\gamma < \overline{\gamma}$, firm 1 and firm 2 do not deviate from the truthful equilibrium strategy. □

## A.5. Proof of Proposition 2

1. Recall from Lemma A.1 that as $\hat{\mu}$ increases (decreases), the consumer's probability of purchasing product 1 increases (decreases), whereas the probability of purchasing product 2 decreases (increases). Moreover,

$$\frac{\partial \hat{\mu}_{hh}}{\partial \gamma} = \frac{-2\gamma(1-\gamma)\mu_0(1-\mu_0)}{((1-\gamma)^2\mu_0 + \gamma^2(1-\mu_0))^2} < 0,$$

$$\frac{\partial \hat{\mu}_{ll}}{\partial \gamma} = \frac{2\gamma(1-\gamma)\mu_0(1-\mu_0)}{(\gamma^2\mu_0 + (1-\gamma)^2(1-\mu_0))^2} > 0. \tag{A.8}$$

Thus, we can conclude that (i) $\pi_1(h,h)$ and $\pi_2(l,l)$ are strictly decreasing in $\gamma$, and (ii) $\pi_2(h,h)$ and $\pi_1(l,l)$ are strictly increasing in $\gamma$.

2. We will show that $\mathbb{E}\Pi_1^*$ decreases in $\gamma$ when $\mu_0$ approaches 0, 1, and 1/2. For this, we first calculate $\partial\mathbb{E}\Pi_1^*/\partial\gamma$ explicitly. For notational convenience, let

$$\lambda_1 = \Pr[s_1 = H, s_2 = H] = \mu_0(1-\gamma)^2 + (1-\mu_0)\gamma^2,$$
$$\lambda_2 = \Pr[s_1 = L, s_2 = L] = \mu_0\gamma^2 + (1-\mu_0)(1-\gamma)^2,$$
$$\lambda_3 = 2(\overline{U} - \underline{U})\gamma(1-\gamma)\mu_0(1-\mu_0).$$

Utilizing these definitions, we construct the expected payoffs for firms 1 and 2:

$$\mathbb{E}\Pi_1^* = \lambda_1 \cdot \pi_1^*(h,h) + \lambda_2 \cdot \pi_1^*(l,l),$$
$$\mathbb{E}\Pi_2^* = \lambda_2 \cdot \pi_2^*(l,l) + \lambda_1 \cdot \pi_2^*(h,h).$$

Changes in utilities based on $\gamma$ are given by

$$\frac{\partial\,\mathbb{E}U_1(\hat{\mu}_{hh})}{\partial\gamma} = -\frac{\lambda_3}{\lambda_1^2},\quad \frac{\partial\,\mathbb{E}U_1(\hat{\mu}_{ll})}{\partial\gamma} = \frac{\lambda_3}{\lambda_2^2},\quad \frac{\partial\,\mathbb{E}U_2(\hat{\mu}_{hh})}{\partial\gamma} = \frac{\lambda_3}{\lambda_1^2},$$
$$\frac{\partial\,\mathbb{E}U_2(\hat{\mu}_{ll})}{\partial\gamma} = -\frac{\lambda_3}{\lambda_2^2}.$$

(1) Analysis at $\mu_0 = 1/2$: With $\mu_0 = 1/2$, we simplify the analysis because of the symmetry:

$$\hat{\mu}_{hh} = \frac{(1-\gamma)^2}{\gamma^2 + (1-\gamma)^2},\quad \hat{\mu}_{ll} = \frac{\gamma^2}{\gamma^2 + (1-\gamma)^2},$$
$$\lambda_1 = \lambda_2 = \frac{\gamma^2 + (1-\gamma)^2}{2},$$

implying $\hat{\mu}_{hh} + \hat{\mu}_{ll} = 1$. Also, $\frac{\partial\hat{\mu}_{hh}}{\partial\gamma} = \frac{2\gamma(\gamma-1)}{4\gamma^4 - 8\gamma^3 + 8\gamma^2 - 4\gamma + 1} < 0$, $\frac{\partial\hat{\mu}_{ll}}{\partial\gamma} = \frac{2\gamma(1-\gamma)}{4\gamma^4 - 8\gamma^3 + 8\gamma^2 - 4\gamma + 1} > 0$. Then, the expected payoff for firm 1 is now rewritten as

$$\mathbb{E}\Pi_1^* = \lambda_1 \cdot \pi_1^*(h,h) + \lambda_2 \cdot \pi_1^*(l,l)$$
$$= \frac{\gamma^2 + (1-\gamma)^2}{2} \cdot (\pi_1^*(h,h) + \pi_2^*(h,h)).$$

We show that $\partial\mathbb{E}\Pi_1^*/\partial\gamma < 0$ because $\pi_1^*(h,h) + \pi_2^*(h,h)$ increases in $\hat{\mu}_{hh}$ and therefore decreases in $\gamma$. Additionally, the function $(\gamma^2 + (1-\gamma)^2)/2$ also decreases in $\gamma$. Therefore, $\mathbb{E}\Pi_1^*$ decreases in $\gamma$. Similarly, we can see $\partial\mathbb{E}\Pi_2^*/\partial\gamma < 0$. Therefore, by continuity, we can conclude that $\partial\mathbb{E}\Pi_1^*/\partial\gamma < 0$, $\partial\mathbb{E}\Pi_2^*/\partial\gamma < 0$ for $\mu_0$ close to 1/2. (2) Approaching $\mu_0$ near zero or one: As $\mu_0$ moves toward the boundaries of its range (either zero or one), the ratios $\frac{\lambda_3}{\lambda_1}$ and $\frac{\lambda_3}{\lambda_2}$ diminish. To see this, we note that $\lambda_1 = (\gamma - \mu_0)^2 + \mu_0(1-\mu_0) \geq \mu_0(1-\mu_0)$, $\lambda_2 = (\gamma - (1-\mu_0))^2 + \mu_0(1-\mu_0) \geq \mu_0(1-\mu_0)$, and $\frac{\lambda_3}{\lambda_1}, \frac{\lambda_3}{\lambda_2} \leq 2(\overline{U} - \underline{U})\gamma(1-\gamma)$, Therefore, for $\gamma < \min\{\mu_0, 1-\mu_0\}$, we have

$$\frac{\lambda_3}{\lambda_1}, \frac{\lambda_3}{\lambda_2} < 2(\overline{U} - \underline{U})\mu_0(1-\mu_0)$$
$$< \min\{2(\overline{U} - \underline{U})\mu_0,\ 2(\overline{U} - \underline{U})(1-\mu_0)\}.$$

Thus, as $\mu_0$ approaches zero or one, $\lambda_3/\lambda_1$ and $\lambda_3/\lambda_2$ diminish to zero. We can now see

$$\frac{\partial\mathbb{E}\Pi_1^*}{\partial\gamma} = \frac{\partial}{\partial\gamma}\left(\frac{\gamma^2 + (1-\gamma)^2}{2}\right) \cdot \left(\pi_1^*(h,h) + \pi_2^*(h,h)\right)$$
$$+ \frac{\gamma^2 + (1-\gamma)^2}{2} \cdot \frac{\partial\left(\pi_1^*(h,h) + \pi_2^*(h,h)\right)}{\partial\gamma}, \tag{A.9}$$

where $\frac{\partial}{\partial\gamma}\left(\frac{\gamma^2 + (1-\gamma)^2}{2}\right) = 4\gamma - 2$. For a sufficiently small $\mu_0$ and $\gamma < \mu_0$, we can observe that the first, second, and fourth terms converge to zero, but the third term is bounded away from zero, being a negative number. That is, $\partial\mathbb{E}\Pi_1^*/\partial\gamma < 0$. Also, for a sufficiently large $\mu_0$ close to one and $\gamma < 1 - \mu_0$, we can observe that the second, third, and fourth terms converge to zero, but the first term is bounded away from zero, being a negative number. That is, $\partial\mathbb{E}\Pi_1^*/\partial\gamma < 0$. Similarly, we can get same result for $\mathbb{E}\Pi_2^*$.

Thus, by continuity, for $\mu_0$ near 1/2, and as $\mu_0$ approaches zero or one, $\partial\mathbb{E}\Pi_1^*/\partial\gamma < 0$ and $\partial\mathbb{E}\Pi_2^*/\partial\gamma < 0$, and thus the expected payoff $\mathbb{E}\Pi_i^*$ indeed decreases with increasing $\gamma$. □

## A.6. Proof of Proposition 3

Here, we show that $\overline{c} - \underline{c}$ decreases in $\gamma$. Because $\underline{c} = W(\mu_0)$ is independent of $\gamma$, it suffices to show that $\overline{c} = \min\{W(\hat{\mu}_{hh}), W(\hat{\mu}_{ll})\}$ decreases in $\gamma$. From Lemma 1, $W(\cdot)$ is a convex function symmetric about $\hat{\mu} = 1/2$, decreasing on $(0, 1/2)$ and increasing on $(1/2, 1)$.

By chain rule, $\frac{\partial W(\hat{\mu}_{hh})}{\partial\gamma} = \frac{\partial W(\hat{\mu}_{hh})}{\partial\hat{\mu}_{hh}} \cdot \frac{\partial\hat{\mu}_{hh}}{\partial\gamma}$. Note that $\frac{\partial W(\hat{\mu}_{hh})}{\partial\hat{\mu}_{hh}} > 0$ because $\hat{\mu}_{hh} \in (1/2, 1)$ and $\frac{\partial\hat{\mu}_{hh}}{\partial\gamma} < 0$. Thus, $\partial W(\hat{\mu}_{hh})/\partial\gamma < 0$. Likewise, we have $\frac{\partial W(\hat{\mu}_{ll})}{\partial\gamma} = \frac{\partial W(\hat{\mu}_{ll})}{\partial\hat{\mu}_{ll}} \cdot \frac{\partial\hat{\mu}_{ll}}{\partial\gamma}$. Note that $\frac{\partial W(\hat{\mu}_{ll})}{\partial\hat{\mu}_{ll}} < 0$ because $\hat{\mu}_{ll} \in (0, 1/2)$ and $\frac{\partial\hat{\mu}_{ll}}{\partial\gamma} > 0$. Therefore, $\frac{\partial W(\hat{\mu}_{ll})}{\partial\gamma} < 0$. Together with the previous result that $\frac{\partial W(\hat{\mu}_{hh})}{\partial\gamma} < 0$, this demonstrates that $\frac{\partial\overline{c}}{\partial\gamma} < 0$ and $\frac{\partial(\overline{c} - \underline{c})}{\partial\gamma} < 0$.

For the comparative static analyses with respect to $p$ and $u_H$, see the Online Appendix. □

## A.7. Proof of Proposition 4

1. Without loss of generality, consider the strategy, where firm 1 always sends $h$ and firm 2 always sends $l$. In this case, $\mu_0 = \Pr[\omega = \omega_H | (h,l)]$. Thus, when a pooling equilibrium exists and $W(\mu_0) \leq c$, the consumer does not visit the store. Also, we impose the passive off-equilibrium beliefs such that $\Pr[\omega = \omega_H | (h,h)] = \Pr[\omega = \omega_H | (l,l)] = \mu_0$. When $W(\mu_0) \leq c$, then no firm will deviate because deviating would still result in a payoff of zero. Also, if $W(\mu_0) > c$, then no firm will still deviate because deviating would not change the payoff. Thus, a pooling equilibrium always exists.

2. Consider an asymmetric equilibrium where transactions occur. Without loss of generality, suppose that firm 2 sends $h$ regardless of $s_2$, firm 1 chooses $m_1 = h$ if $s_1 = H$ and $m_1 = l$ if $s_1 = L$. Then, the consumer's posterior beliefs, given these strategies are

$$\hat{\mu}_{hh}^{semi} := \Pr[\omega = \omega_H | (h,h)] \quad = \mu_0(1-\gamma) + (1-\mu_0)\gamma,$$

$$\hat{\mu}_{lh}^{semi} := \Pr[\omega = \omega_H | (l,h)] \quad = \mu_0\gamma + (1-\mu_0)(1-\gamma).$$

Suppose $\mu_0 > 1/2$. Given $\gamma < 1/2$, we have

$$1 - 2\hat{\mu}_{lh}^{semi} = (2\mu_0 - 1)(1-2\gamma) > 0 \;\Rightarrow\; \hat{\mu}_{lh}^{semi} < 1/2 < 1 - \hat{\mu}_{lh}^{semi}.$$

By Lemma A.1, the consumer is more likely to buy product 2 than product 1 after observing $(l,h)$. Similarly, the consumer is more likely to buy product 1 than product 2 after observing $(h,h)$. Therefore, firm 1 has an incentive to deviate to $h$ from $l$ observing $s_1 = L$. Moreover, because $1 - \hat{\mu}_{lh}^{semi} = \hat{\mu}_{hh}^{semi}$, the consumer observing $(l,h)$ and $(h,h)$ will visit the store in both cases if $c < W(\hat{\mu}_{hh}^{semi})$, and will not visit the store in either case if $c \geq W(\hat{\mu}_{hh}^{semi})$. That is, there is no equilibrium when $\mu_0 > 1/2$. Also, for $\mu_0 < 1/2$, a similar analysis shows that firm 1 will also find it profitable to deviate, confirming there is no equilibrium when $\mu_0 < 1/2$. Only when $\mu_0 = 1/2$, both $\hat{\mu}_{hh}^{semi} = \hat{\mu}_{lh}^{semi}$, making the consumer indifferent between purchasing product 1 and product 2 whether he receives $(l,h)$ or $(h,h)$. Thus, firm 1 has no incentive to deviate, confirming the existence of asymmetric equilibrium only at $\mu_0 = 1/2$. □

## A.8. Proof of Proposition 5

Suppose a truthful equilibrium in which the consumer visits the firm's store existed. In this equilibrium, the firm adopts a truthful strategy, that is, $m(H) = h$ and $m(L) = l$. Accordingly, upon observing each message, the consumer updates beliefs about the true state as follows:

$$\hat{\mu}_h = \frac{(1-\gamma)\mu_0}{(1-\gamma)\mu_0 + \gamma(1-\mu_0)},\ \hat{\mu}_l = \frac{\gamma\mu_0}{\gamma\mu_0 + (1-\gamma)(1-\mu_0)}. \tag{A.10}$$

Given the beliefs, the consumer's expected utility from visiting the store is

$$\begin{aligned} W_M(\hat{\mu}) &= \frac{1}{2}\int_{-1}^{1} \max\{\overline{U}_M(\hat{\mu}) + \nu - p, 0\}\, d\nu \\ &= \frac{1}{2}\int_{\nu \geq p - \overline{U}_M(\hat{\mu})} (\mathbb{E}U_M(\hat{\mu}) + \nu - p)\, d\nu, \\ &= \frac{1}{4}(\mathbb{E}U_M(\hat{\mu}) + 1 - p)^2, \end{aligned} \tag{A.11}$$

where $\mathbb{E}U_M(\hat{\mu}) = \hat{\mu}\overline{U} + (1-\hat{\mu})\underline{U}$. The consumer visits the store if and only if $W_M(\hat{\mu}) \geq c$ for $\hat{\mu} = \hat{\mu}_h$ or $\hat{\mu}_l$. Thus, if $c \leq \min\{W_M(\hat{\mu}_h), W_M(\hat{\mu}_l)\}$ holds, the consumer will visit the firm's store following any message $m \in \{h,l\}$. Upon visiting the store, the consumer realizes $\nu$ from a uniform distribution on $[-1,1]$ and buys the product if and only if $\mathbb{E}U_M(\hat{\mu}) + \nu - p \geq 0$, that is, $\nu \geq p - \mathbb{E}U_M(\hat{\mu})$. Thus, the firm's expected profit in this region for $c$ is

$$\pi_M^*(\hat{\mu}) = p \cdot (1 - p + \mathbb{E}U_M(\hat{\mu}))/2. \tag{A.12}$$

Note that this profit function increases in $\mathbb{E}U_M(\hat{\mu})$.

Next, we analyze the existence of the truthful equilibrium for different intervals of $c$.

1. $0 < c < W_M(\hat{\mu}_l)$:

Suppose a truthful equilibrium existed. Note that $\mathbb{E}U_M(\hat{\mu}_h) = \hat{\mu}_h\overline{U} + (1-\hat{\mu}_h)\underline{U} > \hat{\mu}_l\overline{U} + (1-\hat{\mu}_l)\underline{U} = \mathbb{E}U_M(\hat{\mu}_l)$. This implies that the firm always finds it optimal to announce the message $m = m_h$. That is, the firm has a profitable deviation; when it receives a noisy signal $s = L$, it deviates to the message $m = m_h$.

2. $W_M(\hat{\mu}_l) \leq c < W_M(\hat{\mu}_h)$:

In this case, the consumer only visits the firm after receiving the message $m_h$, but not after $m_l$. Thus, the firm's expected profit is zero if it sends $m_l$ and positive if it sends $m_h$. Thus, upon seeing a noisy signal $L$, the firm deviates from the truthful strategy and sends $m_h$ to the consumer.

3. $c \geq W_M(\hat{\mu}_h)$:

In this case, the consumer does not visit the store, and the firm's expected profit is zero, which contradicts our definition (Definition 2) of the truthful equilibrium.

Next, we analyze the existence of pooling equilibria. Whether the firm adopts a pooling strategy $m(s) = h$ or $m(s) = l$, the consumer's posterior beliefs about the true state are the same as the prior $\mu_0$. Thus, the consumer will visit the store if and only if $c < W_M(\mu_0)$. The firm has no reason to deviate from a pooling strategy because a deviation does not affect the consumer's beliefs and the decision for whether to visit the store. Thus, the pooling equilibrium exists. □

## A.9. Proof of Proposition 6

It can be shown that $\bar{c}_M \leq \underline{c} \leq \bar{c}$ holds (see the Online Appendix).

First, consider $c \geq \bar{c}$. Even under the most positive beliefs of the consumer, the consumer does not visit the store(s) under the case of monopoly and duopoly. The firm obtains zero profit under both cases, and thus the firm is indifferent.

Second, consider $\bar{c}_M \leq c < \underline{c}$. In the game of duopoly, a pooling equilibrium exists with the consumer visiting the stores uniquely. In the game of monopoly, the unique equilibrium is a pooling equilibrium with the consumer not visiting the firm. Thus, the firm is better off in a duopoly market.

Third, for $\underline{c} \leq c < \bar{c}$, the truthful equilibrium exists in a duopoly game. In a monopoly game, only a pooling equilibrium with the consumer not visiting the firm exists. Thus, the firm is better off in a duopoly market.

Lastly, for $c < \bar{c}_M$, a unique equilibrium in both the duopoly and monopoly games is a pooling equilibrium with the consumer visiting the store(s). For the profit comparison, see the Online Appendix. □

## A.10. Sketch Proof of Proposition 7

Note that price deviation does not affect the consumer's belief about the state. Given the symmetry between firms because of $\mu_0 = 1/2$, it suffices to consider the deviations of firm 1. If the two firms announce different messages, we assign a pessimistic off-equilibrium belief as follows: $\hat{\mu}((p,h),(p^*,l)) = \hat{\mu}((p,l),(p^*,h)) = 0.5$.

We consider three pricing decisions: (i) a local deviation $p$ near $p^*$, (ii) a nonlocal deviation to a price higher than the equilibrium price $p > p^*$, and (iii) a nonlocal deviation to a lower price $p < p^*$.

1. First, given the equilibrium price $p^*$, we identify thresholds $\underline{c}^1 = W(0.5, p^*) + \varepsilon$ for an arbitrarily small positive $\varepsilon$ and $\bar{c} = W(1, p^*)$ of the consumer search cost such that for

$c \in [\underline{c}^1, \overline{c})$, truth-telling is incentive compatible for firm 1. Then, we identify a unique candidate for the equilibrium price by solving the first-order condition of firm 1's pricing decision, which is $p^* = (\overline{U} - 3) + \sqrt{(\overline{U} - 3)^2 - \overline{U}\underline{U} + \overline{U} + \underline{U} + 3}$.

2. For a nonlocal deviation to $p > p^*$, we show that truth-telling is incentive compatible for firm 1 given $p$. The exact calculation of firm 1's expected payoff depends on the extent of price deviation. Set $\overline{p} := \min\{p^* + \overline{U} - \underline{U}, \underline{U} + 1\}$. We find a condition on $\overline{p}$ such that $p^*$ becomes a local maximum. Moreover, set another threshold $\underline{c} = \max\{\underline{c}^1, W(0, \overline{p})\}$ such that for any $c \in [\underline{c}, \overline{c})$, firm 1 does not deviate to $p > p^*$. This rules out local deviations and a nonlocal deviation to $p > p^*$.

3. Lastly, for $p < p^*$ we can show that for $c \in [\underline{c}, \overline{c})$, truth-telling is incentive compatible for firm 1 given $p$. Firm 1 may deviate to a sufficiently low price and announce dishonestly in order to induce the consumer's visit even with pessimistic beliefs. However, we can show, with an additional condition, that adopting such a low-pricing strategy is dominated by the equilibrium strategy.

The point $(\omega_H, u_H, u_L) = (0.7, 2, 1)$ (and an open set containing this point) satisfies all the sufficient conditions for the existence of the truthful equilibrium with endogenous price $p^*$. □

### A.11. Proof of Proposition 8

Here, we show the existence of pooling equilibria. For the nonexistence of a separating equilibrium, see the Online Appendix.

Suppose that firm 1 uses a pooling strategy. That is, either $\sigma_1(H) = \sigma_1(L) = 1$, or $\sigma_1(H) = \sigma_1(L) = 0$. In each case, we assume that the consumer's off-equilibrium beliefs remain unaffected. That is, irrespective of firm 1's message $m_1 \in \{h, l\}$, $\hat{\mu}(m_1) = \mu_0$. Firm 1's message carries no information about the true state $\omega$. Therefore, the consumer relies only on firm 2's message. Referring to the logic used in Proposition 4, part 2 (asymmetric equilibrium), except when $\mu_0 = 1/2$, firm 2 has a profitable deviation from a truthful strategy.[25] Also, referring to the logic used in Proposition 4, part 1, a pooling equilibrium exists. □

### A.12. Proof of Proposition 9

We show Part 1(a) here. To show the existence of the asymmetric equilibrium in mixed strategies, we need to prove that there exists $\delta \in (0,1)$ such that no player (and no player type) has a profitable deviation, given that the beliefs are consistent with the equilibrium strategy and updated using Bayes rule whenever possible. It is worth noting that the sequence of communication does not affect the existence of this equilibrium because firm 1, assumed to adopt a pooling strategy, does not transmit any information in its messages.

Let $c$ be randomly drawn from a uniform distribution $c \sim U[\underline{c}', \overline{c}']$, where $\overline{c}' = W(1)$ and $\underline{c}' = W(\min\{0.5, \mu_0\})$. The consumer whose posterior belief is $\hat{\mu}$ chooses to visit the stores if and only if $W(\hat{\mu}) - c \geq 0$. Thus, from the firms' perspectives, the likelihood that the consumer will visit the stores is $(W(\hat{\mu}) - \underline{c}')/(\overline{c}' - \underline{c}')$.

Upon observing the messages from the two firms, the consumer updates beliefs about the true state. Considering firm 1's pooling strategy, the consumer does not draw any information from firm 1's message. Therefore, the consumer's posterior belief is determined by firm 2's strategy, characterized by $\delta$, and firm 2's message $m_2 \in \{h, l\}$:

$$\begin{aligned}\hat{\mu}'_{hl}(\delta) &:= \Pr(\omega = \omega_H | (h,l)) \\ &= \frac{\mu_0((1-\gamma)(1-\delta)+\gamma)}{\mu_0((1-\gamma)(1-\delta)+\gamma) + (1-\mu_0)((1-\gamma)+\gamma(1-\delta))} m, \\ \hat{\mu}'_{hh}(\delta) &:= \Pr(\omega = \omega_H | (h,h)) \\ &= \frac{\mu_0(1-\gamma)}{\mu_0(1-\gamma) + (1-\mu_0)\gamma} > \max\{\mu_0, 0.5\}.\end{aligned} \tag{A.13}$$

Because firm 2's strategy is partially truthful, the consumer updates belief about the true state being $\omega = \omega_H$ more negatively if firm 2 sends a message $l$, that is, $\hat{\mu}'_{hl} < \mu_0$. Likewise, $\hat{\mu}^l_{hh} > \max\{\mu_0, 0.5\}$. Moreover, note that $\hat{\mu}'_{hl}(\delta)$ decreases in $\delta$.

We analyze first the case $\mu_0 \geq 0.5$ such that $\underline{c}' = W(0.5)$. Given the strategies specified above, the expected payoff of firm 2 if the consumer observes message $(h,h)$ is $\pi_2^\delta(h,h) := D_2(\hat{\mu}'_{hh}) \cdot (W(\hat{\mu}'_{hh}) - \underline{c}')/(\overline{c}' - \underline{c}')$. Likewise, if the consumer observes messages $(h,l)$, firm 2's expected payoff is $\pi_2^\delta(h,l) := D_2(\hat{\mu}'_{hl}) \cdot (W(\hat{\mu}'_{hl}) - \underline{c}')/(\overline{c}' - \underline{c}')$. With the next lemma, we will have identified conditions under which the equilibrium exists.

**Lemma A.2.** *There exists $\hat{\delta}$ such that $\pi_2^\delta(h,h) = \pi_2^\delta(h,l)$ when $\delta = \hat{\delta}$.*

The proof of Lemma A.2 and the proofs of Parts 1(b) and 2 are provided in the Online Appendix. □

### A.13. Proof of Proposition 10

Without loss of generality, assume that $\mu_0 \geq 1/2$ so that, based on the consumer's prior beliefs, the consumer's expected utility from product 1 is greater than that of product 2, that is, $\mathbb{E}U_1(\mu_0) > \mathbb{E}U_2(\mu_0)$.

First, suppose that the consumer's search sequence is endogenous. We focus on showing nonexistence of the truthful equilibrium in firms make truthful announcements because this strategy acts as a device for the firms to coordinate on sending consistent messages. In this equilibrium, the consumer begins a search process when the messages are consistent but not when the messages are inconsistent.

The messages can be one of four permutations: $(h,h), (h,l), (l,h), (l,l)$. In every case, according to Weitzman (1979), if the consumer begins her search process, the consumer must search the firm from which the consumer expects a higher utility (or, reserve price in the language of search theory literature) first. Note that $\hat{\mu}_{hh} > \mu_0 \geq 1/2 \geq \hat{\mu}_{ll}$. Thus, following a message $\mathbf{m} = (h,h), (h,l)$ or $(l,h)$, the consumer will visit firm 1 first, if at all. Only after the message $\mathbf{m} = (l,l)$ will the consumer visit firm 2 first. Given the beliefs $\mu$, the consumer will visit firm $i$ if and only if $Y_i(\mu) > c$, where $Y_i(\mu)$ is the consumer's expected value from visiting firm $i$ given the belief $\mu$ and the outside option 0:

$$\begin{aligned}Y_i(\mu) &= \mathbb{E}[\max\{0, \mathbb{E}U_i(\mu) + \nu_i - p\}] \\ &= \frac{1}{2}\int_{\nu_i \geq -\mathbb{E}U_i(\mu)+p}^{1} (\mathbb{E}U_i(\mu) + \nu_i - p)\, d\nu_1 \\ &= \frac{1}{4}(\mathbb{E}U_i(\mu) + 1 - p)^2.\end{aligned} \tag{A.14}$$

If $c > Y_1(\mu_0)$, the consumer will not initiate the search process when the messages are inconsistent. Facing consistent messages $\mathbf{m} = (h, h)$, the consumer will first visit firm 1 if $c < Y_1(\hat{\mu}_{hh})$. However, after visiting firm 1, the consumer will never visit firm 2. For the consumer to visit firm 2, the consumer's best alternative then will at least be zero because of the outside option. Thus, a necessary condition for the consumer's decision to visit firm 2 is $Y_2(\hat{\mu}_{hh}) > c$. However, this violates the condition that $c > Y_1(\mu_0)$ because $Y_2(\hat{\mu}_{hh}) < Y_1(\mu_0)$. This shows that the truthful equilibrium in which the consumer initiates the search if and only if the consumer receives consistent messages does not exist when the consumer can choose the sequence of the search.

The remaining proof for the consumer's random search process is available in the Online Appendix. □

## Endnotes

[1] "Which Car Brands Offer Full EVs? 7 EV Manufacturers Compared" (https://www.makeuseof.com/which-car-brands-offer-full-evs/).

[2] "The Best Smart Home Devices of 2024, According to Experts" (https://www.goodhousekeeping.com/home-products/a35880026/best-smart-home-device/).

[3] An alternative model could feature consumers with heterogeneous $\omega$ weights, and the current analysis and outcomes remain robust provided that the heterogeneity in $\omega$ is sufficiently small.

[4] Here, $U_1(\omega_H) = \omega_H \cdot u_H + (1-\omega_H)\cdot u_L = (1-\omega_L)\cdot u_H + \omega_L \cdot u_L = (1-\omega_L)\cdot u_H + \omega_L \cdot u_L = U_2(\omega_L)$, and $U_1(\omega_L) = \omega_H \cdot u_L + (1-\omega_H)\cdot u_H = (1-\omega_L)\cdot u_L + \omega_L \cdot u_H = (1-\omega_L)\cdot u_L + \omega_L \cdot u_H = U_2(\omega_H)$.

[5] Although our main analysis assumes $\gamma \in (0, 1/2)$ to reflect noisy but informative signals, the results also extend to the case where $\gamma = 0$ (i.e., firms receive perfect signals), provided specific off-equilibrium beliefs are imposed. In that setting, both firms observe the true state with certainty, and sustaining truthful communication requires specifying how consumers interpret deviations (such as receiving conflicting messages, which should not occur in equilibrium). Although analytically convenient, these off-equilibrium beliefs (e.g., passive beliefs assigning posterior probability 0.5) may be viewed as arbitrary or ad hoc. By contrast, assuming $\gamma > 0$ avoids reliance on such belief specification, making the main model and its results more general and robust. Although the introduction of a noisy signal adds analytical complexity, it better reflects realistic market conditions, where firms typically rely on imperfect but informative signals from internal metrics, early market feedback, or preliminary data. In our extension with endogenous pricing, we adopt $\gamma = 0$ for tractability and explicitly specify off-equilibrium beliefs. Thus, although the main model avoids assumptions about off-equilibrium beliefs, we impose them only when necessary for analytical tractability in extensions.

[6] In our model, the search cost $c$ is a one-time expense of entering the product category and learning about both firms rather than the usual per-store travel cost in the search literature (Wolinsky 1986, Anderson and Renault 1999). This specification fits markets where engaging with the category is much more expensive than moving between sellers, for example, online channels or multibrand retailers where additional sampling is inexpensive once the consumer is inside. Section 5 shows that when $c$ instead applies to each individual visit, and consumers search firms in random order, our main results still hold.

[7] This assumption is standard in consumer search models, where a consumer must visit at least one firm to make a purchase (Armstrong et al. 2009, Armstrong and Zhou 2011, Zhou 2014, Ke and Lin 2020). It reflects settings such as in-store-only or category-entry situations where consumers face nontrivial uncertainty and must incur effort (e.g., store visits, research) to assess whether any product meets their needs. The outside option, in this context, corresponds to disengaging from the category altogether rather than choosing among known alternatives. This structure allows us to endogenize the consumer's decision to engage with the category, which is shaped by the firms' communication.

[8] Chakraborty and Harbaugh (2014) study cheap talk about attribute levels when the sender does not know the receiver's private valuation weights. Credibility arises because praising one attribute necessarily means forgoing the chance to "talk up" another, which appeals to receivers who value the highlighted attribute most. Their mechanism relies on heterogeneous receiver types and works even with a single sender. Our setting differs on both counts. Firms are jointly uncertain about which attribute is important (whereas attribute levels are common knowledge), and we do not assume heterogeneous consumer types. Even so, we show that cheap talk can remain credible—here because multiple competing firms act as senders, making the presence of rivalry essential to the mechanism.

[9] Formally, $\hat{\mu}$ is a function $\hat{\mu} : \{h, l\} \times \{h, l\} \to \Delta\{\omega_H, \omega_L\}$, denoted by $\hat{\mu}(\cdot|m_1, m_2)$. For simplicity, we use $\hat{\mu}(m_1, m_2)$ or $\hat{\mu}_{m_1 m_2}$ to denote the conditional probability that the consumer assigns to $\omega_H$ given $m_1, m_2$.

[10] There exists an alternative separating equilibrium where firms always report the opposite of their signals. Although this strategy appears different from truth-telling, it leads to the same outcomes as the truthful equilibrium because the consumer will correctly interpret the firm's private signal based on whether the firm adopts the truthful or the opposite of truthful strategy. Thus, among the separating equilibria, we focus on the truthful equilibrium (and do not exclude other equilibria) because they are all equivalent except for labeling.

[11] As a tie breaker, we assume that the consumer does not visit the store and leaves the market when $W(\hat{\mu}) = c$.

[12] We thank an anonymous reviewer for clarifying this point.

[13] For instance, for $\omega = \omega_H$, each firm receives signal $H$ with probability $1-\gamma$ and $L$ with $\gamma$. Thus, for $(m_1, m_2) = (h, h)$, $\Pr[(h,h)|\omega_H] = \Pr[(H,H)|\omega_H]\cdot m_1(H)m_2(H) + \Pr[(H,L)|\omega_H]\cdot m_1(H)m_2(L) + \Pr[(L,H)|\omega_H]\cdot m_1(L)m_2(H) + \Pr[(L,L)|\omega_H]\cdot m_1(L)m_2(L)$, where $\Pr[(H,H)|\omega_H] = (1-\gamma)^2$, $\Pr[(L,H)|\omega_H] = \Pr[(H,L)|\omega_H] = \gamma(1-\gamma)$, and $\Pr[(L,L)|\omega_H] = \gamma^2$.

[14] In contrast, if $\gamma \geq \min\{\mu_0, 1-\mu_0\}$, it could lead to an increased uncertainty for the consumer upon receiving consistent messages compared to when receiving conflicting ones. For example, if $\mu_0 > 1/2$ and $\gamma > \min\{\mu_0, 1-\mu_0\}$, then $\mu_0 - 1/2 > |1/2 - \hat{\mu}_{ll}|$, implying the consumer's posterior belief after receiving $(l, l)$ shifts closer to $1/2$ compared to the prior belief $\mu_0$. Thus, when $\gamma$ is high, indicating a significant amount of noise, the messages become less reliable as indicators of the true state.

[15] The probabilities $\Pr(s_1 = H, s_2 = H)$ and $\Pr(s_1 = L, s_2 = L)$ decrease in $\gamma$, because $\Pr(s_1 = s_2 = H) = \mu_0\cdot(1-\gamma)^2 + (1-\mu_0)\cdot\gamma^2$ and $\Pr(s_1 = s_2 = L) = \mu_0\cdot\gamma^2 + (1-\mu_0)\cdot(1-\gamma)^2$ are decreasing in $\gamma$ for $\gamma < \min\{\mu_0, 1-\mu_0\}$.

[16] This can be directly observed from Equations (5) and (7), where $W(\hat{\mu})$ increases with $u_H$ because $\overline{U}$ and $\underline{U}$ increase with $u_H$.

[17] In repeated games, reputational concerns can sustain truthful communication, even for monopolists (Wernerfelt 1994). Our model, however, considers a one-shot scenario where reputation effects are absent. Thus, credibility emerges solely through competition, reflecting real-world retail contexts with infrequent or one-time consumer interactions.

[18] In Section 5.2, Proposition 9 establishes that no semiseparating equilibrium exists, leaving pooling equilibria as the only possibility.

[19] This sequence of game implies that the firms' pricing decision cannot signal the unobservable state and allows for a tractable analysis. We thank an anonymous reviewer for suggesting this approach.

[20] Thus, the two firms must always receive the same signal. Then, under the truthful equilibrium in which both firms announce their signals truthfully, their messages must coincide on the equilibrium path. We impose an off-equilibrium belief of 1/2 in the event that firms send inconsistent messages such that the consumer's posterior belief is pessimistic.

[21] The "battle of the sexes" game (Fudenberg and Tirole 1991, pp. 18–20) refers to a classic coordination problem in which two players prefer different outcomes (e.g., one prefers the football game, the other the ballet) but prefer attending the same event over going separately. Coordination thus takes precedence over personal preference.

[22] We are grateful to an anonymous reviewer for suggesting that it is the unobservability of rival signals, not merely the timing of moves, that sustains truthful communication in equilibrium.

[23] Likewise, if both firms' incentives coincide and they wish to emphasize the same attribute, each will invariably highlight that attribute regardless of the true state.

[24] More formally, we consider a separating equilibrium in which both firms adopt a separating strategy, and thus the consumer can perfectly infer private messages of both firms.

[25] Technically, firm 2's strategy can depend on firm 1's message. However, because this dependency does not provide any information, the consumer's response is independent of firm 1's message and of how firm 2's message depends on it.

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