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The Taste Trap

How Consumer Reviews Distort Quality Investment

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Abstract

We investigate how biased consumer reviews affect monopolistically competitive firms' investment in the quality of experience goods. Review bias arises because consumer evaluations reflect not only true quality but also idiosyncratic taste, generating ratings that are inflated relative to underlying quality. We show that, compared to a benchmark with fully informative reviews, firms may either underinvest in quality despite the upward bias in ratings, or overinvest; similarly, quality provision may fall short of or exceed the level chosen by a welfare-maximizing planner. We also characterize conditions under which review bias induces firms that are less efficient in delivering quality to choose higher quality than more efficient competitors or to choose lower quality yet earn higher profits. Next, we examine improvements in review informativeness arising, e.g., from tools that systematically collect feedback from verified buyers or use AI to summarize product reviews. We show that unilateral adoption of these tools lowers the adopting firm's profits, whereas market-wide adoption may raise industry profits without necessarily mitigating quality distortions. Finally, we derive conditions under which initiatives aimed at enhancing trust in the review system, e.g., regulation of review manipulation, further exacerbate underinvestment.

Keywords: biased consumer reviews; monopolistic competition; experience goods; quality; taste; investment distortions.

JEL Codes: D11 (Consumer Economics: Theory), D21 (Firm Behavior: Theory), L13 (Oligopoly and Other Imperfect Markets), L15 (Information and Product Quality • Standardization and Compatibility), D9 (Micro-Based Behavioral Economics).

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1 Introduction

This paper studies how consumer reviews affect firms’ incentives to invest in the quality of experience goods. When buyers cannot fully observe quality before purchase –as is the case for experience goods (Nelson, 1970)– their willingness to pay is based on expected rather than actual quality and the resulting price fails to fully reward high-quality goods: this is the foundational intuition for underinvestment in quality provided by Akerlof (1970). A large subsequent literature, briefly reviewed below, has endogenized firms’ quality choices, studied how asymmetric information shapes their investment incentives, and shown that firms may invest either less or more in quality than under full information.

Against the backdrop of this literature, the informational environment surrounding experience goods has undergone a profound transformation due to the irresistible rise of e-commerce and the widespread diffusion of digital devices providing always-on access to tons of consumer reviews. Reviews allow prospective buyers to draw on feedback from previous buyers before purchasing experience goods. Insofar as this development has reduced buyers’ informational disadvantage, one might expect it also to mitigate underinvestment or overinvestment in quality in markets for experience goods.

Indeed, anecdotal evidence from business and industry sources supports the idea that consumer reviews affect firms’ quality incentives, rather than merely consumers’ demand: since ratings shape future demand and reputation, they alter the expected return to quality improvements. In hospitality, managers report using reviews to guide renovations, identify service failures, prioritize property improvements, and adjust staff training (e.g., Skift, 2013; White, 2014; Morrison, 2018). Restaurant operators likewise use reviews to identify recurring quality problems and undertake corrective action (National Restaurant Association, 2023). More systematic evidence is provided by Klein et al. (2016), who document that an eBay feedback reform reducing buyers’ fear of retaliation led sellers to engage in more effort toward improving buyer satisfaction, and by Donati (2026), who finds that a reduction in the cost of accessing reviews on TripAdvisor shifted demand toward higher-rated restaurants, prompting lower-rated establishments to upgrade quality.¹

Precisely because reviews have practical relevance for quality incentives, it is crucial to rec-

¹See also Ananthakrishnan et al. (2023), who provide evidence that hotels that pay attention to reviews on TripAdvisor and Expedia address the issues mentioned by reviewers, and Farronato and Zervas (2026), who show that New York City restaurants with greater visibility on Yelp incur fewer violations on dimensions of hygiene for which reviews are informative.

ognize they are not a frictionless signal of true quality: since most experience goods are both vertically and horizontally differentiated, consumer reviews reflect not only product quality but also the idiosyncratic fit between the product and the reviewer’s tastes (e.g., Sun, 2012). Importantly, the taste component need not be explicitly acknowledged by reviewers: buyers may perceive a product as objectively superior or inferior depending on how well it matches their preferences, thereby conflating personal fit with intrinsic quality (e.g., Spiller and Belogolova, 2017; Chen et al., 2021). In such cases, reviews may not contain clues revealing the role of taste, making the resulting distortion more pervasive and harder for subsequent buyers to detect. As a result, ratings may be systematically distorted relative to underlying quality (e.g., Chen et al., 2021; Bondi, 2025) and subsequent buyers may not be able to adjust for this distortion (e.g., Li and Hitt, 2008; Muchnik et al., 2013; de Langhe et al., 2016).²

The present paper incorporates the above considerations into a theoretical framework. We develop a three-period monopolistically competitive model in which firms supply vertically and horizontally differentiated experience goods. In the first period, each firm chooses the quality level of its product. In the second period, each firm sets its price; a buyer observes the prices set by all firms, but not product qualities prior to purchase; she then decides how many units of each product to buy and, after consumption, writes reviews of the products’ quality. This buyer is referred to as the early buyer and assumed to be representative of the population of early buyers who decide to write reviews or, at least, leave ratings. In the third period, each firm sets a new price for its product; a new buyer observes the updated prices and the reviews, but not actual product qualities, prior to purchase; he then makes his purchasing decisions. This buyer is referred to as the late buyer and assumed to be representative of the population of late buyers.

We assume that the average rating reported by the early buyer for each product is only partially informative about true quality, as it also reflects a taste component. We further assume that average ratings reward products that better match the early buyer’s tastes and that they exhibit an inflated mean. These assumptions capture empirically relevant features of online review systems arising from the interaction of two self-selection biases (e.g., Li and Hitt, 2008;

²The following examples, collected from well-known platforms, illustrate reviews of experience goods in which a taste component appears to affect the quality assessment, either positively or negatively. “Great ramen, especially if you like it spicy” (5 out of 5-bubble rating): https://www.tripadvisor.com/ShowUserReviews-g60864-d13230152-r738763757-Nomiya-New_Orleans_Louisiana.html. “This is not my genre... I didn’t like it much...” (1 out of 5-star rating): <https://www.goodreads.com/book/show/29476351-like-a-love-song>. In these two cases, the preference component is explicitly acknowledged. By contrast, consider the following review of a novel: “...Considering how ordinary, often boring, most people’s lives are, her book actually is about ‘normal people,’ but I expect authors to dress up the everyday. I expect tension, some drama, maybe a little suspense. I need a plot with a compelling reason for being...” (1 out of 5-star rating): <https://www.goodreads.com/book/show/63360780-normal-people>. Here, the preference component is less explicit and can only be inferred from the reviewer’s expectations about what a novel should provide.

Hu et al., 2017; Karaman, 2021): a pre-purchase acquisition bias, reflecting that buyers with stronger taste fit for a product are more likely to purchase and subsequently leave favorable reviews, and a post-purchase underreporting bias, reflecting that, conditional on purchase, buyers with very positive experiences and buyers with very negative experiences are more likely to post reviews than those with moderate experiences. Together, these biases can generate a J-shaped distribution of ratings, characterized by many ratings at the upper end of the scale that drive average ratings upward, fewer ratings at the lower end, and relatively few intermediate ratings. Finally, the late buyer is assumed to interpret average ratings as informative about true quality, without discounting the extent to which ratings are driven and inflated by the early buyer's taste (Besbes and Scarsini, 2018): as noted above, this assumption captures that the taste component can be difficult to detect, or –in case reviews explicitly acknowledge it– that it is too costly to process the individual reviews needed to disentangle quality from taste.

Our baseline analysis yields two sets of insights. First, biased consumer reviews distort firms' quality investment incentives in a nontrivial way. Because ratings are inflated relative to underlying quality, one might expect firms to respond by systematically overinvesting in quality in order to exploit the late buyer's optimistic assessment. We show this intuition is incomplete. Relative to a benchmark with fully informative reviews, firms may either underinvest or overinvest in quality. Underinvestment still arises when the inflation in ratings is not too pronounced because the limited informativeness of reviews weakens the marginal return to quality investment; this mechanism is consistent with the seminal intuition of Akerlof (1970). However, when inflation is sufficiently strong to outweigh this weakened incentive, overinvestment emerges. We also calculate the quality level that a planner would choose to maximize the per-product sum of firm profit and buyer surplus: this level is larger than the equilibrium quality under fully informative reviews because firms do not internalize the surplus that better quality confers on buyers. Nevertheless, particularly pronounced inflation in ratings can induce firms to overprovide quality relative to the level set by the planner.

Second, review bias can distort the ranking of firms in terms of equilibrium quality and profits. When reviews are fully informative, a firm that is less efficient in delivering quality unambiguously chooses lower quality and earns lower profits than a more efficient competitor; Jiang and Yang (2019) deliver a similar result in a model in which reviews reveal true quality. With biased reviews, however, this ordering may no longer hold. A less efficient firm ends up supplying higher quality and earning higher profits if it enjoys a sufficiently favorable taste advantage. Alternatively, it may continue to supply lower quality but nevertheless earn higher

profits when its taste advantage is not strong enough to compensate for its efficiency disadvantage, but is large enough to sufficiently inflate demand.

We next examine managerial initiatives that improve review informativeness, such as the systematic solicitation of feedback from verified buyers or AI-based review summaries, and policy interventions against review manipulation. Three findings are worth highlighting. First, no individual firm has a unilateral incentive to make reviews of its own product more informative because correcting rating inflation reduces its equilibrium profits. Second, a market-wide improvement in informativeness may instead increase industry profits. Third, interpreting regulation of review manipulation as a market-wide improvement in trust in the review system, we derive conditions under which greater trust exacerbates underinvestment in quality.

We finally assess the robustness of the paper's main results against several variations of the basic model.

Contribution and Related Literature. To the best of our knowledge, this paper is the first to examine how consumer reviews that are biased by taste affect competing firms' incentives to invest in product quality. In doing so, it contributes to two streams of literature. First, our analysis is related to the classical literature on quality provision under asymmetric information. [Riordan \(1986\)](#) and [Dranove and Satterthwaite \(1992\)](#) study monopolistic competition with experience goods and derive conditions under which firms provide less than the efficient level of quality. By contrast, [Belleflamme and Peitz \(2014\)](#) show that, when buyers observe quality investment but not realized quality, asymmetric information may induce firms to invest more than under full information, although underinvestment can still arise when quality investment is sufficiently costly. None of these works considers consumer reviews as a signal of quality: our contribution is to identify taste bias in consumer reviews as a key determinant of whether firms underinvest or overinvest in quality.

Second, our analysis contributes to the more recent and growing literature on consumer reviews. One strand studies how consumer reviews affect firms' quality-related decisions. [Kuksov and Xie \(2010\)](#) ask how a firm adjusts its pricing and provision of frills when late buyers rely on early buyers' ratings, while [Godes \(2017\)](#) and [Feldman et al. \(2019\)](#) examine how word of mouth and social learning affect product quality or design by a monopolistic firm. Similar analyses are developed by [Shin and Zeevi \(2024\)](#) and [Yan et al. \(2026\)](#). Most closely related to our competitive setting, [Zhao et al. \(2022\)](#), [Zhao et al. \(2023\)](#), and [Huang et al. \(2025\)](#) examine quality decisions by two competing firms when buyers use online reviews to assess product quality; see also [Kwark et al. \(2018\)](#), and [Donati \(2026\)](#). These papers endogenize firms' quality

responses to reviews, but do not consider reviews that are biased by taste.

A complementary strand examines biases in the information conveyed by consumer reviews. [Acemoglu et al. \(2022\)](#) study how endogenous selection into purchasing and reviewing affects information aggregation and learning from consumer reviews. As mentioned, [Chen et al. \(2021\)](#) show that consumers may mistake favorable product fit for intrinsic quality, generating inflated ratings, while [Fainmesser et al. \(2021\)](#) show that firms may strategically target early consumers with better fit for the product to influence subsequent ratings. In [Bondi \(2025\)](#), high-quality products induce purchases and then reviews even by buyers with weak taste for the product with the effect that reviews understate quality because of a weak average taste match. In [Johnen and Ng \(2026\)](#), consumers rate products on value for money and a low-quality entrant can cut its price to secure favorable ratings: this inflates ratings and reduces their informativeness. In these papers, firms do not choose product quality. Our contribution is to connect these two strands by studying how biased consumer reviews affect quality investments of competing firms.³

The remainder of the paper is organized as follows. Section 2 delineates the scope of the analysis and explains the modeling choices. Section 3 introduces the framework and solves for the equilibrium. Section 4 studies how review bias affects firms' incentives to invest in quality and their equilibrium profits. Section 5 provides a comparative statics analysis and explores its managerial implications. Section 6 discusses policy implications. Section 7 performs robustness checks. Section 8 concludes. The appendix contains the mathematical proofs.

2 Scope of the Analysis and Modeling Choices

What Experience Goods? While the introduction situates the analysis in the general context of experience goods, this paragraph discusses the types of experience goods to which the model is most naturally suited, as well as those for which it is perhaps a poorer fit.

Prospective buyers use consumer reviews for a wide range of experience goods ([OECD, 2019](#)). However, for expensive and durable products such as cars, electronics, appliances, and furniture, buyers often rely on a richer set of quality signals, including prices ([Bagwell and Riordan, 1991](#)), warranties ([Boulding and Kirmani, 1993](#)), and reputation ([Shapiro, 1983](#)). Our analysis assumes consumer reviews to be the only signal of quality for the late buyer; accordingly, its fit is strongest for less expensive and (generally) nondurable experience good markets,

³[Bondi and Rossi \(2026\)](#) provide a recent synthesis of the literature on distortions in online reviews and observe that interventions targeting one source of review distortion may exacerbate another. Our analysis complements this perspective by identifying a related tradeoff: improvements in review informativeness or trust can exacerbate distortions in quality provision.

where consumer reviews play a relatively prominent role in shaping purchasing decisions, while additional signals are less central. Examples of such markets include, but are not limited to, the cultural sector –books, music, movies (Chevalier and Mayzlin, 2006)– the tourism and hospitality sectors –hotels, museums, restaurants (Sparks and Browning, 2011; Luca, 2016)– and the food and beverage sector –coffee, wine, spirits (Gastaldello et al., 2024).

Exogenous Horizontal Differentiation. In our model, the horizontal differentiation dimension of the product supplied by firms is assumed to be exogenous, that is, not chosen by firms, for two reasons. First, from the sellers’ perspective, this assumption seems to fit several real-world situations. For instance, the location of a family-owned hotel (e.g., in the mountains or by the sea) is a common dimension of horizontal differentiation in tourism and often reflects the area in which the owning family grew up; similarly, the grape varieties that a winery can effectively cultivate depend on its mostly exogenous geographical location. Second, and more importantly, from the buyers’ perspective horizontal differentiation can be interpreted as the realized match between a product variety and the tastes of the consumers who evaluate it. This match is partly unpredictable because it depends on heterogeneous preferences, shaped by consumers’ past experiences and social environment: firms may choose the characteristics of the variety they offer, but they do not control the distribution of consumer tastes against which that variety is assessed. Consequently, a variety that appears attractive *ex ante* may turn out to be a poor match *ex post* for the relevant buyers or reviewers, and vice versa.⁴ In this sense, horizontal differentiation is naturally captured on the consumer side through the utility function, while it can be treated as exogenous to the firms’ decision problem.

(Lack of) Expert Reviews. As mentioned, the rapid rise of e-commerce and digital devices has boosted the availability of online information about products, including not only consumer reviews but also expert reviews. We opt to consider consumer reviews only because they are a genuinely new feature of online markets, whereas expert evaluations were already available before the internet through specialized magazines and guidebooks such as *Consumer Reports*, first published in 1936 (Encyclopaedia Britannica, 2026a), and the *Michelin Guide*, first published in 1900 (Encyclopaedia Britannica, 2026b). Additionally, although expert reviews may be regarded as more informative than consumer reviews, they need not provide a fully informative signal of quality, for they may themselves be affected by biases such as conflicts of interest (Vollaard and van Ours, 2022). This suggests that abstracting from expert reviews

⁴Success unpredictability is quite a common feature in different markets for experience goods: for an experimental study in the music market, see Salganik et al. (2006).

is perhaps not essential for the logic of the current analysis, insofar as they too provide an imperfect signal of quality.

Monopolistic Competition. The main analysis focuses on monopolistic competition because this market structure seems to provide a natural description of many markets for inexpensive and nondurable experience goods: the above examples in the cultural, tourism, and food and beverage sectors are typically characterized by a large number of small service providers on the supply side. However, one cannot rule out cases in which similar experience good markets are more appropriately described as oligopolistic. More importantly, analyzing an oligopolistic setting is theoretically valuable, because one may suspect that our results depend crucially on the nonstrategic nature of monopolistic competition. For this reason, Section 7.1 extends the model to a Hotelling framework with quality and price competition.

3 Model and Equilibrium

We develop a three-period model of monopolistic competition, with a continuum of profit-maximizing firms. Each firm produces a distinct variety of a product that is both horizontally and vertically differentiated. As in, e.g., [Jiang and Yang \(2019\)](#), the timing is the following.

- $t = 1$: each firm i chooses the quality level of its variety i .
- $t = 2$: each firm i sets the price of variety i to maximize its second-period profits. There is a representative early buyer that observes the prices of all varieties, but not their qualities prior to purchase; she then decides how many units of each variety to buy and, in case of purchase, writes reviews of the varieties' quality.
- $t = 3$: each firm i sets a new price for variety i to maximize its third-period profits. There is a representative late buyer that observes the updated prices and the reviews, but not the actual qualities prior to purchase; he then makes purchasing decisions.

The model is solved backwards, starting from the third period.

3.1 Third Period: Late Buyer

Demand. The representative late buyer exhibits love-of-variety preferences and is interested in two products: the differentiated product, supplied as a continuum of varieties, and the numéraire, denoting all other products. Formally, the late buyer's preferences are described

by a quasi-linear utility function à la [Ottaviano et al. \(2002\)](#) and [Melitz and Ottaviano \(2008\)](#), modified to incorporate both quality and taste,⁵

$$\int [v + \mathbb{E}(s_i)]q_{i,3}di - \frac{1}{2} \int \frac{q_{i,3}^2}{b_{i,3}}di - \frac{\gamma_3}{2} \left(\int q_{i,3}di \right)^2 + q_{0,3}, \quad (1)$$

where: v denotes an observable minimum quality standard that any variety i must fulfill; s_i is variety i 's (additional) quality chosen by firm i at $t = 1$ and $\mathbb{E}(s_i)$ indicates how this quality is perceived by the late buyer on the basis of the reviews written by the early buyer; $q_{i,3}$ denotes the third-period quantity of variety i ; $b_{i,3} > 0$ is the late buyer's taste –or horizontal differentiation– parameter, measuring how close any variety i is to his taste –the higher $b_{i,3}$, the better the taste match; $\gamma_3 > 0$ captures substitutability between any two varieties in the third period; $q_{0,3}$ is the third-period amount of the numéraire.

The buyer chooses the quantities of each variety $q_{i,3}$ and the numéraire $q_{0,3}$ to maximize (1), subject to the budget constraint

$$\int (p_{i,3}q_{i,3})di + q_{0,3} = y_3,$$

where $p_{i,3} > 0$ is the third-period unit price of variety i , the price of the numéraire is normalized to one, and $y_3 > 0$ is the late buyer's income, which is assumed to be high enough to ensure nonnegative numéraire consumption at equilibrium.⁶ Solving this problem for any variety i yields the late buyer's linear demand function for i ,

$$q_{i,3} = b_{i,3} \left(v + \mathbb{E}(s_i) - p_{i,3} - \gamma_3 \frac{vB_3 + \mathbb{E}(S) - P_3}{1 + \gamma_3 B_3} \right), \quad (2)$$

where $\mathbb{E}(S) \equiv \int [b_{i,3}\mathbb{E}(s_i)]di$, $P_3 \equiv \int (b_{i,3}p_{i,3})di$, and $B_3 \equiv \int b_{i,3}di$ are the market aggregates denoting the taste-weighted perceived quality index, the taste-weighted third-period price index and the third-period taste index: see [Appendix A.1](#) for calculations. For future reference, we also define $S \equiv \int (b_{i,3}s_i)di$ as the taste-weighted true quality index. Among other effects, the demand function $q_{i,3}$ is decreasing in the own price $p_{i,3}$, while increasing in the own taste parameter $b_{i,3}$.⁷

⁵For a similar specification, see [Di Comite et al. \(2014\)](#).

⁶Throughout the paper, we impose no parametric restrictions on how heterogeneous varieties' (firms') characteristics –i.e., taste parameters and quality cost parameters that we define in [Section 3.4](#)– are distributed across the market. We simply assume that all functions appearing under the integral signs are measurable and integrable, so that the utility functions, budget constraints, and market aggregates, defined below, are finite.

⁷This last effect explains why the market indexes are weighted by $b_{i,3}$: varieties that better match the late buyer's tastes contribute more to the market aggregates.

We use the inverse demand function,

$$p_{i,3} = v + \mathbb{E}(s_i) - \frac{q_{i,3}}{b_{i,3}} - \gamma_3 \frac{vB_3 + \mathbb{E}(S) - P_3}{1 + \gamma_3 B_3},$$

to illustrate the different roles played by $\mathbb{E}(s_i)$ and $b_{i,3}$ in our framework: while higher perceived quality shifts the intercept of inverse demand upward, raising the late buyer's maximum willingness to pay for i , better taste match flattens the inverse demand, meaning that, at any given price, the late buyer's demand is larger.

Supply. Firms are assumed to incur zero marginal production cost, hence firm i 's profit function at $t = 3$ can be written as $\pi_{i,3} = p_{i,3}q_{i,3}$.⁸ Each firm i chooses price $p_{i,3}$ to maximize $\pi_{i,3}$. Plugging $q_{i,3}$ as in (2) into the profit function and solving the maximization problem yields

$$p_{i,3} = \frac{\mathbb{E}(s_i)}{2} + \frac{v + \gamma_3[P_3 - \mathbb{E}(S)]}{2(1 + \gamma_3 B_3)}. \quad (3)$$

As is standard in monopolistic competition models, the demand of firm i and, in turn, the optimal price $p_{i,3}$ are not affected by the price charged by any single rival firm $j \neq i$: each individual firm has a negligible market share, hence it does not affect the profit-maximizing choices made by rival firms. However, equation (3) captures the best response of firm i to the market conditions, described by aggregates $\mathbb{E}(S)$, P_3 , and B_3 . Among other effects, $p_{i,3}$ turns out to be increasing in the price index P_3 because varieties are substitutes and, therefore, any firm i can sell at a higher price when the other varieties become more expensive overall.

Equilibrium. In Appendix A.1, we derive the third-period equilibrium price index and plug it into (3) to get the third-period equilibrium price of variety i ,

$$p_{i,3}^* = \frac{\mathbb{E}(s_i)}{2} + H, \quad (4)$$

where $H \equiv \frac{2v - \gamma_3 \mathbb{E}(S)}{2(2 + \gamma_3 B_3)}$.⁹ We then substitute P_3^* and $p_{i,3}^*$ into (2) and obtain the late buyer's equilibrium demand for variety i ,

$$q_{i,3}^* = b_{i,3} \left[\frac{\mathbb{E}(s_i)}{2} + H \right]. \quad (5)$$

⁸In the first-period analysis, we let the cost of investing in quality incurred by firms be increasing in the quality level. Accordingly, assuming that marginal costs are positive and affected by quality too, though sensible, would complicate calculations without qualitatively affecting the results.

⁹We let $H > 0$ at equilibrium, which implies that any variety's minimum quality standard v must be high enough and/or the substitutability parameter γ_3 low enough to (weakly) dominate the competitive pressure exerted by the aggregate market quality $\mathbb{E}(S)$ at equilibrium; this condition is sufficient to ensure a positive equilibrium price (and quantity).

Firm i 's third-period equilibrium profits are therefore given by

$$\pi_{i,3}^* = b_{i,3} \left[\frac{\mathbb{E}(s_i)}{2} + H \right]^2.$$

Intuitively, $\pi_{i,3}^*$ is positively affected by both the perceived quality of its variety, $\mathbb{E}(s_i)$, and the degree of taste match, $b_{i,3}$, albeit through different channels, as shown by expressions (4) and (5). While $\mathbb{E}(s_i)$ affects both the buyer's willingness to pay and the demand for variety i , $b_{i,3}$ has only a demand-scaling effect. By contrast, $\pi_{i,3}^*$ is decreasing in the market aggregates $\mathbb{E}(S)$ and B_3 , which measure how appealing the set of varieties is from the (perceived) vertical and the horizontal differentiation perspective, respectively. Higher values of either aggregate intensify competitive pressure, i.e., they lower H , thereby reducing both variety i 's equilibrium price (4) and demand (5).

3.2 Second Period: Early Buyer

Demand. The representative early buyer shares the late buyer's preferences, with two exceptions. First, her taste parameters $b_{i,2}$ may differ from those of the late buyer, reflecting heterogeneity in idiosyncratic tastes across buyers. For instance, one may interpret the early buyer as an early adopter who has a stronger average taste match with the available varieties and is therefore willing to purchase before the late buyer. Second, the second-period substitutability parameter, denoted by γ_2 , may differ from the third-period one, γ_3 . On top of that, reviews are not yet available in the second period: the early buyer is supposed neither to observe individual varieties' qualities nor to infer them from prices or other information about individual firms. She nevertheless observes the average quality chosen by firms at $t = 1$, denoted by $\bar{s}$, and she is assumed to assign this average quality to every variety; one can think of $\bar{s}$ as publicly available aggregate market information. All in all, the representative early buyer maximizes the utility function,

$$\int (v + \bar{s}) q_{i,2} di - \frac{1}{2} \int \frac{q_{i,2}^2}{b_{i,2}} di - \frac{\gamma_2}{2} \left(\int q_{i,2} di \right)^2 + q_{0,2}, \quad (6)$$

subject to the budget constraint

$$\int (p_{i,2} q_{i,2}) di + q_{0,2} = y_2,$$

where: $q_{i,2}$ is the second-period quantity of variety i ; $\gamma_2 > 0$ captures substitutability between any two varieties in the second period; $q_{0,2}$ is the second-period quantity of the numéraire, whose price is normalized to one; $p_{i,2} > 0$ is the second-period unit price of variety i ; $y_2 >$

0 is the early buyer's income, which is assumed to be high enough to ensure nonnegative numéraire consumption at equilibrium. The early buyer's demand function for any variety i is given by

$$q_{i,2} = b_{i,2} \left(v + \bar{s} - p_{i,2} - \gamma_2 \frac{(v + \bar{s})B_2 - P_2}{1 + \gamma_2 B_2} \right), \quad (7)$$

where $P_2 \equiv \int (b_{i,2} p_{i,2}) di$ and $B_2 \equiv \int b_{i,2} di$.

Supply and Equilibrium. We compute the second-period equilibrium values using the same procedure as in Section 3.1: see Appendix A.2 for calculations. In particular, the profit-maximizing price of variety i is

$$p_{i,2}^* = \frac{v + \bar{s}}{2 + \gamma_2 B_2}, \quad (8)$$

the early buyer's demand for any variety i is

$$q_{i,2}^* = b_{i,2} \frac{v + \bar{s}}{2 + \gamma_2 B_2}, \quad (9)$$

and the second-period equilibrium profits of firm i are

$$\pi_{i,2}^* = b_{i,2} \left[\frac{v + \bar{s}}{2 + \gamma_2 B_2} \right]^2. \quad (10)$$

Interestingly, $\pi_{i,2}^*$ is independent of firm i 's first-period quality choice s_i . The reason is that, under asymmetric information, the early buyer bases her purchase decisions on the market average quality $\bar{s}$, which no individual firm i can influence because of its negligible market share.

3.3 Review Generation and Information Acquisition

After purchase, the early buyer writes reviews reflecting the perceived quality of the varieties. We make several evidence-based reduced-form assumptions about how, in the second period, the early buyer generates reviews and how, in the third period, the late buyer infers quality by reading them.

- As mentioned, the early buyer represents the population of early purchasers who submit reviews or, at least, leave ratings; we assume that this population generates a finite number of reviews for each variety i . We have also noted that, when products are differentiated both vertically and horizontally, a consumer review reflects not only product quality but also the degree of fit between the product and the buyer's taste. Without microfounding these two features, we capture them by assuming that, for any variety i , the

average quality rating reported in the early buyer's reviews is

$$r_i \equiv \alpha s_i + (1 - \alpha)g(b_{i,2}), \quad (11)$$

where $\alpha \in (0, 1)$ captures the precision with which reviews signal true quality, and $g(b_{i,2})$ denotes the taste component of the rating, modeled as a function of the taste parameter. To further capture that the average rating is positively affected by taste fit and to allow for inflated mean ratings, we let $g'(b_{i,2}) > 0$ and make the following

Assumption 1. $g(b_{i,2}) > s_i$ at any i .

Assumption 1 can be rewritten as $r_i > s_i$ and states that the average rating reported in any variety i 's reviews is above true quality.¹⁰

- We let the number of each variety i 's reviews be sufficiently high and assume that the late buyer regards its average rating as informative of true quality. In symbols,

$$\mathbb{E}(s_i) = \alpha s_i + (1 - \alpha)g(b_{i,2}). \quad (12)$$

Formula (12) can be justified on three grounds. First, the taste component may be difficult to detect. Second, even when it is discernible in individual reviews, late buyers may find it too costly to inspect many reviews to disentangle quality from taste; at the same time, an average rating based on many reviews is generally perceived as more reliable than the same average based on only a few reviews (e.g., [Park et al., 2007](#); [Powell et al., 2017](#)). Finally, when buyers observe only the sample mean of past reviews, they do not learn true quality in the long run, as shown by [Besbes and Scarsini \(2018\)](#): the mean converges to a level that overstates it, because only buyers with a sufficiently favorable taste for the product purchase and post reviews.

In the remainder of the paper, we refer to α as review informativeness. This parameter can be affected by several factors, such as initiatives adopted by individual firms, or the design of platforms that collect consumer reviews and ratings and make them available to prospective buyers. In Section 5, we interpret exogenous changes in α as arising from these factors and investigate their implications for firms' equilibrium profits and quality incentives. However, we neither model the adoption of tools that enhance informativeness as a stage of the game nor

¹⁰Assumption 1 involves s_i , which is an endogenous value; we hence assume inequality $g(b_{i,2}) > s_i$ holds before computing the equilibrium value of s_i and then verify under which conditions it is actually fulfilled at equilibrium: for details, see Appendix A.5.

treat review platforms as strategic players that choose α to pursue their own objectives. This reflects our objective of studying firms' quality responses to biased reviews.¹¹

3.4 First Period: Quality Investment

In the first period, each firm i chooses its quality level s_i to maximize the following expression: $\pi_{i,2}^* + \pi_{i,3}^* - c_i f(s_i)$. Assuming a time discount factor of 1, $\pi_{i,2}^* + \pi_{i,3}^*$ is the sum of the second-period and the third-period equilibrium profits, while $c_i f(s_i)$ denotes the first-period investment cost incurred by firm i to provide quality s_i . We let $f(0) = 0$, $f'(s_i) > 0$ for $s_i > 0$, and $f''(s_i)$ sufficiently positive, with parameter $c_i > 0$ (inversely) measuring how efficient firm i is in delivering quality. Since $\pi_{i,3}^*$ depends on s_i , while $\pi_{i,2}^*$ does not, firm i 's first-period problem is equivalent to

$$\max_{s_i} \pi_{i,3}^* - c_i f(s_i). \quad (13)$$

We denote by $s_{i,CR}$ the solution to (13), CR being a mnemonic for Consumer Review, and by $\Pi_{i,CR} \equiv b_{i,3} \left[\frac{\mathbb{E}(s_{i,CR})}{2} + H_{CR} \right]^2 - c_i f(s_{i,CR})$ the resulting profit, with $H_{CR} \equiv \frac{2v - \gamma_3 \mathbb{E}(S_{CR})}{2(2 + \gamma_3 B_3)}$ denoting the equilibrium value of H . We assume $s_{i,CR}$ to be unique and positive. In Appendix A.3, we show that $s_{i,CR}$ is positively affected by $b_{i,2}$ and $b_{i,3}$ and negatively by c_i . Better taste match experienced by the early buyer, as captured by higher $b_{i,2}$, enhances the quality perceived by the late buyer prior to purchase, $\mathbb{E}(s_i) = \alpha s_i + (1 - \alpha)g(b_{i,2})$. Instead, higher $b_{i,3}$ directly increases the late buyer's demand for variety i : see (5). Both effects improve firm i 's marginal benefit from investing in quality for any given s_i and induce firm i to select higher quality. By contrast, higher c_i raises the first-period quality investment cost for any given s_i and induces firm i to select lower quality.

4 Results

In this section, we build on the equilibrium analysis to address two questions. First, we investigate whether the taste bias in consumer reviews induces firms to invest in quality more or less than they would in the absence of this bias and than a welfare-maximizing planner would invest. Second, we examine whether the taste bias drives a firm that is less efficient in delivering quality to choose lower or higher quality and to earn lower or higher profits than a more efficient competitor.

¹¹Note also that, since firms take α as given when choosing quality, our comparative statics in Section 5 characterize firms' responses to whatever level of review informativeness a platform might select.

4.1 Quality Distortions Within Firm

We consider any variety i and calculate two values. First, the quality level firm i would choose if reviews were fully informative of quality, i.e., if $\mathbb{E}(s_i)$ were equal to s_i for any i ; we denote this value by $s_{i,NB}$, NB being a mnemonic for No Bias. Second, the quality level a planner would set to maximize welfare associated with any single variety i , under the assumptions that reviews are fully informative of quality and that the planner does not choose the price;¹² we denote this value by $s_{i,CE}$, CE being a mnemonic for Constrained Efficient. We define variety i 's welfare as the sum of firm i 's third-period profits net of quality cost and the late buyer's surplus from variety i .¹³

Before proceeding, we define $H_{NB}^+ \equiv \frac{2v-\gamma_3 S_{NB}}{2(2+\gamma_3 B_3)}$ as the equilibrium value of the aggregate component of the third-period equilibrium price (4) in the No Bias scenario and $H_{CE}^+ \equiv \frac{2v-\gamma_3 S_{CE}}{2(2+\gamma_3 B_3)}$ as the corresponding value in the Constrained Efficient scenario. We then make the following

Assumption 2. $H_{CE}^+ \geq \frac{2}{3}H_{NB}^+$.

Lemma 1. *Under Assumption 2, the quality level any firm i would choose if reviews were fully informative is lower than its constrained efficient quality level.*

Proof. In Appendix A.4. □

Firm i does not internalize the benefit that a late buyer derives from higher quality. Consequently, its marginal return to quality investment is lower than the marginal benefit internalized by the planner and leads to lower investment. Since the planner's intervention raises the aggregate (true) quality index from S_{NB} to S_{CE} , Assumption 2 ensures that the resulting increase in the market competitive pressure, captured by a decline in H^+ , is not large enough to offset the planner's additional marginal benefit. If the assumption is not fulfilled, the constrained efficient quality level can instead be lower than the no-bias level for some firms with relatively high quality costs.

We proceed by comparing the equilibrium quality $s_{i,CR}$ to both the no-bias level $s_{i,NB}$ and the constrained efficient level $s_{i,CE}$. We say that firm i underinvests (overinvests) in quality if $s_{i,CR}$ is lower (higher) than $s_{i,NB}$, and that it underprovides (overprovides) quality if $s_{i,CR}$ is lower (higher) than $s_{i,CE}$. We derive the following

¹²The second assumption is standard in the literature on quality regulation (e.g., Ronnen, 1991; Crampes and Hollander, 1995), where planners control quality investment while leaving price competition unregulated. At the end of this section, we discuss the case in which the planner also sets prices.

¹³We abstract from second-period profits and early buyer's (perceived) surplus because, as established in Section 3.2, both are invariant with respect to firm i 's quality choices, and therefore do not affect the planner's optimization either. Nevertheless, at the end of this section, we discuss the case in which these two values are included in the welfare function.

Proposition 1. *Under Assumption 2, three alternative scenarios arise depending on the value of $g(b_{i,2})$.*

- (i) *Firm i underinvests in quality and underprovides it if, and only if, $(s_{i,CR} <)g(b_{i,2}) < \hat{g}(b_{i,2})$.*
- (ii) *Firm i overinvests in quality but underprovides it if, and only if, $\hat{g}(b_{i,2}) < g(b_{i,2}) < \tilde{g}(b_{i,2})$.*
- (iii) *Firm i overinvests in quality and overprovides it if, and only if, $g(b_{i,2}) > \tilde{g}(b_{i,2})$.*

Proof. In Appendix A.5, where we provide the values of $\tilde{g}(b_{i,2}) > \hat{g}(b_{i,2})$. □

Under Assumption 1, the early buyer always overestimates true quality in her reviews. One might therefore expect firms to exploit the late buyer's resulting optimistic assessment by overinvesting in quality relative to a fully informative environment. At the same time, Lemma 1 states that firms underprovide quality relative to the constrained efficient level when reviews are unbiased. One might therefore expect the same normative outcome to arise in the presence of taste bias. Interestingly, Proposition 1 shows that neither conjecture need hold in general. The intuition is as follows.

When selecting quality, firm i anticipates how investment affects the late buyer's willingness to pay, and hence equilibrium price and demand, as described by (4) and (5). Two forces operate simultaneously. On the one hand, since reviews are only partially informative –i.e., $\alpha < 1$ – the marginal effect of quality investment on willingness to pay, and hence on profits, is weakened relative to the full-information case: this reduces incentives to invest and explains underinvestment when quality overestimation is not too pronounced, i.e., $g(b_{i,2}) < \hat{g}(b_{i,2})$. On the other hand, marginal returns to true quality are increasing in $g(b_{i,2})$: when the taste component strongly inflates the quality assessment, i.e., $g(b_{i,2}) > \hat{g}(b_{i,2})$, the resulting overestimation of true quality boosts the late buyer's willingness to pay sufficiently to more than offset the first force, leading instead to overinvestment.

The normative assessment adds a third force: following an increase in s_i , the planner internalizes the additional surplus accruing to the late buyer on all inframarginal units, which firm i captures only partially through higher prices. Under Assumption 2, this further weakens firm i 's investment incentives relative to the constrained efficient level of quality, shifting the threshold upward: $\tilde{g}(b_{i,2}) > \hat{g}(b_{i,2})$. As a result, underprovision arises for a strictly wider range of $g(b_{i,2})$ than underinvestment, specifically whenever $g(b_{i,2}) < \tilde{g}(b_{i,2})$: point (ii) of Proposition 1 indeed shows that overinvestment and underprovision can simultaneously occur in equilibrium. However, point (iii) shows this outcome can be reversed when the taste component of reviews heavily affects the quality assessment, i.e., $g(b_{i,2}) > \tilde{g}(b_{i,2})$, in which case overprovision arises at equilibrium along with overinvestment.

Alternative Welfare Analyses. We briefly discuss a welfare analysis, in which the planner also chooses prices for any variety i . Since marginal production costs are zero, the planner sets the price equal to zero, thereby equating inverse demand to marginal cost. This leads to a larger quantity and increases the marginal benefit of quality internalized by the planner. If an optimum exists, the resulting quality level exceeds $s_{i,CE}$ and the qualitative conclusions of Lemma 1 and Proposition 1 remain unchanged.

We also discuss an alternative welfare criterion that includes second-period profits and the early buyer's realized surplus. At the time of purchase, the early buyer evaluates variety i on the basis of market average quality, so her demand does not depend on its actual quality s_i . After consumption, however, her realized utility does depend on s_i . Consequently, second-period profits remain independent of s_i , whereas the early buyer's realized surplus adds a positive term to the marginal benefit of quality internalized by the planner. If an optimum exists, the resulting quality level is higher than $s_{i,CE}$, leaving the qualitative results of Lemma 1 and Proposition 1 unchanged.

4.2 Distortions Across Firms

We consider two firms, denoted by B and G , which are characterized by different parameters $b_{i,2}$ and c_i ; in particular, we let $\Delta g \equiv g(b_{B,2}) - g(b_{G,2}) \neq 0$ and $\Delta c \equiv c_B - c_G > 0$. The difference Δg captures whether the early buyer's taste match, and therefore the taste component of her reviews' average rating, is higher ($\Delta g > 0$) or lower ($\Delta g < 0$) for variety B relative to variety G : we refer to Δg as the taste gap. By contrast, the positive difference $\Delta c > 0$ captures the higher costs incurred by firm B vis-à-vis firm G in delivering the same level of quality; we refer to Δc as the efficiency gap.

As anticipated, our goal is to assess how the taste bias in consumer reviews shapes the comparison between firms B and G in terms of equilibrium quality and profits. This has two implications for our analysis. First, by construction, second-period equilibrium profits are unaffected by consumer reviews in our model; accordingly, we abstract from $\pi_{i,2}^*$ and focus only on $\Pi_{i,CR} \equiv \pi_{i,3}^*(s_{i,CR}) - c_i f(s_{i,CR})$ to assess the distribution of profits across firms.¹⁴ Second, third-period equilibrium profits depend on $b_{i,2}$ via the taste bias in consumer reviews and on $b_{i,3}$ via its direct impact on the late buyer's demand. To isolate the (former) review-bias effect from the (latter) bias-independent one, we let $b_{B,3} = b_{G,3} = b_3$, which is equivalent to $g(b_{B,3}) = g(b_{G,3}) = g(b_3)$, given $g' > 0$.

As a first step, we consider the benchmark case of fully informative reviews –i.e., $E(s_i) =$

¹⁴At the end of this section, we discuss the case in which second-period equilibrium profits are also included.

s_i for any i – by comparing the no-bias equilibrium quality levels, $s_{B,NB}$ and $s_{G,NB}$, and the resulting equilibrium profits, $\Pi_{B,NB}$ and $\Pi_{G,NB}$. We state the following

Lemma 2. *When consumer reviews are fully informative, a less efficient firm B chooses lower quality and earns lower profits than a more efficient firm G in equilibrium.*

Proof. In Appendix A.6. □

Lemma 2 provides a straightforward result that is driven by the following mechanism. Firm B invests less in quality than firm G because it incurs higher costs to invest in quality and $s_{i,NB}$ is only negatively affected by such costs when the late buyer is assumed to observe true quality. This lower equilibrium quality level, in turn, yields both third-period price-reducing and demand-reducing effects vis-à-vis the more efficient competitor, as described by (4) and (5), respectively, after substituting $\mathbb{E}(s_i) = s_{i,NB}$. As a result, firm B earns lower third-period equilibrium profits than firm G, $\pi_{B,3}^*(s_{B,NB}) < \pi_{G,3}^*(s_{G,NB})$. The lower quality set by firm B only mitigates its cost disadvantage at equilibrium, with the effect that $\Pi_{B,NB} < \Pi_{G,NB}$.

We now turn to the case of partially informative reviews by comparing the equilibrium quality levels $s_{B,CR}$ and $s_{G,CR}$, and the resulting equilibrium profits $\Pi_{B,CR}$ and $\Pi_{G,CR}$. We fix $g(b_{G,2})$ and c_G and state the following

Proposition 2. *When consumer reviews are biased,*

- (i) *a less efficient firm B chooses lower quality and earns lower profits than a more efficient firm G in equilibrium if, and only if,*

$$\Delta g < \Delta g_{\Pi}(\Delta c); \tag{14}$$

- (ii) *it chooses lower quality, but earns higher profits if, and only if,*

$$\Delta g_{\Pi}(\Delta c) < \Delta g < \Delta g_s(\Delta c); \tag{15}$$

- (iii) *it chooses higher quality and earns higher profits if, and only if,*

$$\Delta g > \Delta g_s(\Delta c). \tag{16}$$

Proof. In Appendix A.7, where we provide the implicit values of $\Delta g_s(\Delta c) > \Delta g_{\Pi}(\Delta c) > 0$ and show that they are both increasing in Δc . □

With biased consumer reviews, the equilibrium quality $s_{i,CR}$ remains decreasing in c_i but becomes increasing in $g(b_{i,2})$. Consequently, if the taste gap Δg is sufficiently large, the predic-

tions in Lemma 2 may be reversed, leading to distortions in firms' quality investments and in their financial performance compared to the full-information scenario.

In particular, Proposition 2 shows that, under condition (14), the taste gap Δg is either negative, or positive but low for any given efficiency gap Δc .¹⁵ In other words, the early buyer's taste match for variety B is either worse relative to variety G , or not sufficiently better to compensate for the efficiency disadvantage suffered by firm B . As a result, the prediction is in line with Lemma 2: firm B supplies a variety of lower quality and earns lower profits.

The opposite, and probably less intuitive, scenario occurs under condition (16): albeit less efficient than competitor G , firm B decides to produce a variety of higher quality and ends up with larger profits. The reason is that the taste gap is particularly pronounced in favor of variety B . As a result, the efficiency disadvantage suffered by firm B is more than compensated by the taste advantage, which makes the early buyer's quality assessment particularly generous and, in turn, the late buyer's demand for variety B particularly large. All in all, firm B decides to invest in higher quality; its profits are higher too because variety B combines higher quality with a taste advantage over variety G .

The existence of the intermediate scenario (15) can be explained by the fact that a taste advantage benefits firm B via two channels. First, it raises the marginal return to quality investment, inducing firm B to increase $s_{B,CR}$. Second, it raises the perceived quality of variety B , increasing its equilibrium price, demand, and profits, even for a given $s_{B,CR}$. Under condition (15), the taste advantage does not raise the marginal return enough to offset firm B 's higher quality costs. However, it raises variety B 's perceived quality sufficiently to make firm B more profitable.

To conclude this section, we observe that including second-period profits in the profit comparison would leave equilibrium quality choices unchanged but reinforce the profitability advantage associated with a favorable taste match; this is because $\pi_{i,2}^*$ is independent of s_i , but increasing in $b_{i,2}$. As a result, the cutoff value $\Delta g_s(\Delta c)$ would remain unchanged, while $\Delta g_\Pi(\Delta c)$ would diminish, with no qualitative effects on the results of Proposition 2.

5 Comparative Statics

Our analysis rests, among other things, on two assumptions regarding the processes of review generation and information acquisition. First, the average quality rating reported by the early buyer is only partially informative of true quality because it also reflects taste fit. Second, the late buyer uses the early buyer's average rating to infer true quality without discounting its

¹⁵ Assumption 1 requires Δg to be higher than $s_{B,CR} - g(b_{G,2})$, which is negative under condition (14).

taste component. Together, these assumptions imply that the late buyer's perceived quality inherits the partial informativeness of the average rating, and, accordingly, $\alpha < 1$ is the same in both formulas (11) and (12).

As anticipated in Section 3.3, several factors may however affect these two informational frictions and, in turn, the level of α . On the one hand, platforms such as Trustpilot, Feefo, and Judge.me offer automated tools enabling merchants to systematically collect feedback from verified buyers, instead of relying solely on unsolicited reviews (Trustpilot, 2026; Feefo, 2026; Judge.me, 2026). This practice can help reduce the post-purchase underreporting bias, according to which buyers with very positive or very negative experiences are more likely to post, therefore making the average rating reported in reviews more informative of true quality. This effect can be captured in our framework by a higher α in formula (11), which is then transmitted to (12). On the other hand, there is growing use of AI tools that help prospective buyers navigate consumer reviews. For instance, review platforms such as Bazaarvoice and REVIEWS.io offer merchants AI-based tools that summarize reviews of their products, thereby making review content easier for prospective buyers to process (Bazaarvoice, 2026; REVIEWS.io, 2026); the resulting effect can be captured by a higher α in formula (12), while the average rating (11) stays the same.

Importantly, we assume that these tools attenuate but do not fully eliminate review bias. This is plausible for two reasons. First, even if the post-purchase underreporting bias were fully eliminated, the pre-purchase acquisition bias would remain. Second, on several popular platforms (e.g., Google Maps or Booking.com), reviewers must provide a numerical rating but may omit textual content. In the presence of such blank reviews, even a thorough AI-based textual analysis could not perfectly disentangle quality from taste. Formally, we consider a finite increase from α to α' in either (11) or (12), such that α' remains strictly below one.

Managerial Implications. One important question is whether firms find it profitable to adopt measures that improve the review informativeness of their products. In particular, we focus on individual incentives for adoption by assuming that informativeness rises from α to α' for any single firm i , while remaining at α for all rival firms $j \neq i$. This may capture a real-world situation in which a seller activates, e.g., Trustpilot's invitation and integration tools for its own customers, without competitors doing the same. We derive the following

Result 1. *If any firm i individually adopts measures that raise variety i 's review informativeness from α to α' , its equilibrium profit $\Pi_{i,CR}$ falls.*

Proof. In Appendix A.8. □

Under Assumption 1, a rise in α directly lowers variety i 's perceived quality for any given s_i , because it shifts weight from the taste component $g(b_{i,2})$ toward true quality $s_i < g(b_{i,2})$. Result 1 shows that allowing the firm to reoptimize its quality does not overturn the resulting profit loss. Consequently, no firm has a unilateral incentive to make the reviews of its product more informative.¹⁶ Result 1 yields a perhaps counterintuitive managerial implication: measures aimed at mitigating taste bias in consumer reviews harm firms when adopted unilaterally.

A natural question is whether this adverse effect also arises at the market level. We therefore examine how a market-wide increase in review informativeness affects industry profits, defined as the sum of all firms' third-period equilibrium profits net of quality investment costs. One possible example of such a market-wide increase comes from Amazon.com, which has recently modified its design by introducing AI-generated review highlights on product pages (Amazon, 2023). If this tool helps prospective buyers extract more accurate information about true quality from consumer reviews, and if all firms in the relevant market conduct their transactions through a platform that introduces it, the effect on informativeness can be represented as a common increase from α to α' in (12). We derive the following

Result 2. *A market-wide adoption of measures that raise review informativeness from α to α' increases industry profits $\Pi^* \equiv \int \Pi_{i,CR} di$ if, and only if,*

$$2 \int_{\alpha}^{\alpha'} \frac{dH_{CR}(\tilde{\alpha})}{d\tilde{\alpha}} \int q_{i,3}^*(\tilde{\alpha}) di d\tilde{\alpha} > \int_{\alpha}^{\alpha'} \int q_{i,3}^*(\tilde{\alpha}) [g(b_{i,2}) - s_{i,CR}(\tilde{\alpha})] di d\tilde{\alpha}, \quad (17)$$

where $\tilde{\alpha} \in [\alpha, \alpha']$.

Proof. In Appendix A.8. □

Result 2 shows that the adverse effect on profits experienced by firms at the individual level need not extend to industry profits when adoption is at the market level. The reason is that a market-wide increase from α to α' produces two opposing effects on industry profits. On the one hand, greater informativeness may reduce the equilibrium perceived quality index $\mathbb{E}(S_{CR})$ and relax competitive pressure by raising H_{CR} : in this case, the left-hand side of (17) captures the resulting industry profit benefit; crucially, this effect is zero in Result 1 because any individual firm has zero measure and, therefore, no impact on market aggregates. On the other hand, correcting inflated own ratings generates the industry profit loss on the right-hand side, in the spirit of Result 1.¹⁷

¹⁶This echoes the result in Guan et al. (2026) that a firm facing biased reviews benefits from correcting negatively biased ones and from preserving the upside of favorable ones.

¹⁷Consistent with the analysis in the two previous sections, we do not include the second-period aggregate equilibrium profits in the definition of industry profits because they are not affected by the taste bias. In doing so, we

Quality Incentives. We conclude this section by studying how a market-wide enhancement in informativeness affects firms' quality incentives. We consider any firm i whose equilibrium quality investment differs from the no-bias level, i.e., $s_{i,CR} \neq s_{i,NB}$: as α rises to α' in (12), one might expect the equilibrium quality $s_{i,CR}$ to move closer to $s_{i,NB}$, thereby attenuating the firm's quality investment distortion, whether underinvestment or overinvestment. We show this need not be the case.

Result 3. (i) Assume firm i underinvests in quality at α , i.e., $s_{i,CR}(\alpha) < s_{i,NB}$: a market-wide adoption of measures that raise review informativeness from α to α' exacerbates underinvestment if, and only if,

$$(\alpha' - \alpha)p_{i,3}^*(\alpha) + \alpha' \Delta H_{CR} < \frac{\alpha'(\alpha' - \alpha)}{2} [g(b_{i,2}) - s_{i,CR}(\alpha)], \quad (18)$$

where $\Delta H_{CR} \equiv H_{CR}(\alpha') - H_{CR}(\alpha)$. (ii) Assume instead firm i overinvests in quality at α , i.e., $s_{i,CR}(\alpha) > s_{i,NB}$: a market-wide adoption of measures that raise review informativeness from α to α' exacerbates overinvestment if, and only if, the strict reverse of (18) holds.

Proof. In Appendix A.9. □

The increase in informativeness generates two opposing effects on quality incentives. On the one hand, greater informativeness makes perceived quality more responsive to true quality, thereby increasing the marginal return to quality investment, as captured by $(\alpha' - \alpha)p_{i,3}^*(\alpha)$; this effect is reinforced if better informativeness reduces the perceived quality index and consequently raises H_{CR} , i.e., if $\Delta H_{CR} > 0$, relaxing competitive pressure. On the other hand, greater informativeness corrects rating inflation and weakens the marginal return to quality, as captured by the right-hand side of (18).

If firm i underinvests at α and (18) holds true, firm i will respond to better informativeness by investing even less, therefore exacerbating the underinvestment distortion. Instead, if firm i overinvests at α and the strict reverse of (18) holds true, firm i will exacerbate the overinvestment distortion as reviews become more informative.

6 Policy Implications

Our analysis has implicitly disregarded fake and otherwise manipulated reviews that, however, are a widespread phenomenon (e.g., Luca and Zervas, 2016) and a growing source of concern, as reflected in recent legislative interventions explicitly targeting them. For instance, in the UK, the Digital Markets, Competition and Consumers Act 2024 (Schedule 20, paragraph

leave out the potential effect of a market-wide change in α on the market average quality $\bar{s}$ observed by the early buyer and, through (10), on aggregate second-period profits.

13) prohibits the submission or commissioning of fake reviews and requires publishers to take measures to prevent and remove them (UK Parliament, 2024; Competition and Markets Authority, 2025). In Italy, Chapter IV of Law No. 34/2026 regulates online reviews in the tourism and catering sectors and, among other provisions, prohibits the purchase and sale of reviews (Repubblica Italiana, 2026).

With the aim of investigating the impact of these policy measures on firms' quality incentives, we introduce the possibility of review manipulation in our framework. The literature identifies two opposing effects on the quality reported in reviews of experience goods. On the one hand, ratings tend to be systematically too positive relative to underlying quality when reviews are incentivized by sellers (Park et al., 2023) or fake reviews are bought by sellers (He et al., 2022). On the other hand, ratings can be systematically too negative for some firms when reviews are manufactured by competitors (e.g., Mayzlin et al., 2014). Other studies show instead that review manipulation adds noise and undermines trust in the signal, making reviews less reliable (e.g., Glazer et al., 2021; Gandhi et al., 2025).

Since review manipulation may either raise or lower the quality reported in reviews, its overall effect on average ratings may vary across firms and markets. We therefore abstract from this direct effect and focus on its negative impact on trust. We capture this effect through two assumptions. First, we specify the quality perceived by the late buyer as $\mathbb{E}(s_i) = \tau r_i + (1 - \tau)\mu_i$, where $\tau \in (0, 1]$ measures the late buyer's trust in reviews and $\mu_i > 0$ is his prior expectation of variety i 's quality. Second, we assume that $\mu_i < r_i$ at equilibrium: whenever trust is incomplete, i.e., $\tau < 1$, the late buyer discounts the observed rating, so that $\mathbb{E}(s_i) < r_i$. We then represent the intended effect of regulatory intervention as a market-wide increase in τ to 1.

We consider any firm i that underinvests in quality when $\mathbb{E}(s_i) = \tau r_i + (1 - \tau)\mu_i$, i.e., $s_{i,CR}(\tau) < s_{i,NB}$, and observe that, as τ rises to 1, one might expect the equilibrium quality to increase—and so underinvestment to attenuate—for two reinforcing reasons.¹⁸ First, the marginal effect of quality investment on the late buyer's willingness to pay rises from $\tau\alpha$ to α ; second, perceived quality rises as the late buyer shifts weight from the prior μ_i to the higher rating r_i . We derive conditions under which this is not the case.

Result 4. *Assume firm i underinvests in quality at τ , i.e., $s_{i,CR}(\tau) < s_{i,NB}$: a market-wide increase in trust from τ to 1 exacerbates underinvestment if, and only if,*

$$(1 - \tau)p_{i,3}^*(\tau) + (1 - \tau)\frac{r_{i,CR}(\tau) - \mu_i}{2} + \Delta H_{CR,\tau} < 0, \quad (19)$$

¹⁸Consistent with this intuition, Rhodes and Wilson (2018) investigate the related context of false advertising and show that stronger penalties encourage quality investment in a monopoly model.

where $r_{i,CR}(\tau) \equiv \alpha s_{i,CR}(\tau) + (1 - \alpha)g(b_{i,2})$ and $\Delta H_{CR,\tau} \equiv H_{CR}(1) - H_{CR}(\tau)$.

Proof. In Appendix A.10. □

The first two positive terms on the left-hand side of (19) capture the abovementioned increases in the marginal impact of actual quality on perceived quality and in the perceived quality itself. Condition (19) then holds when $\Delta H_{CR,\tau}$ is sufficiently negative to outweigh both effects. This can occur, in turn, if restoring trust raises the perceived quality index $\mathbb{E}(S)$ enough to intensify competition. The resulting fall in H_{CR} pushes down the price firm i can charge relative to the case in which H_{CR} remains unchanged or goes up, and may induce it to invest less in quality despite the two positive direct effects.

7 Robustness

In Section 4, we have shown that our conclusions remain qualitatively unchanged when the planner is allowed to choose prices as well as quality and when second-period equilibrium values are included in the welfare function and in the profit comparison across firms. In this section, we assess the robustness of Section 4's results along three further dimensions: (i) strategic quality and price competition in a Hotelling framework; (ii) the relaxation of Assumption 1 for a positive measure of firms to allow ratings to underestimate quality; and (iii) a CES specification of buyers' preferences à la Dixit and Stiglitz (1977).

7.1 Hotelling Quality and Price Competition

We replicate the analysis of Sections 3 and 4 by developing a Hotelling framework. This entails two principal changes. First, we consider two firms, denoted $i = B, G$, that supply differentiated product varieties and interact strategically, rather than a continuum of firms. Second, in each period $t = 2, 3$ we introduce a unit mass of buyers uniformly distributed along a unit-length Hotelling line and with unit demand for either variety B or G , rather than a representative buyer with love-of-variety preferences.

Before proceeding, we remark that a natural way to incorporate the taste parameters $b_{i,t}$ into the Hotelling framework is to interpret them as the firms' locations along the line. As will be discussed, assuming $\Delta g \equiv g(b_{B,2}) - g(b_{G,2}) \neq 0$ and $g(b_{B,3}) = g(b_{G,3})$ as in Section 4—or, equivalently, $b_{B,2} - b_{G,2} \neq 0$ and $b_{B,3} = b_{G,3}$ —is indeed akin to assuming that firms are asymmetrically (symmetrically) located on the line in the second (third) period.

Firms and buyers play the same game as in Section 3; we solve it starting from the third period. Since our aim is simply to check the robustness of our results, we will rely on an

explicit quality cost function and we will illustrate the results using numerical examples.

Third Period: Late Buyers. We denote by $b_{B,3} \geq 0$ and $1 - b_{G,3} \in (b_{B,3}, 1]$ the third-period locations of firms B and G . In this case, the utility of a late buyer located at point $x \in [0, 1]$ is given by $v + \mathbb{E}(s_B) - p_{B,3} - (x - b_{B,3})^2$, if he buys the variety from firm B , and $v + \mathbb{E}(s_G) - p_{G,3} - (1 - b_{G,3} - x)^2$, if he buys from firm G . Terms v , $\mathbb{E}(s_i)$, and $p_{i,3}$ play the same role as in Section 3; instead, $(x - b_{B,3})^2$ or $(1 - b_{G,3} - x)^2$ denote the quadratic disutility of the late buyer located at x when buying from firm B or G , respectively, due to a taste mismatch between the variety consumed, $b_{B,3}$ or $1 - b_{G,3}$, and his ideal variety, x .¹⁹ Solving $v + \mathbb{E}(s_B) - p_{B,3} - (x - b_{B,3})^2 = v + \mathbb{E}(s_G) - p_{G,3} - (1 - b_{G,3} - x)^2$ for x yields the location of the third-period indifferent buyer, denoted by $x_{I,3}$. We let v be high enough to ensure that the indifferent buyer gets nonnegative equilibrium utility when buying from either firm, so the demands of firm B and firm G are given by $D_{B,3} = x_{I,3}$ and $D_{G,3} = 1 - x_{I,3}$, respectively.

To show that the role played by firms' locations on the Hotelling line is analogous to that played by the taste parameters in the monopolistic competition model, we first plug $p_{B,3} = p_{G,3}$ and $\mathbb{E}(s_B) = \mathbb{E}(s_G)$ into (2), solve $q_{B,3} \gtrless q_{G,3}$ for $b_{B,3}$, and get $b_{B,3} \gtrless b_{G,3}$. Next, we substitute $p_{B,3} = p_{G,3}$ and $\mathbb{E}(s_B) = \mathbb{E}(s_G)$ into $D_{i,3}$ and get

$$D_{B,3} = \frac{1}{2} + \frac{b_{B,3} - b_{G,3}}{2} \text{ and } D_{G,3} = \frac{1}{2} + \frac{b_{G,3} - b_{B,3}}{2}.$$

Finally, we solve $D_{B,3} \gtrless D_{G,3}$ for $b_{B,3}$ and obtain $b_{B,3} \gtrless b_{G,3}$. Therefore, in both the monopolistic competition and Hotelling models, assuming $b_{B,3} - b_{G,3} \gtrless 0$ —and therefore $g(b_{B,3}) - g(b_{G,3}) \gtrless 0$ —would imply higher/equal/lower demand for variety B , if prices and perceived qualities of the two varieties were equal, that is, if taste were the only determinant of demand.

We consider firms' symmetric locations at the line's endpoints, $b_{B,3} = b_{G,3} = 0$, and solve the following game: each firm $i = B, G$ simultaneously chooses $p_{i,3}$ to maximize the third-period profit function $\pi_{i,3} = p_{i,3}D_{i,3}$. Standard calculations lead to third-period equilibrium profits equal to

$$\pi_{B,3}^* = \frac{[3 + \mathbb{E}(s_B) - \mathbb{E}(s_G)]^2}{18} \text{ and } \pi_{G,3}^* = \frac{[3 + \mathbb{E}(s_G) - \mathbb{E}(s_B)]^2}{18},$$

after assuming that $|\mathbb{E}(s_B) - \mathbb{E}(s_G)| < 3$, so that the equilibrium demand of each firm is strictly positive.

¹⁹The taste disutility is assumed to be quadratic in the distance between the buyer and the firms because it is well known since d'Aspremont et al. (1979) that the Hotelling linear-disutility price competition game may yield no pure-strategy equilibria when firms can be located inside the line.

Second Period: Early Buyers. Denoting by $b_{B,2}$ and $1 - b_{G,2} \in (b_{B,2}, 1]$ the second-period locations of firms B and G , we have asymmetric location whenever $b_{B,2} \neq b_{G,2}$. In particular, we let $0 = b_{G,2} < b_{B,2} < 1$, so firm B is located in the interior of the line, while firm G is located at 1: by our third-period analysis, which applies mutatis mutandis to the second period, this is analogous to assuming $\Delta g \equiv g(b_{B,2}) - g(b_{G,2}) > 0$ in the monopolistic competition model. The utility of an early buyer located at point $x \in [0, 1]$ is given by $v + \bar{s} - p_{B,2} - (x - b_{B,2})^2$, when buying the product from firm B , and $v + \bar{s} - p_{G,2} - (1 - 0 - x)^2$, when buying the product from firm G . Recall that early buyers cannot infer quality before purchase but observe average quality $\bar{s}$, which they assign to both varieties; here, $\bar{s} = \frac{s_B + s_G}{2}$. Solving $v + \bar{s} - p_{B,2} - (x - b_{B,2})^2 = v + \bar{s} - p_{G,2} - (1 - 0 - x)^2$ for x yields the location of the second-period indifferent buyer, denoted $x_{I,2}$. Again, we let v be sufficiently high to ensure full market coverage at equilibrium.

Each firm $i = B, G$ simultaneously chooses $p_{i,2}$ to maximize the second-period profit function $\pi_{i,2} = p_{i,2} D_{i,2}$. Standard calculations lead to the following second-period equilibrium profits:

$$\pi_{B,2}^* = \frac{(1 - b_{B,2})(3 + b_{B,2})^2}{18} \text{ and } \pi_{G,2}^* = \frac{(1 - b_{B,2})(3 - b_{B,2})^2}{18}.$$

Notice that, consistent with the analysis in Section 3.2, second-period profits are not affected by s_i . However, while in the monopolistic competition model the reason is that the market average quality cannot be influenced by any individual firm given its negligible market share, here the driver is asymmetric information that leads early buyers to perceive the two varieties as vertically undifferentiated.

Review Generation and Information Acquisition. In line with Section 3.3, we assume that:

(i) the average quality rating reported by the set of early buyers purchasing variety i is $r_i \equiv \alpha s_i + (1 - \alpha)g(b_{i,2})$, with $g(b_{i,2})$ increasing in $b_{i,2}$ and larger than s_i as in Assumption 1; (ii) each late buyer purchasing variety i takes the early buyers' average quality rating as indicative of true quality, $\mathbb{E}(s_i) = \alpha s_i + (1 - \alpha)g(b_{i,2})$. This means that, given $b_{G,2} = 0$, $\mathbb{E}(s_B) - \mathbb{E}(s_G) = \alpha(s_B - s_G) + (1 - \alpha)\Delta g$, with $\Delta g \equiv g(b_{B,2}) - g(0)$.

First Period: Quality Investment. In the first period, firms simultaneously choose s_B and s_G to maximize $\pi_{i,3}^* - c_i f(s_i)$. We let $f(s_i) = \frac{s_i^2}{2}$ and assume $c_B = 1 > c_G = c > 0$: in line with Section 4, firm B (G) denotes the less (more) efficient one in delivering quality, with $\Delta c \equiv c_B - c_G = 1 - c > 0$. We find the following equilibrium quality levels:

$$s_{B,CR} = \frac{9c\alpha - 2\alpha^3 + 3c\alpha(1 - \alpha)\Delta g}{27c - 3\alpha^2 - 3c\alpha^2}$$

and

$$s_{G,CR} = \frac{9\alpha - 2\alpha^3 - 3\alpha(1-\alpha)\Delta g}{27c - 3\alpha^2 - 3c\alpha^2}.$$

To check the robustness of our results in Section 4, we need to calculate the equilibrium levels of quality and profits under the assumption that consumer reviews are fully informative, that is $\mathbb{E}(s_i) = s_i$ for $i = B, G$. We find $s_{B,NB} = \frac{9c-2}{24c-3}$, $s_{G,NB} = \frac{7}{24c-3}$; moreover,

$$\pi_{B,3}^*(s_{B,NB}) - c_B f(s_{B,NB}) = \frac{4(9c-2)^2}{9(8c-1)^2} \text{ and } \pi_{G,3}^*(s_{G,NB}) - c_G f(s_{G,NB}) = \frac{49c(9c-1)}{18(8c-1)^2}.$$

We also compute the constrained efficient quality level set by a planner that maximizes third-period industry profits plus the surplus of all late buyers, net of quality costs. We get $s_{B,CE} = \frac{9c-5}{13c-5}$ and $s_{G,CE} = \frac{4}{13c-5}$.²⁰

First, one can verify that $s_{G,NB} < s_{G,CE}$ for any admissible c , whereas $s_{B,NB} < s_{B,CE} \Leftrightarrow c > \frac{38+\sqrt{949}}{99} \approx 0.695 (> \frac{5}{9})$: Lemma 1 remains valid for firm G , but may fail for firm B under the Hotelling specification. The intuition is that, under full market coverage, higher s_B not only benefits firm B 's existing buyers, but also allows B to attract buyers from G . Because firm B supplies lower quality when reviews are fully informative, reallocating buyers from G to B without increasing aggregate demand has a negative effect on total surplus. This effect becomes dominant when c is relatively low –hence firm B is particularly inefficient compared to firm G – inducing the planner to reduce quality compared to the no-bias equilibrium level set by B .

Next, one can easily show that $s_{B,NB} < s_{G,NB}$ and $\pi_{B,3}^*(s_{B,NB}) - c_B f(s_{B,NB}) < \pi_{G,3}^*(s_{G,NB}) - c_G f(s_{G,NB})$ for any admissible c : this confirms the results of Lemma 2.

To check the robustness of Propositions 1 and 2, we instead rely on Figures 1 and 2, respectively, where $c = \frac{7}{10}$, $\alpha = \frac{1}{2}$, and $g(b_{i,2}) = \frac{1}{4} + \frac{11}{2}b_{i,2}$.²¹

Since $b_{G,2}$ is fixed at zero, whereas $b_{B,2}$ varies over $(0, 1)$, Figure 1 focuses on firm B and plots $s_{B,CR}$, $s_{B,NB}$, and $s_{B,CE}$ as functions of $b_{B,2}$. For low values of $b_{B,2}$ –and hence of $g(b_{B,2})$ – firm B 's equilibrium quality (the increasing solid line) lies below both the no-bias level (the horizontal dashed line) and the constrained efficient level (the horizontal dotted line), implying underinvestment and underprovision. For intermediate values of $b_{B,2}$, firm B overinvests relative to the no-bias benchmark but still underprovides quality relative to the constrained efficient level. Finally, for high values of $b_{B,2}$, both overinvestment and overprovision arise.²²

²⁰We let $c > \frac{5}{9}$ along with a sufficiently low Δg to ensure that all equilibrium quality levels are nonnegative and finite and that the second order conditions of all maximization problems are fulfilled.

²¹Under our calibration, Assumption 1 holds at equilibrium, equilibrium qualities are positive, and the third-period indifferent buyer's location is interior for every $b_{B,2} \in (0, 1)$.

²²Under our calibration, Lemma 1 also holds for firm B , so that $s_{B,NB} < s_{B,CE}$. This inequality can however be

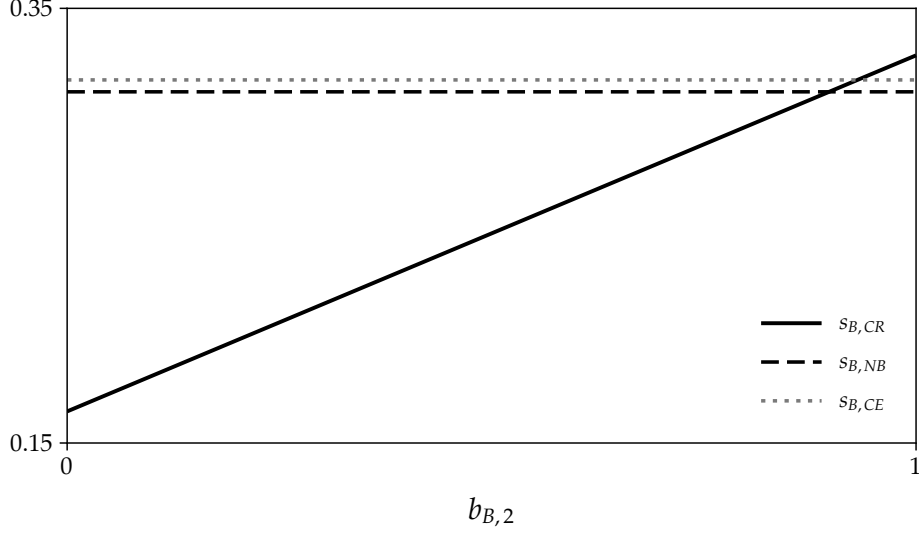


Figure 1: ILLUSTRATION OF PROPOSITION 1 IN THE HOTELLING FRAMEWORK

Figure 2 plots the equilibrium quality (solid lines) and the equilibrium profits (dashed lines) for firm B (black lines) and firm G (gray lines) as functions of $b_{B,2}$. The three regions labeled I, II, and III replicate the results corresponding to conditions (14), (15), and (16), respectively, in Proposition 2.²³ Overall, the two figures show there are admissible values of the model parameters that confirm the results of Propositions 1 and 2.

7.2 Quality Underestimation

Assumption 1 states that the average rating of any variety i is always above its true quality at equilibrium. This assumption is empirically motivated by the pre-purchase and post-purchase selection biases discussed above, which tend to generate inflated ratings. Nevertheless, the direction of review bias need not be uniform in the market: specific firms may instead be penalized by biases and reviews may underestimate their product quality (e.g., Bondi, 2025; Bondi et al., 2025). Motivated by these exceptions, we relax Assumption 1 for a positive measure of firms, while maintaining it for the remainder of the market. Denoting by k any variety whose true quality is underestimated, we let $g(b_{k,2})$ be lower than s_k at equilibrium. We also assume that the contribution of these firms to the perceived quality index is sufficiently small, so that

reversed, in which case Proposition 1 could change: for intermediate values of $b_{B,2}$, firm B could underinvest, while overproviding quality.

²³The results of Proposition 2 are stated in terms of Δg , rather than $b_{B,2}$. Under our calibration, however, $\Delta g \equiv g(b_{B,2}) - g(0) = \frac{11}{2}b_{B,2}$. Therefore, Figure 2, which uses $b_{B,2}$ on the horizontal axis, provides an equivalent illustration of the proposition. Note also that, unlike the equilibrium outcome under monopolistic competition, firm G 's equilibrium quality and profits are negatively affected by $b_{B,2}$. This is due to the strategic nature of Hotelling competition: even though firm G 's location stays at $1 - b_{G,2} = 1$, the perceived quality of its variety vis-à-vis that of variety B , $\mathbb{E}(s_G) - \mathbb{E}(s_B) = \alpha(s_G - s_B) - (1 - \alpha)\Delta g$, shrinks as $b_{B,2}$, and therefore Δg , rises, inducing firm G to invest less in quality and reducing its profits.

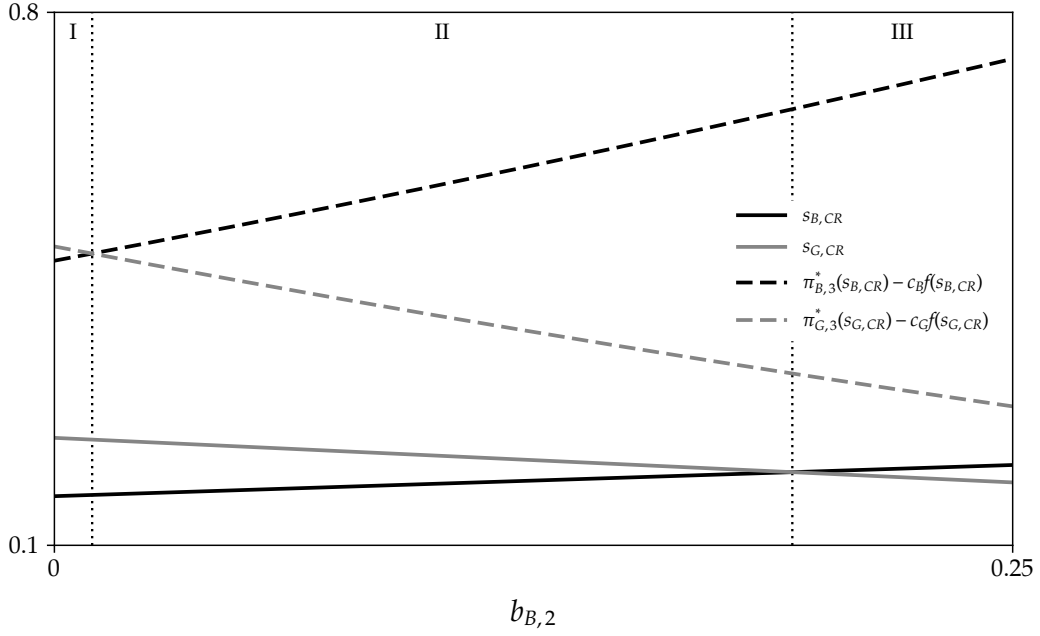


Figure 2: ILLUSTRATION OF PROPOSITION 2 IN THE HOTELLING FRAMEWORK

$\mathbb{E}(S_{CR})$ and, consequently, H_{CR} , are little affected.

In this case, it is straightforward to verify that, among our results in Section 4, only Proposition 1 is affected. In particular, one can show that quality underestimation necessarily implies underinvestment for any firm k : $g(b_{k,2}) < s_{k,CR} < s_{k,NB}$. Under Assumption 2, these firms also underprovide quality, since $s_{k,NB} < s_{k,CE}$. Thus, allowing for quality underestimation introduces additional admissible cases of underinvestment and underprovision, while ruling out overinvestment and overprovision for the affected firms.

7.3 CES Specification

Our analysis adopts the quasi-linear utility function (1), which belongs to the linear-quadratic demand framework introduced by Dixit (1979) and Singh and Vives (1984) for the duopoly case and later extended to a continuum of varieties by Ottaviano et al. (2002) and Melitz and Ottaviano (2008). By contrast, the seminal contribution to the monopolistic competition literature, Dixit and Stiglitz (1977), employs a CES (sub)utility function, rather than a quadratic one, for the differentiated good. A natural question is whether our results are robust to this alternative specification that has been adopted by many subsequent papers. Below, we verbally describe the conditions under which they are and briefly explain the underlying economic logic; formal derivations are available upon request.

Suppose one retains the numéraire in (1), but replaces the quadratic subutility over differ-

entiated varieties with a CES one and also assumes that firms incur a positive constant, rather than zero, marginal production cost that is independent of quality. It can then be shown that CES demand yields a constant markup, with the effect that perceived quality no longer affects equilibrium price. Nevertheless, a result analogous to Lemma 1 holds under an appropriate CES counterpart of Assumption 2: equilibrium changes in aggregate demand conditions must not offset the additional marginal benefit of quality internalized by the planner. Lemma 2 continues to hold since a higher quality cost parameter still reduces equilibrium quality and profits. The mechanism underlying Proposition 1 continues to operate, provided that the constant elasticity of substitution between any two differentiated varieties is high enough to ensure that any firm i 's third-period equilibrium profits are convex in $\mathbb{E}(s_i)$, as is the case in our linear-quadratic framework: this condition guarantees that a sufficiently large taste component raises the marginal return to true quality and can generate overinvestment and overprovision. As for Proposition 2, the profit ranking between firms B and G can be reversed after the quality ranking, potentially leading a less efficient firm to choose higher quality, yet earn lower profits. Overall, the finding that taste bias can generate different distortions in quality investment is robust to a CES specification of buyers' preferences, subject to the conditions discussed above.

8 Discussion and Conclusion

In this final section, we discuss one further aspect of our analysis before concluding.

Ceiling on Ratings. In our analysis, the reviews' taste component $g(b_{i,2})$ can take any positive value above s_i . In practice, however, consumer rating platforms impose a ceiling $\bar{r}$ on ratings, for instance, five bubbles/stars on TripAdvisor, Amazon, and Google Maps, and ten points on Booking.com. Mapping this real-world feature onto our model has implications for Propositions 1 and 2. Indeed, as $r_{i,CR} \equiv \alpha s_{i,CR} + (1 - \alpha)g(b_{i,2})$ is strictly increasing in $g(b_{i,2})$, $\bar{r}$ determines a unique implicit upper bound on the taste component, denoted by $\bar{g}(b_{i,2})$ and defined by $\alpha s_{i,CR}(\bar{g}(b_{i,2})) + (1 - \alpha)\bar{g}(b_{i,2}) = \bar{r}$. As a result, all three regions in Proposition 1 are attainable only if $\bar{r}$ is high enough, i.e., only if the rating scale is wide enough, so that $\bar{g}(b_{i,2}) > \tilde{g}(b_{i,2})$. A similar qualification applies to Proposition 2. Holding $g(b_{G,2})$ fixed and assuming that $r_{G,CR}$ is below $\bar{r}$, the rating ceiling imposes an implicit upper bound on the taste advantage attainable by firm B , denoted by $\Delta\bar{g}$ and given by $\alpha s_{B,CR}(g(b_{G,2}) + \Delta\bar{g}) + (1 - \alpha)[g(b_{G,2}) + \Delta\bar{g}] = \bar{r}$. It follows that all three regions identified in Proposition 2 can arise only if $\Delta\bar{g} > \Delta g_s(\Delta c)$.

Conclusion. This paper shows that biased consumer reviews have nonobvious effects on firms’ quality incentives. First, depending on the importance of taste fit in ratings, firms may underinvest or overinvest relative to the quality level they would choose in an environment with fully informative reviews and may underprovide or overprovide quality relative to the constrained efficient benchmark. Second, review bias can also overturn quality and profit rankings across competitors, allowing a less efficient firm that, however, enjoys a sufficiently favorable taste advantage to outperform a more efficient rival. Third, measures that improve review informativeness generate similarly nuanced effects: under Assumption 1, unilateral adoption harms the adopting firm, whereas market-wide adoption may increase industry profits. Finally, greater trust in reviews prompted by policies against manipulation may exacerbate quality underinvestment.

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A Mathematical Proofs

A.1 Third Period

We focus on an arbitrary variety i and rewrite the part of the utility function (1) that is relevant for the choice of $q_{i,3}$ after substituting the budget constraint $q_{0,3} = y_3 - p_{i,3}q_{i,3} - \int_{j \neq i} (p_{j,3}q_{j,3}) di$:

$$[v + \mathbb{E}(s_i)]q_{i,3} - \frac{1}{2} \frac{q_{i,3}^2}{b_{i,3}} - \gamma_3 q_{i,3} Q_3 + y_3 - p_{i,3}q_{i,3} - \int_{j \neq i} (p_{j,3}q_{j,3}) dj,$$

where $Q_3 = \int q_{i,3} di$ denotes the third-period total quantity of the differentiated product. We calculate the first order condition with respect to $q_{i,3}$ to derive the third-period demand function for variety i ,

$$q_{i,3} = b_{i,3} [v + \mathbb{E}(s_i) - p_{i,3} - \gamma_3 Q_3]. \quad (\text{A1})$$

To get Q_3 , we then integrate both sides of (A1) over the mass of varieties,

$$Q_3 = \int [b_{i,3} (v + \mathbb{E}(s_i) - p_{i,3} - \gamma_3 Q_3)] di,$$

and solve for Q_3 ,

$$Q_3 = \frac{vB_3 + \mathbb{E}(S) - P_3}{1 + \gamma_3 B_3}. \quad (\text{A2})$$

Finally, we plug (A2) into (A1) and get (2).

To compute the third-period equilibrium price index, we multiply both sides of (3) by $b_{i,3}$ and integrate over the continuum of varieties. Solving the resulting equation for P_3 yields

$$P_3^* = \frac{\mathbb{E}(S) + vB_3}{2 + \gamma_3 B_3}.$$

A.2 Second Period

We rewrite (6) as

$$(v + \bar{s}) q_{i,2} - \frac{1}{2} \frac{q_{i,2}^2}{b_{i,2}} - \gamma_2 q_{i,2} Q_2 + y_2 - p_{i,2}q_{i,2},$$

where $Q_2 = \int q_{i,2} di$. Maximizing this function with respect to $q_{i,2}$ yields the second-period demand function (7). Similarly, the maximization of the profit function $\pi_{i,2} = p_{i,2}q_{i,2}$ yields

$$p_{i,2} = \frac{v + \bar{s} + \gamma_2 P_2}{2(1 + \gamma_2 B_2)}. \quad (\text{A3})$$

Following the same procedure used to calculate the third-period equilibrium values, we can derive the second-period equilibrium price index,

$$P_2^* = \frac{(v + \bar{s})B_2}{2 + \gamma_2 B_2}. \quad (\text{A4})$$

Plugging this value into (A3) gives (8). Substituting (8) and (A4) into (7) yields (9). Expression (10) follows readily.

A.3 First Period

Omitting the subscript i , problem (13) can be rearranged as

$$b_3 \left[\frac{\alpha s + (1 - \alpha) g(b_2)}{2} + H \right]^2 - c f(s).$$

The first order condition with respect to s is

$$\alpha b_3 \left[\frac{\alpha s + (1 - \alpha) g(b_2)}{2} + H \right] - c f'(s) = 0. \quad (\text{A5})$$

The second order condition is

$$\alpha^2 \frac{b_3}{2} - c f''(s) < 0, \quad (\text{A6})$$

which we assume to hold. Denoting by s_{CR} the solution to (A5), $H_{CR} \equiv \frac{2v - \gamma_3 \mathbb{E}(S_{CR})}{2(2 + \gamma_3 B_3)}$ the equilibrium level of H , and applying the implicit function theorem to (A5) yields

$$\begin{aligned} \frac{\partial s_{CR}}{\partial b_2} &= \frac{\frac{\alpha(1-\alpha)b_3 \times g'(b_2)}{2}}{c f''(s_{CR}) - \alpha^2 \frac{b_3}{2}} > 0, \\ \frac{\partial s_{CR}}{\partial b_3} &= \frac{\alpha \left[\frac{\alpha s_{CR} + (1-\alpha)g(b_2)}{2} + H_{CR} \right]}{c f''(s_{CR}) - \alpha^2 \frac{b_3}{2}} > 0, \end{aligned}$$

and

$$\frac{\partial s_{CR}}{\partial c} = - \frac{f'(s_{CR})}{c f''(s_{CR}) - \alpha^2 \frac{b_3}{2}} < 0. \quad (\text{A7})$$

A.4 Lemma 1

We first reconsider problem (13) under NB , omit subscript i , and compute its first order condition,

$$b_3 \left(\frac{s}{2} + H^+ \right) - c f'(s) = 0. \quad (\text{A8})$$

where $H^+ \equiv \frac{2v - \gamma_3 S}{2(2 + \gamma_3 B_3)}$. We denote by s_{NB} the solution to (A8). The second order condition is

$$\frac{b_3}{2} - c f''(s) < 0, \quad (\text{A9})$$

which is assumed to hold.

We now move to the planner. Recalling that reviews are assumed to be fully informative of quality and omitting the subscript i , the planner's objective function is

$$[p_3 \times q_3 - c f(s)] + \left[\int_0^{q_3} \left(v + s - \frac{q}{b_3} - \gamma_3 \frac{v B_3 + S - P_3}{1 + \gamma_3 B_3} \right) dq - p_3 \times q_3 \right],$$

where the first term in square brackets is firm i 's profit, while the second term is the late buyer's

surplus from consumption of variety i , given by the difference between the area under the inverse demand function and the total expenditure for this variety. Recalling that the planner does not choose prices, substituting the equilibrium value of P_3 into the expression above, and denoting by W_3 the resulting function, the planner's problem becomes

$$\max_s W_3 \equiv \int_0^{q_3^*} \left(s + 2H^+ - \frac{q}{b_3} \right) dq - cf(s).$$

The first order condition is

$$\left(s + 2H^+ - \frac{q_3^*}{b_3} \right) \frac{\partial q_3^*}{\partial s} + \int_0^{q_3^*} 1 dq - cf'(s) = 0 : \quad (\text{A10})$$

$\left(s + 2H^+ - \frac{q_3^*}{b_3} \right)$ is the late buyer's marginal willingness to pay at q_3^* , which equals the third-period equilibrium price under full information. Hence, the first addend measures the value of the additional units the late buyer consumes when s rises, which firm i collects as additional revenue. The second addend can be rewritten as q_3^* and measures the increase in the late buyer's willingness to pay for all the q_3^* units consumed: when s rises, his willingness to pay for each unit rises one-for-one, whereas the equilibrium price $s/2 + H^+$ rises by only one half. Firm i therefore captures $q_3^*/2$ of the second addend through the higher price, while the remaining $q_3^*/2$ accrues to the late buyer as additional surplus. Note that the market aggregates, and hence H^+ , are taken as given by the planner when choosing the quality level of any individual variety i . Rearranging (A10) yields

$$\frac{3}{2}b_3 \left(\frac{s}{2} + H^+ \right) - cf'(s) = 0. \quad (\text{A11})$$

We denote by s_{CE} the solution to (A11). The second order condition is

$$\frac{3}{4}b_3 - cf''(s) < 0, \quad (\text{A12})$$

which is stronger than both (A9) and (A6). We let (A12) be fulfilled for any s , so all SOC's are globally fulfilled.

To prove the lemma, we observe that Assumption 2 is sufficient for the firm's marginal benefits from investing in quality –first term of (A8)– to be lower than the planner's marginal benefits –first term of (A11)– at any given s , after substituting the equilibrium aggregates, H_{NB}^+ and H_{CE}^+ , respectively. It follows that $\frac{\partial \Pi_{NB}(s)}{\partial s} < \frac{\partial W_3(s)}{\partial s}$ at any given s . In particular, $\frac{\partial \Pi_{NB}(s_{CE})}{\partial s} < \frac{\partial W_3(s_{CE})}{\partial s} = 0$ when $s = s_{CE}$. Since Π_{NB} is strictly concave in s and its derivative is negative at s_{CE} , Π_{NB} must be decreasing in $s \geq s_{CE}$. As a consequence, its maximum point s_{NB} must be strictly lower than s_{CE} . The result in the text follows.

A.5 Proposition 1

We omit subscript i and note that $s_{CR} < (>)s_{NB} \Leftrightarrow \frac{\partial \Pi_{CR}}{\partial s} \Big|_{s=s_{NB}} < (>)0$ under strict concavity of the profit function. Using (A5), these inequalities are equivalent to

$$\alpha b_3 \left[\frac{\alpha s_{NB} + (1-\alpha)g(b_2)}{2} + H_{CR} \right] - cf'(s_{NB}) < (>)0. \quad (\text{A13})$$

From (A8)

$$cf'(s_{NB}) = b_3 \left(\frac{s_{NB}}{2} + H_{NB}^+ \right).$$

Plugging this value into (A13) yields

$$\alpha b_3 \left[\frac{\alpha s_{NB} + (1 - \alpha) g(b_2)}{2} + H_{CR} \right] < (>) b_3 \left(\frac{s_{NB}}{2} + H_{NB}^+ \right).$$

Solving the equality for $g(b_2)$ gives $\hat{g}(b_2) \equiv \frac{(1+\alpha)s_{NB}}{\alpha} + \frac{2H_{NB}^+ - 2\alpha H_{CR}}{\alpha(1-\alpha)}$.

To derive $\check{g}(b_2)$, we apply the same reasoning using (A11) instead of (A8). This yields

$$\alpha b_3 \left[\frac{\alpha s_{CE} + (1 - \alpha) g(b_2)}{2} + H_{CR} \right] < (>) \frac{3}{2} b_3 \left(\frac{s_{CE}}{2} + H_{CE}^+ \right)$$

We get $\check{g}(b_2) \equiv \frac{(3-2\alpha^2)s_{CE}}{2\alpha(1-\alpha)} + \frac{3H_{CE}^+ - 2\alpha H_{CR}}{\alpha(1-\alpha)}$. Simple algebra and the fact that $s_{CE} > s_{NB}$ yield $\hat{g}(b_2) < \check{g}(b_2)$ under Assumption 2. The results in the text follow.

In conclusion, we remark that $\check{g}(b_2) - s_{CE} > \hat{g}(b_2) - s_{NB}$ and that the latter difference is positive if, and only if, $H_{CR} < \frac{1}{\alpha} H_{NB}^+ + \frac{1-\alpha}{2\alpha} s_{NB}$. For underinvestment to be feasible under Assumption 1 this inequality must be fulfilled, in which case any $\check{g}(b_2) \in (s_{NB}, \hat{g}(b_2))$ satisfies $s_{CR}(\check{g}(b_2)) < s_{NB} (< \check{g}(b_2))$.

A.6 Lemma 2

The implicit function theorem ensures

$$\frac{\partial s_{NB}}{\partial c} = - \frac{f'(s_{NB})}{cf''(s_{NB}) - \frac{b_3}{2}} < 0.$$

The envelope theorem ensures

$$\frac{\partial [\pi_3^*(s_{NB}) - cf(s_{NB})]}{\partial c} = -f(s_{NB}) < 0.$$

The result in the text follows.

A.7 Proposition 2

We start with the equilibrium quality comparison and let Δg be such that the quality level chosen by both firms is $s_{G,CR}$ for any given Δc . At this value of Δg , the marginal profit of both firms is zero. Subtracting firm G 's marginal profit from firm B 's and using the shorthand $g_i = g(b_{i,2})$ then yields

$$\begin{aligned} & \left\{ \alpha b_3 \left[\frac{\alpha s_{G,CR} + (1 - \alpha) g_B}{2} + H_{CR} \right] - c_B f'(s_{G,CR}) \right\} \\ & - \left\{ \alpha b_3 \left[\frac{\alpha s_{G,CR} + (1 - \alpha) g_G}{2} + H_{CR} \right] - c_G f'(s_{G,CR}) \right\} = 0. \end{aligned}$$

Rearranging and solving for Δg yields

$$\Delta g = \Delta c \frac{2f'(s_{G,CR})}{\alpha(1-\alpha)b_3} \equiv \Delta g_s(\Delta c) > 0.$$

Conditions (15) and (16) then stem from the following two properties: if Δg were 0, $s_{B,CR} < s_{G,CR}$ from (A7); the equilibrium quality $s_{B,CR}$ is a continuous and strictly increasing function in Δg , while $s_{G,CR}$ is fixed. Finally, note that $\Delta g_s(\Delta c)$ is increasing in Δc .

Moving to the equilibrium profit comparison, note that firms B and G would differ only in c if Δg were 0. In this case, the envelope theorem ensures that $\Pi_{B,CR} < \Pi_{G,CR}$. We then assess the sign of $\Pi_{B,CR} - \Pi_{G,CR}$ at $\Delta g = \Delta g_s$, when both firms choose quality $s_{G,CR}$. To this aim, we rearrange firms' FOCs to get

$$\frac{\alpha s_{i,CR} + (1-\alpha)g_i}{2} + H_{CR} = \frac{c_i f'(s_{i,CR})}{\alpha b_3}. \quad (A14)$$

Plugging the right-hand side of (A14) into $\Pi_{i,CR}$ and rearranging yields

$$\Pi_{i,CR} = \frac{[c_i f'(s_{i,CR})]^2}{\alpha^2 b_3} - c_i f(s_{i,CR}).$$

It follows that, at Δg_s ,

$$\Pi_{B,CR} - \Pi_{G,CR} = \Delta c \left\{ \frac{(c_B + c_G) [f'(s_{G,CR})]^2}{\alpha^2 b_3} - f(s_{G,CR}) \right\}.$$

Note that

$$\frac{(c_B + c_G) [f'(s_{G,CR})]^2}{\alpha^2 b_3} > \frac{2c_G [f'(s_{G,CR})]^2}{\alpha^2 b_3}.$$

Moreover, (A12) implies

$$\frac{2c_G [f'(s_{G,CR})]^2}{\alpha^2 b_3} > s_{G,CR} f'(s_{G,CR}).$$

Finally, strict convexity of $f(s)$ and $f(0) = 0$ give $s_{G,CR} f'(s_{G,CR}) > f(s_{G,CR})$. We conclude that

$$\frac{(c_B + c_G) [f'(s_{G,CR})]^2}{\alpha^2 b_3} - f(s_{G,CR}) > 0$$

and $\Pi_{B,CR} > \Pi_{G,CR}$ at $\Delta g = \Delta g_s$. Since $\Pi_{B,CR} < \Pi_{G,CR}$ at $\Delta g = 0$ and Π_B is continuous and strictly increasing in $g(b_{B,2})$, there exists a unique cutoff value of Δg , denoted by $\Delta g_\Pi(\Delta c) \in (0, \Delta g_s(\Delta c))$, at which $\Pi_{B,CR} = \Pi_{G,CR}$. Condition (14) follows.

In conclusion, we show that $\Delta g_\Pi(\Delta c)$ is increasing in Δc . To this aim, note that, for any fixed Δg and c_G ,

$$\frac{\partial (\Pi_{B,CR} - \Pi_{G,CR})}{\partial \Delta c} = \frac{\partial \Pi_B}{\partial c_B} = -f(s_{B,CR}) < 0.$$

Moreover, for any fixed Δc and $g(b_{B,2})$,

$$\frac{\partial (\Pi_{B,CR} - \Pi_{G,CR})}{\partial \Delta g} = \frac{\partial \Pi_B}{\partial g(b_{B,2})} > 0.$$

Start from $\Pi_{B,CR} - \Pi_{G,CR} = 0$ at $\Delta g = \Delta g_\Pi$ and suppose Δc rises: then $\Pi_{B,CR} - \Pi_{G,CR} < 0$.

Restoring equality then requires an increase in Δg .

A.8 Results 1 and 2

We organize this appendix into three parts: 1) the proof of Result 1; 2) the proof of Result 2; 3) the discussion of the sign of $\frac{dH_{CR}}{d\alpha}$.

1) If α increases only for variety i , H_{CR} remains fixed. Starting from

$$\Pi_i = b_{i,3} \left[\frac{\alpha s_i + (1 - \alpha) g(b_{i,2})}{2} + H_{CR} \right]^2 - c_i f(s_i),$$

we can write

$$\frac{\partial \Pi_i}{\partial \alpha} = b_{i,3} \left[\frac{\alpha s_i + (1 - \alpha) g(b_{i,2})}{2} + H_{CR} \right] [s_i - g(b_{i,2})],$$

which is negative under Assumption 1. It follows that, for any finite increase $\alpha < \alpha' < 1$, $\Pi_i(s_{i,CR}(\alpha'); \alpha') < \Pi_i(s_{i,CR}(\alpha'); \alpha) \leq \Pi_i(s_{i,CR}(\alpha); \alpha)$: the first inequality stems from $\frac{\partial \Pi_i}{\partial \alpha} < 0$; the second follows because $\Pi_i(s; \alpha)$ is maximized at $s_{i,CR}(\alpha)$. This proves Result 1.

2) If α increases for all firms, H_{CR} is affected and

$$\frac{d\Pi_i}{d\alpha} = b_{i,3} \left[\frac{\alpha s_i + (1 - \alpha) g(b_{i,2})}{2} + H_{CR} \right] \left[s_i - g(b_{i,2}) + 2 \frac{dH_{CR}}{d\alpha} \right].$$

It follows that

$$\frac{d\Pi_i}{d\alpha} > 0 \Leftrightarrow \frac{dH_{CR}}{d\alpha} > \frac{g(b_{i,2}) - s_i}{2},$$

for any given s_i . Recalling that equilibrium industry profits are $\Pi^* = \int \Pi_{i,CR} di$, we invoke the envelope theorem and get

$$\frac{d\Pi^*}{d\alpha} = \int b_{i,3} \left[\frac{\alpha s_{i,CR} + (1 - \alpha) g(b_{i,2})}{2} + H_{CR} \right] \left\{ 2 \frac{dH_{CR}}{d\alpha} - [g(b_{i,2}) - s_{i,CR}] \right\} di$$

or, equivalently,

$$\frac{d\Pi^*}{d\alpha} = 2 \frac{dH_{CR}}{d\alpha} \int b_{i,3} p_{i,3}^* di - \int b_{i,3} p_{i,3}^* [g(b_{i,2}) - s_{i,CR}] di.$$

Plugging $b_{i,3} p_{i,3}^* = q_{i,3}^*$ into the right-hand side and integrating it over $[\alpha, \alpha']$ yields $\Pi^*(\alpha') - \Pi^*(\alpha)$, which is positive if, and only if, (17) holds. Result 2 follows.

3) We calculate

$$\frac{dH_{CR}}{d\alpha} = - \frac{\gamma_3}{2(2 + \gamma_3 B_3)} \frac{d\mathbb{E}(S)}{d\alpha},$$

where

$$\frac{d\mathbb{E}(S)}{d\alpha} = \int b_{j,3} [s_{j,CR} - g(b_{j,2})] dj + \alpha \int b_{j,3} \frac{ds_{j,CR}}{d\alpha} dj. \quad (\text{A15})$$

Under Assumption 1, the first term of (A15) is negative: holding equilibrium qualities fixed, greater informativeness reduces the perceived quality index and therefore raises H_{CR} . The second term captures the firms' quality response to a change in α and can offset the negative effect. Since the sign of $\frac{dH_{CR}}{d\alpha}$ is generally ambiguous and the right-hand side of (17) is positive under Assumption 1, condition (17) can hold only if $\frac{dH_{CR}}{d\alpha}$ is assumed positive for at least some $\tilde{\alpha} \in (\alpha, \alpha')$.

A.9 Result 3

We omit subscript i and investigate how the sign of $[s_{CR}(\alpha') - s_{NB}] - [s_{CR}(\alpha) - s_{NB}]$ is affected by α . Since s_{NB} is defined under fully informative reviews and is therefore independent of α , this difference is equivalent to $s_{CR}(\alpha') - s_{CR}(\alpha)$. As α rises to α' , underinvestment (overinvestment) is exacerbated when this expression is negative (positive). Using strict concavity of the profit function with respect to s , this occurs if, and only if, the marginal profit evaluated at $s_{CR}(\alpha)$, given α' , is negative (positive), that is, $R \equiv \frac{\partial \Pi_{CR}(s_{CR}(\alpha))}{\partial s} \Big|_{\alpha'} - \frac{\partial \Pi_{CR}(s_{CR}(\alpha))}{\partial s} \Big|_{\alpha} < (>) 0$, where the subtrahend is zero. We divide R by b_3 and manipulate the resulting expression to get

$$\alpha' \left[\frac{\alpha' s_{CR}(\alpha) + (1 - \alpha') g(b_2)}{2} + H_{CR}(\alpha') \right] - \alpha \left[\frac{\alpha s_{CR}(\alpha) + (1 - \alpha) g(b_2)}{2} + H_{CR}(\alpha) \right].$$

The sign of this difference is equivalent to that of R . Result 3 follows.

A.10 Result 4

We omit subscript i . The proof follows the same logic as the one in Appendix A.9. In particular, we evaluate the marginal profit at $s = s_{CR}(\tau)$, given $\tau = 1$, i.e., $\frac{\partial \Pi(s_{CR}(\tau))}{\partial s} \Big|_{\tau=1}$. Dividing this expression by αb_3 and manipulating yields the left-hand side of (19). When this expression is negative, then $s_{CR}(1) < s_{CR}(\tau)$. Since s_{NB} is independent of τ , a decrease in quality exacerbates initial underinvestment. This proves the result.