Discussion Paper Series – CRC TR 224

Discussion Paper No. 509
Project B 05

Harvesting Ratings

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September 2025
(First version : February 2024)

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Support by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) through CRC TR 224 is gratefully acknowledged.

Collaborative Research Center Transregio 224 - www.crctr224.de
Rheinische Friedrich-Wilhelms-Universität Bonn - Universität Mannheim

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September 9, 2025

Abstract

Ratings play a crucial role in online marketplaces, shaping consumer decisions and firm strategies. We investigate how firms strategically use pricing to influence ratings, and how this undermines ratings as signals of product quality. We develop a two-period model of price competition between an established firm and a potentially high- or low-quality entrant, capturing the challenge high-quality newcomers face in building reputation. Consumers rate based on value-for-money, but cannot distinguish whether positive ratings result from genuine quality or discounted prices. Low-quality entrants take advantage of this and may offer low prices to harvest good ratings in the future, or mimic high prices to signal high quality. We show that ratings harvesting inflates positive ratings, reduces their informativeness, and exacerbates the cold-start problem, discouraging high-quality entry. Our results mirror empirical patterns and generate implications for how rating design affects market outcomes: reducing effort-costs to rate induces more but less-informative ratings, and discourages entry. Policy implications include discouraging excessive discounts for new sellers, incorporating price-paid into rating displays, and balancing rating effort-costs to preserve informativeness. While the effects of individual entrants' harvesting may appear temporary, harvesting hinders high-quality entrants from building reputation, discouraging entry and causing lasting distortions.

JEL: D21, D83, L10

Keywords: Ratings, digital economy, reputation, cold-start problem, biased ratings

This paper was previously titled 'Ratings and Reciprocity'. We thank Yair Antler, Paul Belleflamme, Maren Hahnen, Paul Heidhues, Botond Kőszegi, Xavier Lambin, François Maniquet, Simon Martin, Martin Peitz, Andrew Rhodes, Robert Somogyi, Clément Staner, Nikhil Vellodi, Julian Wright, and many seminar participants for helpful comments. We thank the Fédération Wallonie-Bruxelles for funding the Action de recherche concerée grant 19/24-101 'PROSEco'. Robin Ng gratefully acknowledges support from the Belgian National Fund for Scientific Research (FNRS) through the Aspirant Grant (FC46885), the Deutsche Forschungsgemeinschaft (DFG) through the CRC TR 224 (Project B05) and the SSRC-SMU Graduate Research Fellowship.

1 Introduction

Ratings play a central role in everyday decisions. Whether choosing a holiday resort, buying a car, or picking a lunch spot, we often rely on the experiences of others. But how reliable are ratings as indicators of product quality?

The answer partly depends on the relationship between ratings and prices. Empirical evidence suggests a dual relationship. On the one hand, firms with higher ratings tend to raise prices (Cabral & Hortaçsu, 2010; Cabral & Li, 2015; Cai et al., 2014; Carnehl et al., 2025; Ert & Fleischer, 2019; Gutt & Herrmann, 2015; Jin & Kato, 2006; Jolivet et al., 2016; Lewis & Zervas, 2019; Li et al., 2020; Livingston, 2005; Luca & Reshef, 2021; McDonald & Slawson, 2002; Mimra et al., 2016; Neumann et al., 2018; Proserpio et al., 2018; Reimers & Waldfogel, 2021), implying that ratings convey some information about quality. On the other hand, lower prices have been shown to boost ratings (Cai et al., 2014; Carnehl et al., 2025; Li & Hitt, 2010; Luca & Reshef, 2021; Neumann et al., 2018), indicating that perceptions of value-for-money influence consumer evaluations. However, if value-for-money shapes ratings, then firms can strategically adjust prices to manipulate their own ratings—thereby distorting the extent to which ratings reflect true product quality. We investigate how firms' strategic pricing decisions affect the informativeness of ratings as signals of quality.

Classic models on reputation typically assume that firm reputation is based on past observations of quality (see Bar-Isaac & Tadelis, 2008). Thus, they capture how ratings affect future prices. This paper extends that view by analyzing how firms use prices to shape ratings—and how this strategic behavior undermines ratings as quality signals.

To model how prices shape ratings, we assume consumers leave positive (negative) ratings when value-for-money is sufficiently high above (below) their outside option, making the effort of rating worthwhile. This captures the above evidence, and also aligns with plausible psychological mechanisms like reciprocity (Bolton & Ockenfels, 2000; Dufwenberg & Kirchsteiger, 2004; Rabin, 1993), which seems relevant for ratings (Fradkin et al., 2021), and that consumers are more inclined to rate when they experience especially positive or negative outcomes.

We analyze a two-period model with price competition between an established firm and a newcomer who chooses to enter or not. The established firm's quality is common knowledge while the newcomer's quality is their private information and either higher or lower. Both firms may operate in both periods, setting prices to maximize lifetime profits. Consumers are short-lived and participate in only one period. At the start of each period, they observe current prices and past ratings but cannot tell whether high ratings reflect true quality or low prices. Consumers learn the true quality of a product after consumption and may leave a positive, negative, or no rating. Rating incurs an effort cost drawn from a continuous distribution, so newcomers may receive no rating with positive probability. Consequently, consumers face uncertainty about quality of the newcomer, but ratings can still convey partial information.

This model represents marketplaces such as Amazon and Taobao. Such platforms feature both established sellers—e.g. with a large number of existing ratings—and substantial entry by newcomers.[1] According to evidence by Farronato and Fradkin (2022), entry elasticities are very high, suggesting entry is sensitive to market features. Our two-period entry model captures that ratings are particularly important (Reimers & Waldfogel, 2021)—and arguably less informative (Dendorfer & Seibel, 2024; Hui et al., 2024)—for newcomers. In a reduced form, it captures the critical phase in which newcomers struggle to build a reputation (Dendorfer & Seibel, 2024; Hui et al., 2024). This central challenge for high-quality newcomers is known in the literature as the cold-start problem. Additionally, consumers rely on ratings to form beliefs about product quality. But since platforms typically display only past ratings and current prices, consumers cannot tell whether a high rating reflects high quality or past low prices.

Our key mechanism is a trade-off faced by low-quality newcomers. In period 1, they either (i) set a low price to induce positive ratings—*ratings harvesting*—and profit from better ratings in period 2, or (ii) match the high-quality firm's price—*price mimicking*—to signal high quality by blending its price. However, since consumers discover the true (low) quality after purchase, mimicking induces a lower value-for-money and yields worse ratings and lower profits in period 2.

If entry occurs in equilibrium, high-quality newcomers offer the best value-for-money and thus are most likely to earn positive ratings. For low-quality newcomers, ratings depend on their pricing strategy: harvesting can generate positive ratings through lower prices, but—after consumer expectations adjusted—harvesting lowers the value of reputation in equilibrium; mimicking leads to worse ratings, allowing future consumers to more accurately distinguish the quality of newcomers.

Our key trade-off induces several interesting equilibrium features.

First, our equilibrium links newcomer pricing strategies to the informativeness of ratings: the more low-quality firms engage in *ratings harvesting*, the less precise positive ratings signal high quality. Thus, the equilibrium probability that low-quality firms choose *price mimicking* also reflects how precisely ratings convey quality.

This mirrors empirical findings on the dual relationship of prices and ratings. In our framework, both high-quality firms, and low-quality firms that harvest ratings, receive positive feedback and eventually raise prices. This aligns with evidence that sellers first build reputation through favorable ratings, then increase prices (Cabral & Hortaçsu, 2010; Cabral & Li, 2015; Li et al., 2020).

Second, ratings harvesting causes *rating inflation*.[2] Low-quality firms artificially boost their reputations through discounted prices, then free-ride on the reputation of high-quality firms. This erodes the system's ability to distinguish quality.

Third, ratings harvesting affects entry and worsens the *cold-start problem*—the difficulty newcomers

[1]According to https://grabon.com/blog/amazon-seller-statistics/, accessed June 19th, 2025, in 2024 839,000 new sellers joined Amazon marketplace. Using data on AirBnB Manhattan, Dendorfer and Seibel (2024) and Farronato and Fradkin (2022) report entry and exit rates of 3-4% each month.

[2]That is, ratings improve over time for reasons unrelated to product quality, making them less informative. See Filippas et al. (2022) for evidence that low effort costs, reciprocity, and retaliation all contribute to this trend.

face in establishing a reputation. Existing work on the issue assumes that sellers have no private information on their quality (Bergemann & Välimäki, 1997, 2000; Che & Hörner, 2018; Kremer et al., 2014; Vellodi, 2018). We contribute by showing that private information induces harvesting, which in turn worsens the cold-start problem. Entry occurs if and only if there is not too much harvesting. Excessive harvesting erodes informativeness, making consumers hesitant to buy from newcomers—even those with good ratings—and deters entry. Crucially, also high-quality newcomers stay out if ratings cannot signal their quality sufficiently well. Conversely, when harvesting is limited and ratings sufficiently informative, all types of newcomers enter. Thus, harvesting distorts entry in multiple ways: harvesting (i) diminishes the value of reputation, which (ii) discourages entry of high-quality firms. Both issues reinforce the cold-start problem. Additionally, low-quality newcomers can enter even if they sell worthless products.

These results have key policy implications. First, fully excluding low-quality entrants is inherently difficult: if only high-quality sellers enter, the reputation of newcomers skyrockets—thereby attracting strategic low-quality entrants looking to free-ride on this reputation. Second, while major platforms like Amazon and Airbnb often recommend steep discounts to help new sellers build reputation, this may backfire. Our results show that low-quality sellers are especially likely to follow this advice, undermining rating informativeness. Instead, platforms may want to consider discouraging ratings harvesting. While this may not fully prevent entry of low-quality sellers, it does weed them out quicker.

Our findings also suggest how platform design can discourage rating harvesting.

Many platforms lower the effort required to rate, aiming to boost the number of ratings. For instance, Amazon replaced its 20-word written review requirement with a one-click rating system, arguing that more ratings "more accurately [...] reflect the experience of all purchasers."[3] We show that this reasoning overlooks sellers' strategic response. Conditional on entry, lowering the effort costs means that, holding prices and beliefs constant, low-quality sellers are more likely to receive positive ratings—thereby incentivizing further rating harvesting. While this raises the probability of getting a rating, it also reduces rating precision. In turn, increasing the effort costs to rate discourages rating harvesting and makes ratings more informative, but also reduces the probability of getting a rating. Thus, maintaining the quality of a rating system may require balancing incentives to encourage consumer participation against measures that discourage rating harvesting.

Evidence supports that this mechanism is relevant and that lowering costs to rate can substantially improve ratings for low-quality sellers. Cabral and Li (2015) show that paying eBay buyers $1 to leave a rating—compensating them for rating effort—lowers negative ratings by 22%.

The previous result applies conditional on entry. Additionally, we show that reducing rating effort-

[3] Quote from Rey (2020), vox.com. Prior to 2019, Amazon required at least 20 written words per review; see (Amazon Customer, 2012; crebel, 2017).

costs discourages entry: ratings may become so uninformative that even newcomers with positive ratings do not sell, discouraging entry.

Taken together with broader evidence that platforms have increasingly facilitated the rating process over time, these results suggest that platforms may be engaged in a race toward less-informative ratings that discourage entry. Hence, platforms seeking to preserve the quality of their rating systems and encourage entry may need to re-balance efforts to indiscriminately encourage rating.

Our results suggest other measures to discourage harvesting: low-quality newcomers can harvest ratings, because consumers cannot distinguish whether a positive rating results from high quality or low prices. Thus, rating systems that reflect the price raters paid discourage rating harvesting and make ratings more informative. Interestingly—and in contrast to increasing the effort costs to rate—this policy does not discourage ratings for high-quality newcomers.

Finally, our findings inform policy proposals targeting rating manipulation. Crawford et al. (2023) advocate banning conditional compensation for ratings. While this addresses overt manipulation, we show that even unconditional payments—by reducing rating effort costs—can distort rating informativeness.

We further explore the implications of ratings harvesting for competition and surplus. We have two key insights. First, more informative rating systems encourage market entry, increasing competition and benefiting consumers. Second, conditional on entry, greater informativeness can reduce competitive pressure on the incumbent. More informative ratings differentiate products and soften competition.

This leads to a nuanced conclusion: consumers prefer *moderately*, but not *maximally*, informative ratings. Ratings should be informative enough to induce entry, but overly precise ratings differentiate products too much and reduce post-entry competition.

Finally, one might worry that the effects of rating harvesting are merely transitory, as low-quality sellers may eventually be exposed and leave the market. However, we argue that rating harvesting can have persistent and economically meaningful consequences. First, it impedes reputation-building by high-quality entrants. Given the substantial entry/exit rates and elasticities on major platforms, this reputational bottleneck can create substantial distortions—even if ratings eventually become accurate. Second, beyond the evidence that discounts strongly affect ratings, the findings of Carnehl et al. (2025) suggest that entry discounts could have lasting effects on revenue: on Airbnb, a €5-per-night discount at entry is linked to an average revenue gain of €68 per month over six months. Thus, ratings harvesting may generate substantial and persistent profit effects.

We introduce the basic model in Section 2, and discuss the equilibrium in Section 3. Section 4 shows how various features in the rating system influence how well ratings reflect quality. We then discuss implications on surplus in Section 5. We discuss extensions and robustness in Section 6. In particular, we extend our results to a three-period model to illustrate how results extend to longer time horizons. We show that harvesting induces low-quality newcomers to stay longer in the market, reinforcing the cold-start problem. In Section 7, we discuss the implications for rating management. Section 8 connects our results to the literature, and Section 9 concludes. Some extensions are in the Online Appendix B.[4]

2 Basic Model

We set up a two-period model of incomplete information where a newcomer competes with an established firm over a consumer in each period.

Firms. The established firm A has quality $q^A > 0$, which is common knowledge for all players. The newcomer B can have either a high or low quality, i.e. $B \in \{h, l\}$. We assume $q^h > q^A > q^l$. The probability that the newcomer is of type q^h or q^l is common knowledge and given by $\gamma \in (0, 1)$ and $(1 - \gamma)$, respectively. The realized quality of the newcomer is private information to the newcomer and is constant between periods. To simplify illustration and focus on the striking case where the low-quality newcomer may sell even though they produce no value, we assume $q^l = 0$.

After firms learn their quality and before they set prices, the newcomer chooses to enter the market or not. To study entry in a simple way, we assume a newcomer enters if and only if they attract strictly positive demand.[5]

In periods 1 and 2, firm $j \in \{A, B\}$ sets the price of its product to maximize its lifetime profit, $\sum_{t=1}^{2} p_t^j \cdot d_t^j$, where p_t^j is the price of firm j in period t, and $d_t^j \in \{0, 1\}$ is the demand of firm j in period t. We assume that the cost of production is zero regardless of quality.[6] After selling in period 1, sellers may receive a rating R_1 from consumers. If they do, this rating is common knowledge to firms and consumers in subsequent periods.

Consumers. A consumer participates in only one of the two periods and a new consumer arrives in each period. When choosing to consume a product in period t, consumers observe the current price, past ratings, and q^A. They do not observe the newcomer's quality or the price the rater paid.[7] Consumers choose to buy or not to buy. If they buy, they observe the firm's true quality after purchase and decide to leave a rating.

Consumers choose if and how to rate, i.e. $R_t \in \{1, 0, -1\}$. The informational content of a rating

[4]The Online Appendix is available at https://robinng.com/research/HR/Harvesting_Ratings_Online_Appendix_B.pdf.

[5]We impose this assumption to simplify illustration by avoiding a fixed cost of entry. With fixed costs of entry, our results remain qualitatively unaffected if these entry costs are not too large.

[6]We assume zero marginal cost of both firms to focus on information transmission via ratings. With sufficiently different marginal costs, we might have cost-based signaling as in Bagwell and Riordan (1991).

[7]In practice, consumers may learn about past prices via other channels. First, raters may comment on price in a review (e.g. 'good product for that price'). However, the exact prices themselves are rarely mentioned in reviews, which is why this channel seems rather noisy. Second, consumers may access external databases for historical prices. However, it is difficult to link this information to the prices past raters paid.

is determined in equilibrium, but we say a rating is positive if $R_t = 1$, negative if $R_t = -1$, and when $R_t = 0$ consumers choose not to rate. Without loss of generality, we say a newcomer has no previous rating. To save on notation, we may drop the subscripts from R_1.

Throughout we focus on ratings for the newcomer. Since the quality of established firms is common knowledge, ratings will not affect beliefs about its quality. This captures evidence that a marginal positive rating boosts sales for newcomers with few ratings, but has little impact on the sales of established firms (Dendorfer & Seibel, 2024; Hollenbeck, 2018; Hui et al., 2024; Livingston, 2005; Luca & Zervas, 2016; Resnick et al., 2006).

We distinguish between consumption utility and rating utility. This serves two purposes. First, we capture evidence that consumers do not factor the intention to rate into their purchase decision.[8] Second, this simplifies presentation of results. The consumption utility for consuming a product from firm j in period $t \in \{1, 2\}$ is $u_t = q^j - p_t^j$, where p_t^j is the price of the firm. If a consumer does not buy, they receive their outside option, which we normalize to zero.

The rating utility captures what motivates consumers to rate. Formally, the rating utility of consumers in period t is

$$v_t = \begin{cases} (q^j - p_t^j) - e & \text{if } R_t = 1, \\ -(q^j - p_t^j) - e & \text{if } R_t = -1, \\ 0 & \text{if } R_t = 0, \end{cases}$$

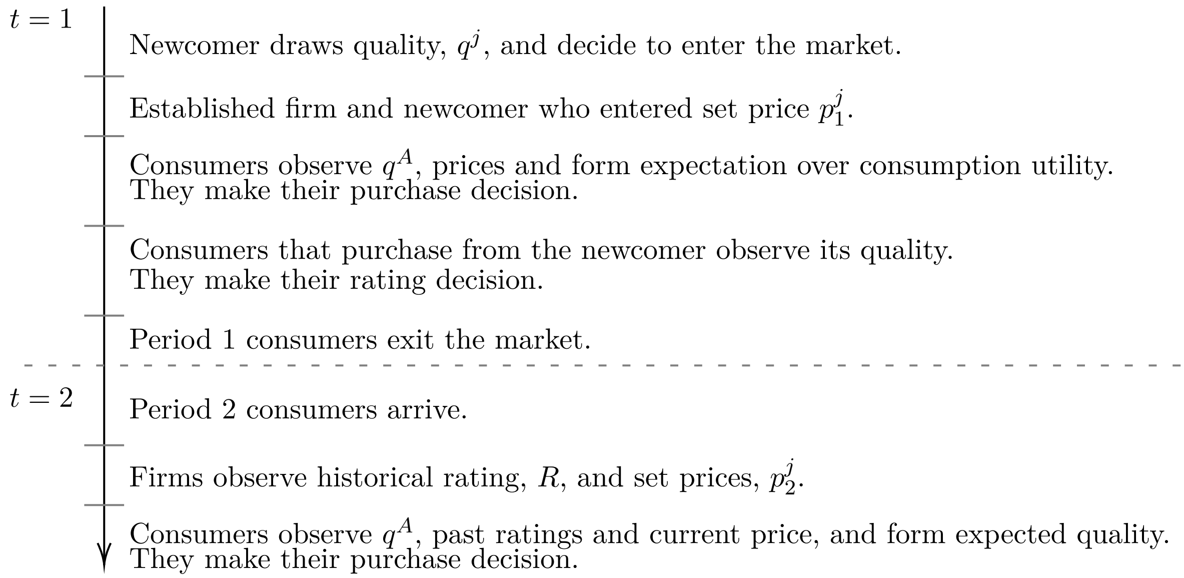
Here, $e \sim F[0, \bar{e}]$ reflects the time and effort consumers need to invest to provide a rating. We assume that F is the uniform distribution $U[0, \bar{e}]$,[9] and that $\bar{e}$ is large enough such that some consumers do not rate. Thus, consumers leave a positive rating if their value-for-money is far-enough above their outside option, i.e. if $q^j - p_t^j \geq e$. They leave a negative rating if their value-for-money is sufficiently far below their outside option, or they do not rate at all otherwise.

We provide two foundations for this mechanism. First, this rating utility is a simplification of models of intrinsic reciprocity (Dufwenberg & Kirchsteiger, 2004; Rabin, 1993). Reciprocity is a long-studied and well-established decision-making phenomenon and therefore provides a solid foundation for our rating utility. Intuitively, consumers reciprocate a sufficiently high (low) value for money with a positive (negative) rating. Second, consumers rate out of self-expression, i.e. if they feel good (bad) about a purchase. Firms can induce this good (bad) feeling by giving consumers a good (bad) value-for-money.

Timing. We now summarize the timing of the game.

[8] Cabral and Li (2015) find that incentivizing consumers to rate does not change their willingness to pay for a product.

[9] We can generalize to other distributions. The uniform distribution focuses on the effect that seems most relevant in practice, that facilitating ratings leads to more ratings. For general distributions, shifting F can differently affect the marginal propensity to leave a positive or negative or no rating. But these effects seem second order.



Equilibrium and Restrictions. To simplify exposition, we make two assumptions that restrict the parameter space. First, we assume that the established firm has a higher quality than the average newcomer—$\gamma q^h < q^A$. This focuses our analysis on the interesting case where newcomers do not sell without a rating system.[10] Second, we focus on equilibria where newcomers either enter with probability zero or with probability one. Formally, this holds for our main proposition if

$$\gamma q^h - q^A + F(q^A - \gamma q^h) \left[\frac{\gamma F(q^A + (1-\gamma)q^h)}{\gamma F(q^A + (1-\gamma)q^h) + (1-\gamma)F(q^A - \gamma q^h)} q^h - q^A \right] \geq 0. \qquad (1)$$

Without this assumption, low-quality newcomers may enter with strictly positive probability less than one, but our results remain qualitatively unaffected.[11]

We look for perfect Bayesian equilibria. We make the following restrictions to ensure that firms are competing effectively in the spirit of a Bertrand duopoly with different quality levels.

First, we assume that the p.d.f. of the rating-effort distribution F is sufficiently flat. For the main two-period model, a sufficient condition is $f(x) < \frac{1}{\pi_2(R_1=1)}$ for all x where $\pi_2(R_1 = 1)$ is the period 2 profit conditional on a positive rating.[12] It ensures that firms set the largest price at which they win the competition for consumers. Without it, the consumer in period 1 may strictly prefer to buy from the newcomer, meaning that firms are not competing.

Second, the following selection assumptions ensure pessimistic off-path beliefs do not prevent entry and competition.

[10] Without this assumption, we can have $\underline{\delta} = 0$.

[11] We discuss this in more detail in Section 3.1. Note that $\frac{\gamma F(q^A+(1-\gamma)q^h)}{\gamma F(q^A+(1-\gamma)q^h)+(1-\gamma)F(q^A-\gamma q^h)} > \gamma$, which is why (1) can be satisfied despite $\gamma q^h < q^A$.

[12] We provide the precise (and weaker) conditions in the proof. Those conditions are (4), (5) and (6).

Selection Assumption 1. [Entry] *We select equilibria without entry if and only if there exists no equilibrium where at least one type of newcomer enters.*

This selection assumption rules out that pessimistic off-equilibrium beliefs prevent entry and thereby competition. I.e. there can be equilibria where no newcomer enters, and consumers have off-equilibrium beliefs that entrants have quality q^l, making entry unprofitable. Because our focus is on studying entry and competition, we only select such equilibria if there exists no equilibrium where at least one newcomer enters. Clearly, relaxing this assumption can only lead to less entry, so all our results that high-quality newcomers do not enter enough only become stronger if we relax this assumption.

Selection Assumption 2. [Competition after Entry] *If entry occurs, consumers are indifferent between the newcomer and the established firm, and they purchase from the firm that earns strictly larger marginal profits from that sale. Offers with zero demand are optimal also if a negligible share of indifferent consumers would purchase them.*

This assumption selects equilibria where, after entry, firms are competing. First, it ensures that pessimistic off-equilibrium beliefs do not prevent the newcomer from competing. It rules out equilibria where all consumers in a period strictly prefer to purchase from the newcomer, yet the newcomer does not raise its price because at such off-equilibrium prices, overly pessimistic beliefs prevent the newcomer from making a sale. Similarly, it rules out equilibria where overly pessimistic consumer beliefs prevent the newcomer from improving upon the offer of the established firm. Second, the selection assumption rules out that firms with no demand make non-credible offers—i.e. offers that would strictly reduce profits—if some indifferent consumers were to purchase.

Discussion of Modeling Assumptions. This model applies to platforms such as Airbnb, Amazon, Taobao, eBay, Yelp, and Google Reviews, where consumers heavily rely on ratings to form or update their expectations about product quality.

First, our rating utility function reflects growing evidence that value-for-money—rather than quality alone—drives consumer ratings. This effect can be substantial. For instance, Li and Hitt (2010) show that in digital camera marketplaces, a 1% increase in price reduces ratings by 0.36 stars (on a 5-star scale) and by 0.71 stars (on a 10-star scale). On Airbnb, Gutt and Kundisch (2016) and Neumann et al. (2018) find that higher prices negatively affect ratings. Similarly, Luca and Reshef (2021) report that on Yelp, a 1% price increase leads to a 3–5% decline in average ratings. In the hotel sector, Abrate et al. (2021) find that a 1% price increase reduces ratings by approximately one star (on a 10-star scale). As these studies control for product quality, the evidence strongly suggests that value-for-money—not quality alone—drives consumer ratings.

Second, a key feature of our model is that ratings are coarse: consumers cannot infer whether a high rating reflects high quality or simply a low price in the past. In practice, consumers typically do not observe the exact price paid by the rater.[13]

Third, our two-period entry model captures, in reduced form, that ratings are particularly important—and arguably less informative—for newcomers. Reimers and Waldfogel (2021) find that book ratings affect consumer surplus ten times more than New York Times reviews, largely because many genres and titles have few reviews, so even a small number of ratings can significantly influence demand. Thus, ratings are crucial for establishing reputation. Furthermore, the marginal effect of a positive rating on sales is substantial for the first 20–30 reviews but diminishes thereafter (Dendorfer & Seibel, 2024; Hui et al., 2024). Even if ratings eventually reveal quality, this creates a distinct asymmetry in the early stages: new entrants with few or no reviews face an uphill battle against established sellers. Our model captures this critical phase in which newcomers struggle to build a reputation.

Fourth, our simplified rating mechanism reflects systems like that used by eBay. In Section 6, we discuss how our results extend to more complex systems, such as five-star ratings.

3 Equilibrium

The following proposition characterizes equilibrium, where δ^* and $(1-\delta^*)$ are the probabilities with which low-quality newcomers mimic prices and harvest ratings, respectively. The formal proof is in Appendix A.

Proposition 1. *Suppose the following condition holds:*

$$\frac{q^h - q^A}{q^A} < \frac{(1-\gamma)\left[\delta^*(1-F(|\overline{p})|)) + (1-\delta^*)(1-F(q^A))\right]}{\gamma(1-F(q^h-\overline{p}))}. \tag{2}$$

Then an equilibrium exists that is unique up to off-path beliefs. There exists a unique $\underline{\delta} \in (0,1)$ such that both types of newcomers enter if and only if $\delta^* > \underline{\delta}$; otherwise, neither enters. If newcomers enter:

1. ***Ratings build reputation:*** $E[q_2 \mid R=1] > E[q_2 \mid R=0] > E[q_2 \mid R=-1]$.
2. ***Ratings are valuable:*** $p_2^B = E[q_2^B \mid R=1] - q^A > 0$. *Firm A sells in period 2 if and only if $R \in \{-1,0\}$.*

Furthermore, in period 1:

3. ***Firm** A sets $p_1^A = 0$ and faces no demand.*
4. ***Firm** h charges $\overline{p} = \frac{\gamma q^h}{\gamma+(1-\gamma)\delta^*} - q^A$ with probability 1 and receives $R \in \{0,1\}$.*

[13] Moreover, reviews rarely mention prices. Even five-star systems are inherently coarse: since value-for-money is continuous but ratings are discrete, sellers with different price–quality combinations receive identical ratings.

5. ***Firm*** *l randomizes over prices in period 1 if*

$$\frac{\gamma(q^h - q^A)}{(1-\gamma)q^A} > \underline{\delta} \quad \text{and} \quad F(q^A) > \frac{(q^A)^2}{\gamma(q^h)^2 - (q^A)^2}. \tag{3}$$

In that case:

(a) *It charges $\overline{p} > 0$ with probability δ^* and receives $R \in \{-1, 0\}$, where $\delta^* \in \left(\underline{\delta}, \frac{\gamma(q^h - q^A)}{(1-\gamma)q^A}\right)$.*

(b) *It charges $\underline{p} \equiv -q^A < 0$ with probability $1 - \delta^*$ and receives $R \in \{0, 1\}$.*

Otherwise, firm l sets $\delta^* = 1$ such that $\overline{p} \leq 0$ and receives $R \in \{0, 1\}$.

Condition (2) ensures that in period 2, newcomers with no rating do not attract demand. We impose this condition in the main text for two reasons. First, if Condition (2) is violated, low-quality newcomers always enter, so this case is less interesting to study entry. Second, the condition aligns with extensive evidence that silence is bad news—firms with few or no ratings perform similarly to those with negative ratings, and only positive ratings significantly boost sales (Bolton et al., 2013; Cabral & Hortaçsu, 2010; Dellarocas & Wood, 2008; Dendorfer & Seibel, 2024; Hollenbeck, 2018; Hui et al., 2024; Luca & Zervas, 2016; Nosko & Tadelis, 2015; Resnick et al., 2006; Tadelis, 2016). Condition (2) holds when q^h is sufficiently large—that is, when identifying high-quality entrants is especially valuable. In such cases, high-quality firms are unlikely to receive no rating, which diminishes the informational value of no rating.[14] Nevertheless, we show in the Online Appendix B that our main results conditional on entry continue to hold even when this condition fails.

To understand the core trade-off underlying equilibrium, we begin with two key observations:

Observation 1: By Points 1 and 2 of Proposition 1, ratings help newcomers build reputation, enabling them to earn higher profits in period 2. This is because high-quality entrants provide better value-for-money than low-quality ones: $q^h - \overline{p} > q^A = q^l - \underline{p} > q^l - \overline{p}$. Consequently, high-quality firms are more likely to receive positive ratings. Consumers infer that positive ratings signal quality, helping positively rated newcomers to earn higher profits in the second period.

Observation 2: In period 1, newcomers choose between two pricing strategies. High-quality firms always charge the high price $\overline{p}$—the maximum price at which consumers prefer the entrant over incumbent firm A. If consumers could perfectly identify firm types, this price would equal the entrant's quality advantage: $q^h - q^A$. However, since low-quality firms can mimic high-quality ones by charging the same price, consumers anticipate this behavior, reducing $\overline{p}$ accordingly. In contrast, the low price $\underline{p}$ is such that a low-quality firm can attract demand when consumers correctly expect its quality to be q^l. At this price, the firm incurs a loss in period 1 but may charge it to gain a positive rating and earn higher profits in period 2.

This sets up the key trade-off faced by low-quality newcomers in period 1:

[14] Formally, if q^h is large, the denominator on the right-hand side of Condition (2) converges to zero.

Rating Harvesting: Charging the low price $\underline{p} = -q^A < q^l = 0$ to induce a positive rating. A good rating allows the firm to free-ride on the reputation of high-quality entrants and charge a higher price in period 2 (Point 5b of Proposition 1).

Price Mimicking: Charging the high price $\overline{p}$ to imitate high-quality firms. However, since this yields lower value-for-money, the firm obtains worse ratings and thus earns lower profits in the next period (Point 5a).

The probability that a low-quality firm chooses price mimicking over rating harvesting—denoted δ^*—captures how firms resolve this trade-off in equilibrium. When $\delta^* \in \left(\underline{\delta}, \frac{\gamma(q^h - q^A)}{(1-\gamma)q^A}\right)$, a mixed-strategy equilibrium can arise. Why would low-quality firms mix prices? Intuitively, they harvest ratings to free-ride on the reputation of high-quality entrants. For this to be profitable, reputation must be sufficiently valuable—ensured when (3) holds, i.e. if q^h is sufficiently large.[15] However, as more low-quality firms engage in rating harvesting, the equilibrium beliefs associated with a positive rating deteriorate. This weakens the incentive to harvest, until firms are indifferent between harvesting and mimicking—hence the emergence of a mixed strategy.

Low-quality firms may also play pure strategies. If $\delta^* \leq \underline{\delta}$, harvesting is so widespread that positive ratings lose their value and even highly rated newcomers fail to attract demand; hence, newcomers do not enter. Conversely, if $\delta^* \geq \frac{\gamma(q^h - q^A)}{(1-\gamma)q^A}$, price mimicking dominates: $\overline{p} < q^l = 0$, so mimicking alone yields positive ratings and firm l sets $\delta^* = 1$.

Finally, entry or non-entry can occur in equilibrium depending on parameters. Entry requires $\delta^* > \underline{\delta}$, which holds if q^h is large enough to make reputation valuable. If $q^A \to q^h$, then $\delta^* \leq \underline{\delta}$ and ratings provide less reputation than that of the incumbent.

3.1 Discussion and Implications

The equilibrium illustrates the dual relationship of prices and ratings highlighted in the Introduction: lower prices allow firms to build a reputation, enabling them to charge higher prices in the future. In equilibrium, all firms that receive a good rating raise their prices in period 2.

In the rest of our analysis, we often study the effect of changes in δ^* on outcomes. While δ^* is endogenously determined in equilibrium, we analyze its variation directly as a shortcut. Formally, we could introduce exogenous parameters that influence first-period profits—and thereby affect δ^*—without directly influencing other variables that will be of interest below like consumer expectations or the rating-effort cost distribution. For brevity, we omit these parameters and focus directly on how equilibrium outcomes change with δ^*.[16]

[15] The second condition ensures that the value of reputation is high enough for free-riding to be attractive. The first condition guarantees that entry occurs with the mixed-strategy equilibrium.

[16] Such parameters include: (i) an exogenous probability that consumers dissatisfied with their purchase receive a refund from the seller, (ii) capital costs incurred when a firm charges a negative price, or (iii) a discount factor that alters the relative importance of the two periods.

Pricing and Informativeness of Ratings. The equilibrium links firms' pricing strategies with the informativeness of ratings. Specifically, for larger δ^* such that low-quality firms more frequently mimic high-quality pricing, they are less likely to receive positive ratings. After consumers adjust their expectations, ratings become more indicative of quality. Thus, changes in the firm's pricing strategy δ^* affect how much information ratings convey. This yields a key insight: rating harvesting reduces the informativeness of ratings. The corollary formalizes this:

Corollary 1. *Suppose $\delta^* > \underline{\delta}$. If δ^* increases, then $E[q_2^B \mid R = 1]$ increases strictly.*

This result implies that rating harvesting leads to rating inflation—the phenomenon where most ratings cluster at the top of the scale, e.g. 5 out of 5 stars (Filippas & Horton, 2022; Filippas et al., 2022; Nosko & Tadelis, 2015; Zervas et al., 2021). A central concern with rating inflation is that it weakens ratings' ability to distinguish quality. Our model reinforces this concern: rating harvesting increases the number of positive ratings, thereby diluting their informational content.

Even when rating harvesting is absent (i.e., $\delta^* = 1$), ratings remain noisy signals of quality. In this case, $\overline{p} < 0$, so price mimicking by low-quality entrants still delivers positive value-for-money, resulting in some positive ratings. Nevertheless, increasing δ^* enhances the informativeness of ratings. Two mechanisms drive this effect. First, as δ^* rises, high-quality firms (h) deliver higher value-for-money, which increases their likelihood of receiving positive ratings. Second, low-quality firms mimic more often and charge higher prices ($q^l - \overline{p} < q^l - \underline{p} = q^A$), which reduces the value-for-money they offer and lowers the likelihood of receiving a good rating. Together, these effects ensure that less harvesting makes ratings more informative.

Entry and the Cold-start Problem. Entry and exit are major features of online platforms. On Airbnb, for instance, Dendorfer and Seibel (2024) report monthly entry and exit rates of hosts of 3–4%. Farronato and Fradkin (2022) find substantial supply elasticities in this market, suggesting entry responds to changing market conditions. Amazon also experiences significant seller turnover.[17]

Proposition 1 provides new insight into how ratings influence entry decisions. Rating harvesting discourages entry: newcomers enter if and only if there is not too much harvesting, i.e., if $\delta^* \geq \underline{\delta}$. In other words, newcomers enter if and only if positive ratings are sufficiently informative to induce future sales. Clearly, if they enter, they must get positive ratings sometimes, or they would never sell. If newcomers get positive ratings, they enter: In the mixed-strategy equilibrium this is immediate, as newcomers set weakly positive prices and attract demand in each period. In the pure-strategy equilibrium, Condition (1) ensures that newcomers sell with probability one. But even if this condition is violated, the result holds qualitatively: in that case, low-quality newcomers enter with strictly positive probability.[18]

[17] www.marketplacepulse.com, accessed June 5, 2025, reports 4 million new sellers on Amazon from 2020 to 2024.

[18] Suppose Condition (1) is violated. Then, in the pure-strategy equilibrium, low-quality newcomers who enter with probability one earn strictly negative profits. Then, in equilibrium, they would enter with a lower probability,

Empirical evidence supports this mechanism. Luca (2016) and Hollenbeck (2018) show that Yelp ratings spur entry by small, independent restaurants, intensifying competition for large chains. Similarly, Leyden (2025) show that when Apple stopped resetting average App Store ratings after product updates, developers released more upgrades—suggesting that more informative ratings encouraged participation.

This result is closely related to the cold-start problem (Dendorfer & Seibel, 2024; Li et al., 2020; Stanton & Thomas, 2016), in which newcomers struggle to build reputation—even when they offer higher quality than incumbents. Our framework connects these two ideas: informative ratings foster entry and help high-quality newcomers gain traction.

However, and this is a key takeaway, rating harvesting exacerbates the cold-start problem in two ways. First, when $\delta^* < \underline{\delta}$, a good rating is no longer a strong-enough signal of quality to induce sales in period 2. Consumers prefer to buy from incumbents, and high-quality newcomers are discouraged from entering. Second, even when entry occurs, increased rating harvesting lowers the value of a good rating, reducing period-2 profits for high-quality firms (by Corollary 1).

Our analysis also reveals that it is difficult to deter entry only of low-quality sellers. That is, there is no equilibrium in which only high-quality firms enter. If that was the case, consumers would expect high quality from all newcomers, encouraging low-quality firms to enter and exploit those expectations.[19] Free-riding is thus a robust feature of equilibrium.

Platforms are acutely aware of the cold-start problem and often encourage sellers to offer steep discounts to build a reputation. Airbnb, for example, recommends that new hosts offer a 20% discount to their first guests (Dendorfer & Seibel, 2024). Amazon permits sellers to offer discounted products in exchange for ratings and reviews.[20] Our model suggests that low-quality entrants are especially likely to pursue this strategy—further undermining the informativeness of ratings.

Instead, our findings suggest that platforms should discourage rating harvesting if they aim to promote entry. While this won't fully prevent low-quality entry, it ensures that such firms are sorted out more quickly. In the next section, we discuss how platform design can reduce rating harvesting and improve the informativeness of ratings.

4 Designing Ratings Environments

In this section, we examine how the rating environment influences the informativeness of ratings. We identify two strategies to discourage rating harvesting: (i) linking ratings to the prices raters paid, and (ii) increasing the cost of leaving a rating.

raising consumer expectations and profits until low-quality newcomers are indifferent between entry and no entry.

[19]Indeed, even if (1) was violated, firm h enters if and only if firm l enters with strictly positive probability.

[20]See https://sell.amazon.com/tools/vine, accessed June 5, 2025.

Link Ratings with Paid Prices. While platforms typically provide easy access to past ratings, they do not connect these ratings to the prices that raters actually paid.[21] We show that this is a key driver of rating harvesting: consumers cannot tell whether a rating reflects high product quality or simply a low purchase price. If consumers in period 2 knew what raters paid, they could distinguish genuine high-quality firms from those using steep discounts to harvest ratings.[22] This would eliminate the incentive to harvest ratings. In equilibrium, low-quality firms would then mimic high-quality pricing with probability 1, and ratings would become more informative.

Facilitating Ratings. Platforms can encourage ratings by adjusting the effort required to leave them. Verification steps, multi-dimensional evaluations, rewards, or rebates and reminders all affect the cognitive and time costs associated with rating. These design choices directly influence the "cost of rating", which we model via the upper bound $\overline{e}$ of the effort-cost distribution. Changes in $\overline{e}$ induce first-order stochastic dominant shifts in the cost distribution.

To keep the analysis tractable, we focus on settings in which, after entry, condition (3) holds—i.e., when q^h is sufficiently large and identifying high-quality newcomers is particularly valuable. Under these conditions, the low-quality entrant plays a mixed strategy.

At first glance, making ratings easier seems desirable. Holding firm behavior fixed, lower rating effort costs yield more ratings. However, this intuition is misleading, as it ignores how firms adjust their pricing in response.

In our setting, lower rating costs induce more ratings but reduce their informativeness. When $\overline{e}$ falls, the rating utility increases, leading to more positive ratings. Anticipating this, low-quality firms find it more attractive to harvest ratings, increasing the likelihood of rating harvesting in equilibrium. As a result, positive ratings become more likely to stem from low-quality firms, making ratings less informative about quality. The corollary formalizes this relationship:

Corollary 2. *If $\delta^* > \underline{\delta}$, then $\frac{\partial \delta^*}{\partial \overline{e}} > 0$.*

The key takeaway is that—conditional on entry— lowering $\overline{e}$ increases the number of ratings but reduces their informativeness.

Empirical evidence supports this mechanism. Cabral and Li (2015) use shipping speed as a proxy for quality and show that offering rebates for ratings reduces negative reviews especially for low-quality products. Since rebates lower the cost of leaving a rating, their findings are consistent with our model: reducing rating costs can make ratings less informative.

We use this result to explore how rating-effort costs affect entry.

[21] Amazon does not reveal historical prices in product listings, nor do they disclose the price a reviewer or rater paid. Third-party sites like https://camelcamelcamel.com/ and https://keepa.com/ track price histories, but they do not link prices to individual ratings, and thus cannot reveal whether price influenced a given rating.

[22] Some marketplaces ask reviewers to rate value-for-money on a scale. But they typically do not report prices raters paid, so this may not help consumers distinguish ratings based on high quality or low prices.

Corollary 3. *There exists a constant $\alpha > 0$ such that newcomers enter if and only if $\overline{e} \geq \alpha$.*

Encouraging consumers to rate, via lower rating effort-costs, discourages entry. Encouraging consumers to rate encourages rating harvesting (Corollary 2), which makes ratings less informative (Corollary 1). But if ratings are less informative, newcomers with positive ratings may no longer sell, so they will no longer enter (by Proposition 1).

These insights cast a new light on platform efforts to encourage ratings. Many platforms have worked to encourage rating over time. Yelp and Google offer perks such as invitations to exclusive events or discounts to active raters.[23] Google also prompts users to leave quick feedback, allowing for one-tap reviews. Amazon similarly simplified its rating system: prior to 2020, users had to write a review alongside their rating; now, one-click ratings are allowed. They justified the shift by claiming that it would increase the accuracy of ratings through higher volume.[24]

However, our results suggest that these changes may have unintended consequences. First, while these measures increase rating volume, they also encourage rating harvesting, leading to a greater number of ratings that are less informative. Second, less-informative ratings make it harder for newcomers to sell after a positive rating, discouraging entry. Ultimately, both effects weaken the ability of high-quality newcomers to build a reputation and exacerbate the cold-start problem.

Rather than simply increasing the quantity of ratings, platforms may want to consider how to preserve or enhance their informational value. One way to do this is by increasing the cost of leaving a rating (raising $\overline{e}$), which discourages rating harvesting. Although this would reduce the overall number of ratings, it would increase their informativeness and encourage entry.

Comparing Policies. Raising the costs of leaving a rating induces less ratings, but also discourages rating harvesting. This may not discourage entry of low-quality sellers, but it helps to weed them out more quickly. However, the effect on high-quality sellers is ambiguous: more-informative ratings increase their profits after a good rating, but larger rating costs lower the probability they get one (we show formally in the next section). Instead, linking ratings to the prices raters paid does not directly harm high-quality newcomers and might therefore fight the cold-start problem more effectively.

5 Surplus Analysis

We now examine how rating harvesting influences competition and surplus. As before, we focus on equilibria in which, after entry, newcomers play mixed strategies.

The analysis proceeds in two steps. First, we study how the informativeness of ratings affects consumer surplus. Second, we explore how shifts in the rating-effort cost distribution impact

[23]See the Yelp Elite Squad and Google Local Guides programs, as described by Yelp (Yelp, 2022) and Donaker et al. (2019).

[24]See Forbes (Masters, 2021), and TechCrunch reporting in (Perez, 2019).

surplus. This distinction helps to illustrate how changes along the intensive (how to rate) and extensive margin (rate or not) affect outcomes differently.

More Informative Ratings. We begin by analyzing the link between rating informativeness and surplus. Informativeness, i.e. different levels of δ^*, captures whether low-quality newcomers charge low or high prices and therefore get positive or negative ratings. This captures how changes along the intensive margin of ratings associate with equilibrium outcomes.

Two main insights emerge: (i) Consumer-optimal rating systems are somewhat—but not fully—informative. (ii) Conditional on entry, greater rating informativeness reduces consumer surplus by softening competition for the established firm.

Let π^B, π^h, and π^l denote the expected total profits of the average newcomer, the high-quality entrant, and the low-quality entrant, respectively. Let π^A denote the established firm's profits, and CS the expected consumer surplus.

We first examine how δ^*—which captures the extent of price mimicking and hence the informativeness of ratings—affects profits:

Corollary 4. *If $\delta^* \leq \underline{\delta}$, then $\pi^A = 2q^A$ and $\pi^B = 0$. If $\delta^* > \underline{\delta}$, then $\pi^A < q^A$, $\pi^B > 0$, and both $\frac{\partial \pi^A}{\partial \delta^*} > 0$ and $\frac{\partial \pi^B}{\partial \delta^*} > 0$.*

When δ^* is low, entry does not occur, and the incumbent is a monopolist. For larger δ^* where entry occurs, newcomers earn positive profits, and the incumbent's profits shrink below monopoly profits. However, conditional on entry, both π^A and π^B increase in δ^*. This is because more informative ratings enhance differentiation: highly rated newcomers can charge more, while non-rated or poorly rated entrants are perceived as lower quality, reducing competitive pressure on the incumbent.

Next, we analyze consumer surplus, which we equate with consumption utility.[25]

Corollary 5. *If $\delta^* \leq \underline{\delta}$, then $CS = 0$. If $\delta^* > \underline{\delta}$, then $CS > 0$ and $\frac{\partial CS}{\partial \delta^*} < 0$.*

Consumers prefer ratings that are sufficiently informative to induce entry—but not so informative as to relax competition post-entry. When $\delta^* < \underline{\delta}$, no newcomer enters, and the incumbent charges monopoly prices. Once $\delta^* > \underline{\delta}$, competition emerges, boosting surplus. However, further increases in δ^* reduce surplus.

The mechanism is differentiation. As ratings become more informative, positively rated newcomers are more-clearly identified as high quality. In turn, consumers who observe non-positive ratings will reduce their beliefs about these firms' quality. Since the incumbent's quality is not subject to

[25]Results are qualitatively robust if rating utility is included, provided it gets a lower weight than consumption utility. As long as this is so, consumer surplus increases in $q - p$ and our results hold. If rating utility dominated and consumers make many negative ratings, consumer surplus may decrease in $q - p$, which is implausible.

rating-based uncertainty, its market power grows relative to non-positively rated entrants, relaxing price competition.

In line with this mechanism, evidence suggests that less-precise quality signals intensify competition. Gandhi et al. (2024) show that when firms are exposed to more fake reviews of their rivals—which makes them less informative—firms that do not purchase fake reviews lower their prices.

Overall, consumers prefer somewhat, but not fully-informative ratings. Consumers want sufficiently informative ratings to support entry, but not too informative ratings as this relaxes competition.

Cost of Rating. We now examine the effect of increasing $\overline{e}$. Our analysis yields two additional insights: (i) conditional on entry, higher rating costs have an ambiguous effect on high-quality newcomers, incumbents, and consumer surplus, but harms low-quality newcomers; (ii) rating-effort costs that maximize consumer surplus must be at least large enough to induce entry.

From Corollary 2, we know that increasing $\overline{e}$ raises δ^* and thereby increases the informativeness of ratings. This generates the effects along the intensive margin of ratings we outlined in the previous subsection. At the same time, it reduces the likelihood that consumers leave ratings (extensive margin), which directly influences newcomer and consumer outcomes. For this reason, a change in $\overline{e}$ often has ambiguous effects on outcomes. For high-quality and average newcomers, the effect is ambiguous—they benefit from more-precise information but lose from fewer ratings. However, the impact on low-quality entrants is unambiguous.

Corollary 6. *Suppose $\delta^* > \underline{\delta}$. Then $\frac{\partial \pi^l}{\partial \overline{e}} < 0$, and an increase in $\overline{e}$ can increase or decrease π^B, π^h, π^A, and CS.*

The effect on low-quality entrants is unambiguously negative: fewer ratings and greater informativeness reduce their profits.

Conditional on entry, rating effort also has an ambiguous impact on consumer surplus: more ratings improve matches (extensive margin), but also relax competition (intensive margin). However, the corollary shows that—to benefit consumers—rating effort must at least induce entry.

Corollary 7. *Consumer-optimal rating effort is such that $\overline{e}^{CS} \geq \alpha$.*

The result follows directly from Corollaries 3 and 5. Rating-effort costs need to induce sufficiently-informative ratings to induce entry, and entry benefits consumers.

More generally, our results in this section suggest that marketplaces that influence the cost of rating affect not only the informativeness of ratings but also the distribution of surplus. By encouraging or discouraging ratings, platforms can shift surplus between buyers and the different sellers.

6 Extensions and Robustness

Negative ratings. If Condition (2) is violated, low-quality newcomers also sell in period 2 after no rating. First, newcomers always enter. If (2) is violated, low-quality newcomers sell in period 2 with strictly positive probability, making entry profitable. Second, also here, lower rating-effort costs $\bar{e}$ induce more rating harvesting. Details are in the Online Appendix B.

More generally, our results extend to rating systems with even more messages like 5-star ratings. Intuitively, in our framework, the value of ratings is determined endogenously in equilibrium. Thus, also with more complex rating systems, there exist equilibria where one rating has the same informational content as our good rating, other ratings have the same informational content as our bad rating, and the others are uninformative or not used in equilibrium. This equilibrium is plausible because it reflects the common finding that ratings are strongly bimodal and raters leave either five stars or zero stars (Dellarocas & Wood, 2008; Filippas & Horton, 2022; Filippas et al., 2022; Hu et al., 2009; Nosko & Tadelis, 2015).

Longer Horizon Model. We indicate how our results extend to longer time horizons by showing how they extend to a three-period model. In this model, newcomers who enter in period 1 can also choose to exit in period 2. First, we establish equilibria that are similar to those in Proposition 1. In particular, there are equilibria where newcomers enter (and do not exit in period 2) if and only if low-quality newcomers do not harvest too much. In equilibrium, low-quality firms play mixed strategies as in our main model's period 1 in every non-terminal period. Thus, harvesting is not just driven by endgame effects: low prices in period 1 pay off already in period 2, since low-quality newcomers with a good rating charge a large price with positive probability. Second, low-quality firms who enter get a positive rating in every non-terminal period with strictly positive probability. Intuitively, if they only received a good rating in period 1, but not in period 2, then the value of reputation would skyrocket in period 3; but that induces strong incentives to also receive a good rating in period 2. This suggests that while low-quality firms may disappear over time, this may not happen fast. Third, a lower rating effort $\bar{e}$ encourages rating harvesting in periods 1 and 2. Thus, low-quality firms who harvest more ratings may also stay longer in the market. This suggests another dimension through which rating harvesting reinforces the cold-start problem: low-quality firms who harvest ratings stay longer, making it harder for high-quality newcomers to establish a reputation. Details are in the Online Appendix B.

7 Implications for Platform Management

Our results carry important implications for the design and management of platform rating systems, summarized as follows:

First, as discussed, many major platforms have made concerted efforts to increase consumer participation in ratings. However, we show that overly incentivizing ratings can be counterproductive.

When rating becomes too easy, low-quality firms are more likely to harvest ratings, reducing the informativeness of ratings. Eventually, this also discourages entry and reinforces dominant positions of established firms. Both effects exacerbate the cold-start problem. Thus, encouraging entry and maintaining an informative rating system may thus require not to encourage ratings too much.

Second, the ideal solution to eliminate the cold-start problem is preventing entry of low-quality sellers. Our results highlight the difficulty of doing so in practice. Free-riding is a robust feature of equilibrium: if only high-quality firms enter, reputation skyrockets, which encourages free-riding. Similarly, encouraging newcomers to offer steep discounts in order to build reputation can inadvertently promote rating harvesting. A more effective approach is to discourage harvesting—even if this does not prevent entry from low-quality entrants, it helps weed them out quicker. This can be done by increasing the relative profitability of price mimicking—for example, by making rating more costly, by tying ratings to the price paid, or by implementing penalties that target deteriorating ratings.

Third, while platforms typically provide easy access to past ratings, they rarely link them to the prices paid by raters. This disconnect enables rating harvesting: consumers cannot distinguish whether a high rating reflects genuine product quality or simply a low price. Platforms seeking to discourage harvesting could design rating systems that better account for the price raters paid. For instance, they might give lower weight to ratings from buyers who paid lower prices. Such a policy would make ratings more reflective of true quality, helping high-quality sellers build reputation and alleviating the cold-start problem. A key advantage is that it discourages harvesting without directly discouraging ratings for high-quality newcomers. However, these adjustments must be implemented carefully, as they may also reduce sellers' incentives to lower prices. For example, one may apply such adjustments only to sellers with few ratings, where the risk of harvesting is most acute.

Fourth, even though more informative ratings stimulate entry, they asymmetrically affect competition. Conditional on entry, more informative ratings enhance surplus extraction particularly for established firms, because consumers' outside option—purchasing from a newcomer with non-positive ratings—becomes less attractive.

Fifth, our results offer a broader insight for two-sided platforms: rating systems can be used to shift surplus between buyers and sellers. In our model, consumers may prefer more informative ratings than sellers, primarily because these ratings facilitate entry and intensify competition. As such, platforms can influence the distribution of surplus—and ultimately platform participation—by shaping the informativeness of their rating systems.

8 Related Literature

Our key novelty, which we have not seen elsewhere, is that we endogenize if and how consumers rate based on value-for-money to study how firms price to free-ride on the reputation of others. Based on this mechanism, we derive novel predictions for how informative ratings are, entry and the cold-start problem, competition and surplus allocation, and the design of rating systems.

We connect to the wider theoretical literature on **trust and information transmission in the digital economy**. Platforms may recommend products (Hagiu & Jullien, 2011; Peitz & Sobolev, 2022), shroud additional fees and features of third-party sellers (Johnen & Somogyi, 2024), and marketplaces may have fake reviews (He et al., 2022). We contribute by studying information transmission via ratings, and how firms can use prices to affect their own ratings.

A growing literature studies the **cold-start problem** (Bergemann & Välimäki, 1997, 2000; Che & Hörner, 2018; Kremer et al., 2014; Vellodi, 2018). In existing models, newcomers and their consumers have symmetric information. So newcomers may offer discounts to encourage experimentation, but they cannot distort the type of signal that is generated. Our key contribution here is that newcomers have private information about quality, which seems a reasonable feature in many markets. This induces rating harvesting and its various novel implications, i.e. that harvesting makes ratings less precise, discourages entry also of high-quality newcomers, and makes it harder to build a reputation.

We contribute to the **theoretical literature on reputation** (Bar-Isaac & Tadelis, 2008; Cabral, 2000; Holmström, 1999; Hörner, 2002; Jullien & Park, 2014; Kovbasyuk & Spagnolo, 2021; Martin & Shelegia, 2021; Tadelis, 1999, etc.), and **word-of-mouth** (Chakraborty et al., 2022). In existing work usually (i) buyers do not endogenously choose if and how to rate, and (ii) ratings mostly reflect quality, and prices do not affect how consumers rate. While some papers relax some of these assumptions (e.g. Chakraborty et al. (2022) and Martin and Shelegia (2021) relax (i), Carnehl et al. (2023) and Sobolev et al. (2021) relax (ii)), no article seems to feature both that buyers choose strategically if and how to rate, and sellers price to free-ride on the ratings of others. So our results on rating harvesting and its various implications are new.

Our model features an extensive and an intensive margin for ratings. How consumers rate (intensive margin) depends on whether their value-for-money is positive or negative—i.e. whether low-quality firms mimic prices or harvest ratings—and if they rate (extensive margin) on whether it is sufficiently extreme relative to their effort cost of rating. Many existing articles focus on either of the two. E.g. Hui et al. (2024) and Sobolev et al. (2021) focus in the extensive margin. As in Hui et al. (2024), our extensive margin results from continuously distributed effort-costs to leave a rating. However, since we have endogenous prices, we also have an intensive margin. Martin and Shelegia (2021) focus on the intensive margin. Since we feature both, we can make novel predictions about how lowering the rating effort leads to more, but also less informative ratings.

Recent models incorporate different drivers for ratings. According to the surprise hypothesis, the difference between expected and actual quality drives ratings (Martin & Shelegia, 2021). In Hui et al. (2024), users rate more if they learn more from the experience. Our model follows other recent articles (Carnehl et al., 2023) and focuses on value-for-money. But since the purchase decision depends on expected quality, our equilibrium captures aspects of the other two hypotheses: in equilibrium, high-quality products induce a better-than-expected experience and the highest value-for-money, so they get the best ratings more often. Conversely a low-quality product induces a (weakly) worse-than-expected experience and lower value-for-money, and therefore worse ratings.

Maybe the first theoretical article on how **value-for-money** affects ratings is Carnehl et al. (2023). They focus on prices in long-run equilibria where ratings transmit precise information about quality. Instead, we focus on a setting where firms can harvest ratings to free-ride on the reputation of other sellers, biasing ratings also on the path of play. We argue that our mechanism is especially relevant when firms build a reputation after entry, so both approaches are highly complementary. Also in Sobolev et al. (2021) ratings may be a noisy signal of quality on the path of play. But their mechanism is very different: they start with the premise that more sales can lead to more or less precise ratings, e.g. because the additional raters might know the products better or worse than existing raters. Instead, we study how firms price their products to free-ride on the reputation of others. In addition to both papers, we provide novel insights about how the design of rating environments leads to more informative ratings.

Some researchers argue that consumers should get **paid to rate**. One argument is that sellers should be allowed to pay for feedback: because high-quality firms are more inclined to pay for feedback, feedback is a credible signal for quality (Halliday & Lafky, 2019; Kihlstrom & Riordan, 1984; Milgrom & Roberts, 1986; Nelson, 1974). Others argue that feedback is like a public good that is underprovided (Avery et al., 1999; Bolton et al., 2004; Chen et al., 2010). In contrast, we show that encouraging feedback via ratings encourages low-quality firms to harvest ratings, leading possibly to more ratings, but also less-informative ratings, and discouraging entry. This result is in line with evidence by Cabral and Li (2015) which we discuss above.

We provide a theoretical explanation for why identical products may get **different ratings across platforms** (Chevalier & Mayzlin, 2006). Some evidence suggests that this is due to user self-selection onto marketplaces (Granados et al., 2012; Raval, 2020). We provide a complementary explanation and show that differences in features of the rating system can lead to different ratings for identical products. Our results align with experimental evidence on how the design of rating systems can influence ratings (Lafky & Ng, 2024; Schneider et al., 2021).

We contribute to the literature on **consumer information about differentiated products**. Prior work shows that firms benefit from well-informed consumers, as this strengthens product differentiation and relaxes competition (Anderson & Renault, 2006; Armstrong & Zhou, 2022; Hefti et al., 2022; Johnen & Leung, 2025). By contrast, we show that with entry and rating harvesting, firms may prefer less informative ratings than consumers to deter entry.

9 Conclusion

We study how firms use prices to influence their own ratings. We highlight a qualitatively novel trade-off between rating harvesting and price mimicking, which connects closely to empirical evidence on the dynamic interplay between prices and ratings. We identify the drivers of rating harvesting and show that it can lead to less-informative ratings. We also examine implications for entry and the cold-start problem, as well as for buyer and seller surplus.

In practice, consumers may also read product reviews to form expectations about quality. In principle, such reviews could help consumers disentangle the effects of quality and price on observed ratings. However, we argue that reviews are unlikely to fully resolve this ambiguity. First, even diligent consumers read only a small, selective sample of reviews. Second, even when reviews mention value-for-money or price-quality-ratio, they rarely state the exact price paid—making it impossible to assess whether the value was good relative to that price. Third, empirical evidence supports the disproportionate influence of ratings relative to reviews: Liu and Reimers (2025) estimate that, on Airbnb, ratings alone increase consumer surplus four times as much as reviews alone.

Our model focuses on consumers who rate based on the value-for-money they receive. Consumers may also rate for other reasons—for example, to help others by signaling product quality or out of an intrinsic motivation to report the truth. Importantly, such motivations would lead consumers to rate based on quality alone, especially as prices fluctuate over time. Still, as long as a subset of consumers rates based on value-for-money, we would expect price dynamics consistent with rating harvesting. Our results are therefore robust to a range of consumer motivations, provided value-for-money-sensitive raters remain active.

In practice, another factor that undermines the informativeness of ratings is the presence of fake reviews (He et al., 2022). If low-quality firms are more likely to acquire fake reviews, this also reduces the ability of review systems to signal true quality. In contrast, in our setting, firms use pricing strategies—rather than overt manipulation—to boost their ratings. This distinction is crucial: while fake reviews distort consumer belief about reviews, rating harvesting directly affects prices of raters, which has a range of implications we study above.

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Appendix A Proofs (Intended for Online Appendix)

A.1 Primitives

Towards proving our main Proposition 1, we first show a series of primitives that hold beyond our baseline model: in particular, they hold (i) for any finite $T \geq 2$ periods, (ii) for any q^l such that $q^l < q^A$, (iii) if firm B sells following a positive or no rating. We use them to prove our main proposition and extensions.

In the proofs, we use $\mathbb{H}_t$ to denote histories until t.

Lemma 1. *If the high-quality firm faces no demand in a given period t, the low-quality firm faces no demand in period t.*

Proof of Lemma 1.
Suppose towards a contradiction that in some period t, h is inactive and l is active. Then for any equilibrium price where l sells in t, we have beliefs $E[q_t^B|p] = q^l$. Because $q^l < q^A$, l only sells in t if it charges a price below costs, and since $q^l - q^A < q^l$, it gets no rating with probability strictly less than one in any $t < T$. This is clearly suboptimal in $t = T$, so we must have $t < T$. Next, we show that l earns weakly negative profits for subsequent periods if it gets a positive or a negative rating in period $t < T$. To see this, note that if l sells in t and receives a positive or negative rating, it is identified as a low-quality firm in period $t+1$ and any subsequent period. Thus, since $q^l < q^A$, following a history with $R_t \in \{1, -1\}$, firm l has zero demand and is inactive after any such histories. But if t earns non-positive profits after $R_t \in \{1, -1\}$, and since it sells below cost in t, it must earn strictly positive profits after $R_t = 0$. But then l has a profitable deviation to not selling in t to get $R_t = 0$ with probability one, contradicting that l is active in period t. □

Lemma 2. *If the low-quality firm sells in period $t+1$, it must sell in period t.*

Proof of Lemma 2.
Towards a contradiction, suppose l sells in $t+1$ but not in t.

First consider the case where h is also inactive in period t. But then beliefs are the same in $t+1$ as they were in t, contradicting that l sells in $t+1$.

Next, consider the case where h sells in period t, setting some price p_t with strictly positive probability. Since h sells, we must have $p_t \geq 0$. Because the high-quality firm sells, it obtains $R_t = 1$ with some probability. Since only h gets $R_t = 1$, this rating perfectly identifies h for subsequent periods. If the low-quality firm does not sell in period t, it receives $R_t = 0$ with probability one.

Thus, observing $R_t = 0$, and since l has that rating with probability one and h only with probability strictly less than one, beliefs after $R_t = 0$ in $t+1$ must be strictly lower than beliefs in period t. Hence, prices in $t+1$ following $R_t = 0$ must be strictly lower than prices the high-quality firm sets in period t.

We now distinguish two cases. First, if p_t is above q^l then l has a profitable deviation to set p_t in period t and sell, obtaining $R_t \in \{0, -1\}$. Recalling that p_t must be strictly greater than any price following no rating in period $t+1$ if it did not sell, it must be a strictly profitable deviation for the low-quality firm to set p_t, since it sells at a larger price and, since it did not yet get $R_t = -1$, has a larger demand than in $t+1$, contradicting that l does not sell in t.

Second, if p_t is below q^l, then l has a profitable deviation by starting to set p_t in period t and sell. This deviation induces $R_t \in \{1, 0\}$. Again recalling that p_t must be strictly greater than any price following no rating in period $t+1$ if it did not sell, it must be a strictly profitable deviation for the low-quality firm to set p_t. Additionally, since $R_t = 1$ perfectly identifies a high-quality firm, l also earns strictly larger profits after such histories. This contradicts that l does not sell in period t.

We conclude that if the low-quality firm sells in period $t+1$ it must sell in period t. □

Corollary 8. *If the low-quality firm has positive demand in period t, then the high-quality firm must have positive demand in all periods up to and including period t.*

Proof of Corollary 8.
Suppose the low-quality firm receives demand in period t. From Lemma 2 it also faces demand in period $t-1$. Then from Lemma 1 the high-quality firm faces demand in every period for which the low-quality does. Hence, it must be that the high-quality firm faces demand in both period t and $t-1$. Induction then implies the claim. □

Corollary 9. *If the high-quality firm sells in period t, it only obtains a good rating or no rating with strictly positive probability.*

Proof of Corollary 9.
Note that ratings only follow from a sale, and sales require winning the competition against A which has quality $q^A > 0$. This implies that in any period t where a rating could occur for h, we have $E[q_t^B|\mathbb{H}_t] \geq p_t$. Further, observe that expected quality of firm B is a convex combination of q^h and q^l, which is weakly less than q^h. Therefore, due to competition with A, it must be that $q^h > p_t$ and the high-quality firm obtains a good rating or no rating with strictly positive probability, and cannot obtain a bad rating. □

Corollary 10. *In any history $\mathbb{H}_t$ where firm B obtains at least one bad rating, consumer beliefs are the lowest possible, $E[q_t^B|\mathbb{H}_t] = q^l$.*[26]

Proof of Corollary 10.
By Corollary 9, h cannot receive bad ratings. Hence, for any equilibrium history with a bad rating the firm is perfectly identified as l. □

Lemma 3. *Firm A does not employ a mixed strategy in any period t.*

Proof of Lemma 3.
If firm A has zero demand after some histories, then by Selection Assumption 2, firm A plays $p_t = 0$ with probability 1 following those histories. To see this, note that by Selection Assumption 2, some consumers are indifferent, so offers with zero demand must be optimal. Prices below cost would be suboptimal if they would induce sales; prices above costs would be suboptimal if some indifferent consumers purchased, since consumers are indifferent between both firms, a marginally lower price would induce a discrete jump in demand. Thus, if A has zero demand, it charges marginal cost.

Next, consider histories after which firm A sells with strictly positive probability.

Note first that firm A cannot charge multiple mass points with strictly positive probability. If it sells, it must earn strictly positive profits at some of these mass points. Applying standard Bertrand arguments, either firm B earns strictly positive profits, then either firm can profitably deviate by shifting probability mass for some of its mass points downwards. Or firm B earns zero profits and by Selection Assumption 2, consumers must be indifferent between both firms. Then by Selection Assumptions 2, such offers must be best responses to A's offers, which is why B sets price at marginal cost with probability one (by the same argument used in the first paragraph of this proof). But then firm A cannot be indifferent between multiple mass points and shifts probability mass away from the least profitable ones. We conclude that A does not have multiple mass points.

We show next that both firm A and firm B cannot mix over intervals. Towards a contradiction, suppose firm A mixes over an interval of prices. Since firm A mixes over an interval, firm B must also mix over an interval; otherwise firm A would sell with probability zero (which we ruled out above), or with probability one (in which case mixing over an interval is clearly suboptimal).

Now take one such price $p^A > 0$. Note that since A must earn weakly positive profits in t, and therefore does not charge prices below cost, such a $p^A > 0$ must exist whenever A mixes over an interval. By our Selection Assumption 2, consumers are indifferent between both firms, implying that all prices of B, p^B, must be such that consumers are indifferent between p_A and p^B. Thus, all prices of B must induce the same expected utility with firm B as p^A does from firm A. But then deviating to a marginally smaller price induces a discrete jump in demand for firm A while only

[26]For the two-period model, possible equilibrium histories with negative ratings are $\mathbb{H}_t \in \{\{-1\}\}$. For the three period model, they are $\mathbb{H}_t \in \{\{-1\}, \{1, -1\}, \{0, -1\}, \{-1, 1\}, \{-1, 0\}, \{-1, -1\}\}$.

marginally reducing margins. Thus, such a deviation must be strictly profitable, contradicting that A mixes over an interval. This concludes the proof. □

Lemma 4. *When firm B enters and is high-quality, it sets a unique price, $\overline{p}_t$ conditional the history if in period t:*

- *Good ratings are not beneficial (i.e. conditional on the same history, $R_t = 1$ leads to lower future profits than $R_t = 0$); or*
- *Good ratings are beneficial and* (4) *holds.*

The final period is a special case of obtaining good ratings being not beneficial.

Proof of Lemma 4.
We show that a high-quality firm B sets a unique price in each period conditional on the history.

First, suppose firm h earns zero profits in period t. By our Selection Assumption 2, consumers must be indifferent between h and A and by the same selection assumption, offers with zero demand of h must be optimal even if some indifferent consumers purchase, implying that h charges a price at marginal cost (by the same argument we used in the proof of Lemma 3). Thus, if h earns zero profits, it sets a unique price.

Next, suppose h earns strictly positive profits. Then h must have strictly positive demand for all its prices. Additionally, by Corollary 9, h gets good and no ratings with strictly positive probability. By Selection Assumption 2, consumers are ex-ante indifferent between h and A, which is why firm A must earn zero profits in period t; otherwise A could strictly increase profits by marginally reducing its price. Thus, since A earns zero profits from selling in t and h earns strictly positive profits, our Selection Assumption 2 implies that h sells with probability one for all prices it charges in period t.

We now distinguish two cases, whether good ratings are beneficial and raise continuation profits, or whether they are not beneficial.

Suppose first that good ratings are not beneficial such that obtaining a good rating in period t does not improve the expected continuation payoff. In other words, the sum of expected future profits conditional on obtaining a good rating in period t is weakly less than the sum of expected future profits conditional on obtaining no rating in period t. Then, since all prices in t induce the same demand in t, firm h has a profitable deviation and moves all probability mass in t to its highest price in t from the candidate equilibrium. This strictly raises it's current profits and it's future profits, contradicting that h plays a mixed strategy. Therefore, when good ratings are not beneficial firm h sets a unique price in period t.

Note the special case of the last period. Since ratings from the last period do not influence any future decision, following a history of ratings, if the firm sells in the last period, it sets the highest possible price which induces demand.

Suppose next that, following a history $\mathbb{H}_t$, good ratings are beneficial such that obtaining a good rating in period t improves the expected continuation payoff. In other words, the sum of expected future profits conditional on obtaining a good rating in period t is strictly larger than the sum of expected future profits conditional on obtaining no rating in period t. Here, we have to consider that although firm B would receive the same demand at any price over which it mixes in period t, shifting probability from a lower price to a higher price reduces the probability of receiving a good rating, reducing continuation profits. Therefore, the distribution of effort to leave ratings has to be sufficiently flat such that the probability of receiving a good rating does not decrease by too much if the firm shifts probability mass to the higher price. To derive such a condition, note the total profit of the firm is $p + F(q^h - p)\pi_{t+1}(\{\mathbb{H}_t, R_t = 1\}) + (1 - F(q^h - p))\pi_{t+1}(\{\mathbb{H}_t, R_t = 0\})$, where $\pi_{t+1}(\{\mathbb{H}_t, R_t\})$ is the expected continuation profit from obtaining R_t. Note $\pi_{t+1}(\{\mathbb{H}_t, R_t = 1\}) > \pi_{t+1}(\{\mathbb{H}_t, R_t = 0\})$ for ratings to be beneficial. Then a marginal price increase raises profits if for all $p \in (-q^h, q^h)$, we have

$$1 - f(q^h - p)(\pi_{t+1}(\{\mathbb{H}_t, R_t = 1\}) - \pi_{t+1}(\{\mathbb{H}_t, R_t = 0\})) > 0 \Leftrightarrow$$
$$f(q^h - p) < \frac{1}{\pi_{t+1}(\{\mathbb{H}_t, R_t = 1\}) - \pi_{t+1}(\{\mathbb{H}_t, R_t = 0\})} \tag{4}$$

Therefore if (4) holds for all prices $p \in (-q^h, q^h)$, firm h earns strictly larger profits from its larger candidate equilibrium prices, contradicting that h plays a mixed strategy. The same condition also implies that if h sets a unique price that satisfies Selection Assumption 2, lowering the price cannot increase profits.

Therefore, we conclude that a high-quality firm B sets a unique price $\overline{p}_t$ if in period t good ratings are not beneficial or (4) holds on the support of f. □

Lemma 5. *Suppose firm l enters.*

Firm l charges the following prices when ratings are beneficial. If $\overline{p}_t > q^l$, and (5) and (6) hold in period t:

- *Firm l charges only $\overline{p}_t$ or $\underline{p}_t$ with positive probability in period t.*
- *Firm l charges $\overline{p}_t$ with probability $\delta_t \in [0, 1]$, obtaining a bad rating with probability $F(\overline{p}_t - q^l)$ and no rating otherwise.*
- *And $\underline{p}_t = q^l - q^A \leq q^l$ with probability $1 - \delta_t$, obtaining a good rating with probability $F(q^l - \underline{p}_t)$ and no rating otherwise.*

If $\overline{p}_t \leq q^l$ and (4) holds, $\delta_t = 1$ and firm l obtains either a good rating with probability $F(q^l - \overline{p}_t)$ or no rating otherwise.

If good ratings are not beneficial, then $\delta_t = 1$.

Proof of Lemma 5.
Selection Assumption 2 implies that consumers are, in expectation, indifferent between firm A and B. Hence, the highest price firm l can set in each period is one that leads to this indifference. This price is the unique price, $\overline{p}_t$, from Lemma 4 that also h sets. We start by assuming good ratings are beneficial in period t, showing the low-quality firm B mixes between this price and a unique lower price in period t. This proof follows in two parts. First, by considering $\overline{p}_t > q^l$. Then we consider $\overline{p}_t \leq q^l$.

Consider first the scenario where $\overline{p}_t > q^l$ and good ratings are beneficial in period t. When the low-quality firm sets $\overline{p}_t$, because $\overline{p}_t > q^l$ the firm receives a bad rating with probability $F(\overline{p}_t - q^l)$ and no rating with probability $1 - F(\overline{p}_t - q^l)$. If the firm deviates to a price above $\overline{p}_t$ it never makes a sale and gets no rating with probability 1. If the firm deviates to a price between q^l and $\overline{p}_t$ it sells at most with probability one and gets a bad rating with a lower probability. Hence, by deviating to a lower price it may be possible to increase the continuation payoff. Such a deviation is not profitable if f is sufficiently flat such that the higher probability of receiving the continuation payoff is dominated by the lower profits the firm earns in period t. In other words, for prices above q^l at which firm l sells, the derivative of the total expected profit, $p + F(p - q^l)\pi_{t+1}(\{\mathbb{H}_t, R_t = -1\}) + (1 - F(p - q^l))\pi_{t+1}(\{\mathbb{H}_t, R_t = 0\})$, from playing the price p must be positive for all $p - q^l$ on the support of f. This holds if for all such prices, we have

$$1 + f(p - q^l)(\pi_{t+1}(\{\mathbb{H}_t, R_t = -1\}) - \pi_{t+1}(\{\mathbb{H}_t, R_t = 0\})) > 0 \Leftrightarrow f(p - q^l) < \frac{1}{\pi_{t+1}(\{\mathbb{H}_t, R_t = 0\})}. \tag{5}$$

Where the equivalence follows since by Corollary 10, negative ratings perfectly identify l and induce zero continuation profits. If (5) holds for all prices above $p - q^l$ on the support of f, the low-quality firm sets $\overline{p}_t$ in period t if it sets a price above q^l.

Next consider when the low-quality firm B may receive a good rating with some positive probability in period t. For this to occur the firm has to set prices weakly below q^l. Suppose the low-quality firm B sets more than one such price. This implies that it makes a positive profit at all such prices. However, if f is sufficiently flat such that an increase in price only changes the probability of receiving a rating by a small amount, it must be that raising prices in period t is beneficial as long as firm l continues to sell. In other words, the firm l gathers all its probability mass for prices below q^l at a mass point. This is true if the derivative of the total expected profit of setting a $p \leq q^l$, $p + F(q^l - p)\pi_{t+1}(\{\mathbb{H}_t, R_t = 1\}) + (1 - F(q^l - p))\pi_{t+1}(\{\mathbb{H}_t, R_t = 0\})$, is positive for all $q^l - p$

on the support of f:

$$1 - f(q^l - p)(\pi_{t+1}(\{\mathbb{H}_t, R_t = 1\}) - \pi_{t+1}(\{\mathbb{H}_t, R_t = 0\})) > 0 \Leftrightarrow$$
$$f(q^l - p) < \frac{1}{\pi_{t+1}(\{\mathbb{H}_t, R_t = 1\}) - \pi_{t+1}(\{\mathbb{H}_t, R_t = 0\})}. \tag{6}$$

If (6) holds for all $q^l - p$ on the support of f in period t then the low-quality firm sets a single price $\underline{p}_t$ below q^l in period t.

The low-quality mixes over $\overline{p}_t$ and $\underline{p}_t$ in period t such that it is indifferent between the two expected continuation payoffs. This concludes that if $\overline{p}_t > q^l$ and good ratings are beneficial in period t, a low-quality firm B mixes between $\overline{p}_t$ and some unique $\underline{p}_t$ below q^l in period t.

Next consider the scenario where $\overline{p}_t \leq q^l$ and good ratings are beneficial. The same argument in the previous paragraph implies that l sets a unique price. In this scenario a low-quality firm B would receive a good rating with some strictly positive probability. When $\overline{p}_t \leq q^l$, then at any price above $\overline{p}_t$ consumers have must have beliefs such that deviating to such prices induces no sales. This rules out any upward deviation by firm B. Moreover, no firm receives bad ratings. However, there are potential downward deviations from $\overline{p}_t$, since firm l can set lower prices and receive more good ratings. Such a deviation would not be profitable if f is sufficiently flat such that (6) holds.

Next consider the scenario where ratings are not beneficial. Then to prevent receiving good ratings the low-quality firm trivially plays the highest price at which it is able to sell in period t, playing $\overline{p}$ with probability 1.

Finally, because the high-quality firm B never sets $\underline{p}_t$, then it must be that following any price $\underline{p}_t$ the low-quality firm is perfectly identified. To make a sale, the firm has to set a price which provides at least as much utility as firm B, that is to say $\underline{p}_t \leq q^l - q^A$, and because the firm prefers to set the highest possible price following (6), $\underline{p}_t = q^l - q^A$. This concludes the proof. □

We refer to equations (4), (5) and (6) as sufficiently flat conditions for f.

Lemma 6. *If firm B enters, it plays a unique price in period T, which depends on its rating history.*

Proof of Lemma 6.
Given the consumer's information set in the final period, they condition their beliefs only on historical ratings and current prices. Note first that since there is no future period, future ratings do not affect profits. Selection Assumption 2 implies that consumers are ex-ante indifferent between firms A and B. Additionally, one of the firms must earn zero profits. Otherwise, if both firms earn strictly positive profits, firm A can marginally decrease its price to increase demand by a discrete amount, strictly increasing profits. By Selection Assumption 2, the firm earning zero profits charges a price at costs and earns zero profits (using the same argument as in Lemma 3). Thus, if firm B does not sell, it sets a unique price at marginal cost. If firm B sells, by Selection Assumption

2, consumers must be indifferent between both firms, and by the above result firm A earns zero profits, so firm A will set the largest price at which it can sell. This pins down the price of firm B uniquely. We conclude that firm B sets a unique price in period T, conditional on its rating history. $\square$

Corollary 11. *Suppose h and l enter. In period t, firm A sets $p_t^A = max\{q^A - E[q_t^B|\mathbb{H}_t, p_t], 0\}$. Firm B sets either $\overline{p}_{\mathbb{H}_t} = max\{E[q_t^B|\mathbb{H}_t, \overline{p}_{\mathbb{H}_t}] - q^A, 0\}$ and $\underline{p}_{\mathbb{H}_t} = q^l - q^A$.*

Proof of Corollary 11.
First recall from Lemma 5 that $\underline{p}_{\mathbb{H}_t} = q^l - q^A$, for any history $\mathbb{H}_t$. Next, consider firm B playing $\overline{p}_{\mathbb{H}_t}$ in each period t. Selection Assumption 2 implies that consumers are ex-ante indifferent between firms A and B. Additionally, one of the firms must earn zero profits. Otherwise, if both firms earn strictly positive profits, firm A can marginally decrease its price to increase demand by a discrete amount, strictly increasing profits. By Selection Assumption 2, the firm earning zero profits charges a price at costs and earns zero profits (using the same argument as in Lemma 3). Thus, if $E[q_t^B|\mathbb{H}_t, \overline{p}_{\mathbb{H}_t}] \geq q^A$, firm A charges a price at cost and earns zero profits in that period and firm B charges $\overline{p}_{\mathbb{H}_t} = E[q_t^B|\mathbb{H}_t, \overline{p}_{\mathbb{H}_t}] - q^A$. If, instead, $E[q_t^B|\mathbb{H}_t, \overline{p}_{\mathbb{H}_t}] < q^A$, then firm B sets the price $\overline{p}_{\mathbb{H}_t} = 0$ and firm A sets the price $q^A - E[q_t^B|\mathbb{H}_t, \overline{p}_{\mathbb{H}_t}]$. This concludes the proof. $\square$

Lemma 7. *Suppose h and l enter. If* (4), (5) *and* (6) *hold, first period beliefs are without loss of generality*

$$E[q_1^A|p] = q^A \quad \forall p, \qquad\qquad E[q_1^B|p] = \begin{cases} \frac{\gamma q^h + (1-\gamma)\delta_1^* q^l}{\gamma + (1-\gamma)\delta_1^*} & \forall p \text{ if } \overline{p}_1 \leq q^l \\ \frac{\gamma q^h + (1-\gamma)\delta_1^* q^l}{\gamma + (1-\gamma)\delta_1^*} & \forall p > q^l \text{ if } \overline{p}_1 > q^l \\ q^l & \forall p \leq q^l \text{ if } \overline{p}_1 > q^l. \end{cases}$$

Proof of Lemma 7.
Recall that (4), (5) and (6) are conditions such that the high-quality firm B sets a unique price $\overline{p}_t$ and the low-quality firm B sets either $\overline{p}_t$ or $\underline{p}_t$. The rest of the proof focuses on period 1.

Since firm A's quality is common knowledge, it's quality is known to be q^A regardless of price.

Consider the case where $\overline{p}_1 \leq q^l$. Then firms charge $\overline{p}_1$ with probability one. It is straightforward to check that for the equilibrium price $\overline{p}_1$, the above expectations apply Bayes rule. Additionally, $E[q_1^B|\overline{p}_1]$ is such that consumers believe that firm B provides just as much utility as firm A. At $\underline{p}_1$, consumers would buy from a low-quality firm B. This holds, since $E[q_1^B|\underline{p}_1]$ in expectation provides consumers at least as much utility as firm A. Since $q^l < \frac{\gamma q^h + (1-\gamma)\delta_1^* q^l}{\gamma + (1-\gamma)\delta_1^*}$, consumers buy at both prices if $E[q_1^B|p] = \frac{\gamma q^h + (1-\gamma)\delta_1^* q^l}{\gamma + (1-\gamma)\delta_1^*}$ $\forall p$. For all other off-equilibrium prices, the above beliefs are consistent with our selection assumptions and the necessary equilibrium conditions we derived so far, since deviations to prices above the equilibrium price induce zero demand. Thus, these off-equilibrium beliefs are without loss of generality.

Next, consider the case where $\overline{p}_1 > q^l$. Recall from Lemma 5 that $\underline{p}_1 < q^l$. Applying Bayes rule shows that the beliefs are correct for equilibrium prices $\overline{p}_1$ and $\underline{p}_1$. For all off-equilibrium prices, the above beliefs are consistent with our selection assumptions and the necessary equilibrium conditions we derived so far, since deviations to prices in $(\underline{p}_1, q^l)$ and to prices above $\overline{p}_1$ strictly reduce demand. Thus, these off-equilibrium beliefs are without loss of generality. □

A.2 Proposition 1

To apply the previous Lemmas and Corollaries, it is useful to make the following observations: (i) In a two-period model $\mathbb{H} = R$, i.e. all relevant histories are period-1 ratings of the newcomer. (ii) We apply that $q^l = 0$ to save on notation. (iii) In a model where firm B sells only following a good rating, this occurs when $E[q_2^B|R = 0] \leq q^A$ which implies $\pi_2(R = 0) = 0$. Then (5) always holds. And (6) evaluates to $f(q^l - p) < \frac{1}{\pi_{t+1}(\{\mathbb{H}_t, R_t=1\})}$. Towards proving the proposition, we establish further results in the following Lemmas.

Lemma 8. *Firm B's decision to sell in period 1 is independent of it's quality realization. Thus, in period 1, a high-quality firm B sells if and only if a low-quality firm B also sells. If firm B sells in the second period, it must sell in the first period. Thus, whenever newcomers enter, they sell in period* 1.

Proof of Lemma 8.
First, we know from Corollary 8 that if low-quality firm B sells, a high-quality firm B must also sell.

We now consider firm B selling only when it is high-quality.

Suppose instead firm B is only selling when it is high-quality. This means $E[q^B|p] = q^h\ \forall p$. The high-quality firm B receives a good rating with some positive probability at all prices at which it sells. This allows it to to charge $q^h - q^A > 0$ in both periods. But then l has a profitable deviation to enter the market with strictly positive profits in period 1. Hence it cannot be that only the high-quality firm sells in the market in period 1.

We show next that if firm B sells in period 2, it also sells in period 1. Suppose instead a high-quality firm B sells only in period 2 and not period 1. Then also firm l cannot sell in period 1. But then period 2 is the same as period 1 but without continuation profits, so since both firms did not sell in period 1, they will not sell in period 2, a contradiction. Similarly, if l sold only in period 2, then either h sold in period 1, in which case consumer beliefs about newcomers would be q^h and also l would deviate and mimic h in period 1, or h did not sell in period 1, in which case both firms B did not sell in period 1 and the above result implies that h also does not sell in period 2, contradicting that l sells in period 2. We conclude that if firm B sells in period 2, it also sells in period 1.

Therefore, we can conclude that if firm B enters, it sells in the first period and it's entry decision is independent of it's quality realization. □

This implies that we cannot have efficient entry - that is there is no situation where all high-quality firm Bs enter the market and low-quality firm Bs do not.

Lemma 9. *If (4), (6) hold, and $\overline{p} > 0$, second period beliefs over firm B's quality are*

$$E[q_2^B|R] = \begin{cases} \frac{\gamma F(q^h - \overline{p})q^h}{\gamma F(q^h - \overline{p}) + (1-\gamma)(1-\delta^*)F(q^A)} & \text{if } R = 1 \\ \frac{\gamma(1-F(q^h-\overline{p}))q^h}{\gamma(1-F(q^h-\overline{p}))+(1-\gamma)[\delta^*(1-F(\overline{p}))+(1-\delta^*)(1-F(q^A))]} & \text{if } R = 0 \\ 0 & \text{if } R = -1 \end{cases}$$

where δ^* is the equilibrium probability with which a low-quality firm B plays $\overline{p}$ in period 1.

If (4) and (6) hold, and instead $\overline{p} \leq 0$, second period beliefs are

$$E[q_2^B|R] = \begin{cases} \frac{\gamma F(q^h - \overline{p})q^h}{\gamma F(q^h - \overline{p}) + (1-\gamma)F(-\overline{p})} & \text{if } R = 1 \\ \frac{\gamma(1-F(q^h-\overline{p}))q^h}{\gamma(1-F(q^h-\overline{p}))+(1-\gamma)(1-F(-\overline{p}))} & \text{if } R = 0 \\ 0 & \text{if } R = -1. \end{cases}$$

In either case, ratings are informative in equilibrium as $E[q_2^B|R=1] > E[q_2^B|R=0] > E[q_2^B|R=-1]$.

These are the beliefs after both newcomer types enter. After other histories, consumers believe the quality of newcomers is q^l in both periods.

Proof of Lemma 9.
We first describe how consumer beliefs are constructed when $\overline{p} > 0$, then we show a good rating is beneficial. Then describe beliefs when $\overline{p} \leq 0$.

It is immediate to see consumer beliefs result from applying Bayes rule to the pricing strategies from Lemmas 4 and 5. A high-quality firm always gets good ratings with some positive probability, this probability depends on the price it sets. Conversely, a low-quality firm B obtains a good rating with some positive probability only if it sets a negative price (which occurs with probability $(1-\delta^*)$ or if $\overline{p} \leq 0$). Otherwise, it obtains no rating.

To see that good ratings induce higher beliefs than no rating, we apply $\underline{p} = -q^A$ to the above expectations and get,

$$\frac{\gamma F(q^h - \overline{p})q^h}{\gamma F(q^h - \overline{p}) + (1-\gamma)(1-\delta^*)F(q^A)} > \frac{\gamma(1-F(q^h-\overline{p}))q^h}{\gamma(1-F(q^h-\overline{p}))+(1-\gamma)(\delta^*(1-F(\overline{p}))+(1-\delta^*)(1-F(q^A))}$$
$$\Leftrightarrow F(q^h - \overline{p}) - F(q^A) > (F(q^h - \overline{p})F(\overline{p}) - F(q^A))\delta^*,$$

We now argue that this always holds. Lemma 5 tells us $\underline{p}$ is the maximum price that induces demand for l if consumers know the firm's type. This price provides exactly q^A utility to consumers. Hence the firm receives a good rating with probability $F(q^A)$. Moreover, to obtain any demand, a firm h must provide at least expected utility q^A, which is why the ex-post utility satisfies $q^h - \overline{p} \geq q^A$ and therefore $F(q^h - \overline{p}) \geq F(q^A)$. Hence, we know that $F(q^h - \overline{p}) \geq F(q^A)$. This implies $F(q^h - \overline{p}) - F(q^A) > (F(q^h - \overline{p})F(\overline{p}) - F(q^A))\delta^*$ because $\delta^* \in (0,1]$ and $F(\overline{p}) < 1$. It is straightforward to show that no rating induces higher expectations than a bad rating.

When $\overline{p} \leq 0$, firm B sets a single price in period 1. Hence, there is no mixed strategy involved, and both high- and low-quality firm B would receive good ratings with some positive probability. Note that because $q^h > 0$, obtaining a good rating must be beneficial in equilibrium. It is straightforward to show that no rating induces higher expectations than a bad rating.

Finally, these beliefs apply if both newcomers enter, i.e. if newcomers sell in period 1. By Lemma 8, all other histories are off the path of play, and we set beliefs to q^l. □

Lemma 10. *Suppose h and l enter. Both firms A and B receive some positive demand if and only if firm A sells in period 2, and firm B sells in period 1 with probability* 1. *Both firms sell in period 2 after some ratings if* (7) *holds and* $\delta^* > \max\{0, 1 - \frac{(q^h - q^A)\gamma F(q^h - \overline{p})}{(1-\gamma)F(q^A)q^A}\}$.

Proof of Lemma 10.
Recall that by Lemma 8 the low-quality firm B sells in period 1 if and only if the high-quality firm B also sells in period 1. Furthermore, by Lemma 8 if firm B sells in period 2, it must sell in period 1. This implies the high-quality firm B must sell in period 1 for firm B to sell at all. If the high-quality firm B sells in period 1, the low-quality firm B must also sell in period 1. Hence, firm B must sell with probability 1 in period 1. This means the only possibility for firm A to sell is in period 2.

Thus, we need to check (i) under which conditions firm A sells in period 2; and (ii) under which conditions a high-quality firm B sells in period 2. (i) holds if firm A sells if it faces a rival without rating, i.e. that $q^A > E[q_2^B|R = 0] > E[q_2^B|R = -1]$. Using the expression of $E[q_2^B|R = 0]$ and rearranging, this condition becomes

$$\frac{q^h - q^A}{q^A} < \frac{(1-\gamma)(\delta^*(1 - F(\overline{p})) + (1-\delta^*)(1 - F(q^A)))}{\gamma(1 - F(q^h - \overline{p}))} \text{ when } \overline{p} > 0 \text{ and}$$

$$\frac{q^h - q^A}{q^A} < \frac{(1-\gamma)(1 - F(-\overline{p}))}{\gamma(1 - F(q^h - \overline{p}))} \text{ when } \overline{p} \leq 0.$$

Observing that when $\overline{p} \leq 0$, $\delta^* = 1$ we can equivalently combine and more generally state that $q^A > E[q_2^B|R = 0]$ whenever

$$\frac{q^h - q^A}{q^A} < \frac{(1-\gamma)(\delta^*(1 - F(|\overline{p}|)) + (1-\delta^*)(1 - F(q^A)))}{\gamma(1 - F(q^h - \overline{p}))}. \tag{7}$$

Finally, (ii) requires that a firm with a good rating $R = 1$ in period 2 sells when competing against firm A and earns a positive profit, i.e. if $E[q_2^B|R=1] > q^A$. Using the expression for the conditional expectation and rearranging leads to $\delta^* > 1-\frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{q^A(1-\gamma)F(q^A)}$. Moreover, because δ^* is a probability, $\delta^* > \max\{0, 1-\frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A}\}$ for firm B to sell in period 2 after a good rating. □

Corollary 12. *Good ratings are instrumental (i.e. affect beliefs and outcomes on the path of play) if and only if a high-quality firm B enters, sells in period 2 and firm B sells in period 1 with probability 1. A high-quality firm B sells after a good rating if $\delta^* > \max\{0, 1-\frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A}\}$.*

Proof of Corollary 12.
If a high-quality firm B sells in period 2, we know from Lemma 10 that both high- and low-quality firm B must have sold in period 1. Then we also know from Lemma 9 that good ratings cause consumers to positively update beliefs.

In turn, if good ratings are instrumental, a high-quality firm B must sell after a good rating, which by Lemma 8 implies it sold in 1.

Thus, good ratings are instrumental if and only if a high-quality firm B enters and sells in period 2, which is equivalent to $E[q_2^B|R=1] > q^A$, from Lemma 10, $\delta^* > \max\{0, 1-\frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A}\}$. □

Corollary 13. *Suppose h and l enter and $\overline{p} \leq 0$. Then $\overline{p} = \gamma q^h - q^A < 0$ and $p_1^A = 0$, and (1) implies that firms h and l attract demand and earn positive profits at this price and therefore enter.*

Proof of Corollary 13.
This is immediate because Lemmas 4 and 5 show that if firm B sells and $\overline{p} \leq 0$, it always sets $\overline{p}$. In other words, $\delta^* = 1$ and consumer beliefs in period 1 about firm B are γq^h (Lemma 7). Therefore the consumer only buys from firm B if it offers as much surplus as firm A does, $\overline{p} = \gamma q^h - q^A$. Because firms compete in a Bertrand fashion, the firm not selling charges price at marginal cost and the firm selling in period 1 charges a price equal to the expected difference in quality.

Finally, for firm l to want to sell it must face a positive total profit (across both periods), which is the case if (1) holds. Since h has a higher probability to get a positive rating and therefore earns strictly higher profits, the condition implies that h and l enter for the above prices. □

Corollary 14. *If $\overline{p} > 0$ and $\frac{q^h-q^A}{q^A} > \frac{F(q^A)(1-\gamma)}{\gamma(F(q^A)+F(q^h-\overline{p}))}$, we have $\overline{p} = \frac{\gamma q^h}{\gamma+(1-\gamma)\delta^*} - q^A$, $\underline{p} = -q^A$, $p_1^A = 0$ and $\delta^* \in (\max\{0, 1-\frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A}\}, \frac{\gamma(q^h-q^A)}{(1-\gamma)q^A})$. Both newcomer types attract demand and enter. If $\frac{q^h-q^A}{q^A} > \frac{F(q^A)(1-\gamma)}{\gamma(F(q^A)+F(q^h-\overline{p}))}$ is violated, either we must have $\overline{p} \leq 0$, or $\delta^* > \max\{0, 1-\frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A}\}$ is violated and newcomers do not enter.*

Proof of Corollary 14.
Note that if $\overline{p} > 0$ it must be that firm B prefers to sell in period 1 with probability one. This occurs if $\frac{\gamma q^h}{\gamma+(1-\gamma)\delta^*} - q^A > 0$.

Rearranging leads to

$$\delta^* < \frac{\gamma(q^h - q^A)}{(1-\gamma)q^A}.$$

Therefore, combined with Corollary 12, we know $\delta^* \in (\max\{0, 1 - \frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A}\}, \frac{\gamma(q^h-q^A)}{(1-\gamma)q^A})$, and this is possible only when $\frac{q^h-q^A}{q^h} > \frac{F(q^A)(1-\gamma)}{\gamma(F(q^A)+F(q^h-\overline{p}))}$.

In this case, firms h and l sell at $\overline{p} > 0$ in period 1 and therefore attract demand and enter.

If $\overline{p} \leq 0$, Corollary 13 implies that B still sells. If $\overline{p} > 0$ holds, but $\frac{q^h-q^A}{q^A} > \frac{F(q^A)(1-\gamma)}{\gamma(F(q^A)+F(q^h-\overline{p}))}$ is violated, either $\delta^* < \frac{\gamma(q^h-q^A)}{(1-\gamma)q^A}$, and therefore we must have $\overline{p} \leq 0$, or δ^* is too small for newcomers to sell after a good rating so that there is no entry. □

Corollary 15. *Suppose h and l enter. In period 2, firm A sets $\pi_2^A = p_2^A = max\{q^A - E[q_2^B|R], 0\}$ and firm B sets $\pi_2^B(R) = p_2^B = max\{E[q_2^B|R] - q^A, 0\}$.*

Proof of Corollary 15.
This follows from Lemma 11. And profits in period 2 are equivalent to the price set in period 2. □

Next, we prove the existence and uniqueness of a mixed strategy.

Given (7) and supposing h and l enter, we can characterize an equilibrium δ^*, which satisfies the following: A low-quality firm B must be indifferent between setting $\overline{p}$ in period 1 and getting no or negative rating, obtaining a profit of $\overline{p} + 0$, and setting $\underline{p}$ in period 1 and getting a good rating with some positive probability, obtaining a profit of $\underline{p} + F(q^A)(E[q_2^B|R=1] - q^A)$.

Lemma 11. *Suppose h and l enter, (1), (7), and (4) and (6) hold. If $\delta^* \geq \max\{0, 1 - \frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A}\}$, newcomers have strictly positive demand and there exists a unique δ^* such that:*

- *If $\frac{(q^A)^2}{\gamma(q^h)^2-(q^A)^2} < F(q^A)$ and $\overline{p} > 0$, $\delta^* \in (\frac{F(q^A)}{F(q^h-\overline{p})+F(q^A)}, \frac{\gamma(q^h-q^A)}{(1-\gamma)q^A})$.*
- *If $\frac{(q^A)^2}{\gamma(q^h)^2-(q^A)^2} < F(q^A)$ and $\overline{p} \leq 0$, $\delta^* = 1$,*
- *If $\frac{(q^A)^2}{\gamma(q^h)^2-(q^A)^2} \geq F(q^A)$, $\delta^* = 1$.*

Proof of Lemma 11.
We first characterize the profits that a low-quality firm B would receive if it plays $\overline{p}$ in period 1, then it's profits when playing $\underline{p}$ in period 1. We show the former is decreasing in δ^* while the latter is increasing. Then, we characterize when $\delta^* \in (0,1)$.

Total profits of the low-quality firm B setting $\overline{p}$ is $\overline{p}$. We know from above that a mixed-strategy equilibrium requires $\overline{p} > 0$. Therefore, the low-quality firm B earns $\overline{p} = \frac{\gamma q^h}{\gamma+(1-\gamma)\delta^*} - q^A$. It is immediate to see that this is decreasing in δ^*.

Total profits of l setting $\underline{p}$ is $\underline{p}$ plus a probability of obtaining a good rating and selling in period 2. Therefore, l earns $-q^A + F(q^A)(\frac{\gamma F(q^h-\overline{p})q^h}{\gamma F(q^h-\overline{p})+(1-\gamma)(1-\delta^*)F(q^A)} - q^A)$. This profit is increasing in δ^*. To see this, an increase in δ^* places less emphasis on the firm being low-quality following a good rating. Additionally, an increase in δ^* has an indirect effect of decreasing $\overline{p}$, which increases $F(q^h - \overline{p})$, placing a higher emphasis on the firm being high-quality following a good rating.

In mixed-strategy equilibria, low-quality firms must be indifferent between both strategies, which requires

$$\frac{\gamma q^h}{\gamma + (1-\gamma)\delta^*} = F(q^A)(\frac{\gamma F(q^h - \overline{p})q^h}{\gamma F(q^h - \overline{p}) + (1-\gamma)(1-\delta^*)F(q^A)} - q^A). \tag{8}$$

Note that $\delta^* \geq \max\{0, 1 - \frac{(q^h - q^A)\gamma F(q^h - \overline{p})}{(1-\gamma)F(q^A)q^A}\}$ ensures that newcomers with a good rating sell in period 2. Then, since for all $\overline{p} > 0$, firms earn attract strictly positive demand and earn positive profits.

To see when the solution is interior to $\delta^* \in (0, 1)$, consider $\delta^* = 0$. Then, evaluating equation (8), we get $\frac{\gamma}{\gamma + (1-\gamma)\delta^*}q^h = q^h$ and $F(q^A)(\frac{\gamma F(q^h - \overline{p})q^h}{\gamma F(q^h - \overline{p}) + (1-\gamma)(1-\delta^*)F(q^A)} - q^A) = F(q^A)(\frac{\gamma F(q^h - \overline{p})q^h}{\gamma F(q^h - \overline{p}) + (1-\gamma)F(q^A)} - q^A)$. It is then immediate to see

$$q^h > F(q^A)(\frac{\gamma F(q^h - \overline{p})q^h}{\gamma F(q^h - \overline{p}) + (1-\gamma)F(q^A)} - q^A).$$

This always holds since the term in brackets on the right-hand-side is strictly lower that q^h, and multiplied by a term that is strictly less than one.

Next, note that by Corollary 14, δ^* is bound above, i.e. $\delta^* < \frac{\gamma(q^h - q^A)}{(1-\gamma)q^A}$. Note that $\frac{\gamma(q^h - q^A)}{(1-\gamma)q^A} \leq 1$ if $\gamma q^h \leq q^A$, which we assume throughout. In particular, when $\delta^* = \frac{\gamma(q^h - q^A)}{(1-\gamma)q^A}$ this implies $\overline{p} = 0 \Leftrightarrow \frac{\gamma q^h}{\gamma + (1-\gamma)\delta^*} = q^A$, which can be rearranged to $(1-\gamma)(1-\delta^*) = \frac{q^A - \gamma q^h}{q^A}$. Hence, evaluating (8) at this upper bound, a mixed-strategy equilibrium requires that

$$q^A < F(q^A)(\frac{\gamma F(q^h - \overline{p})q^h}{\gamma F(q^h - \overline{p}) + \frac{q^A - \gamma q^h}{q^A}F(q^A)} - q^A).$$

Recall that F is linear such that $F(x) = x/\overline{e}$. Then we can replace F to obtain

$$q^A < F(q^A)(\frac{\gamma q^h q^h}{q^A} - q^A).$$

Then recall that the terms in the bracket are the second period profits of firm B conditional on a good rating which must be positive when firm B enters. Therefore,

$$\frac{(q^A)^2}{\gamma(q^h)^2 - (q^A)^2} < F(q^A)$$

must hold in an interior solution. Otherwise, if this condition is violated, l prefers to set $\delta^* = 1$.

We now show that when (7) holds, $\overline{p} > 0$ and $\frac{(q^A)^2}{\gamma(q^h)^2 - (q^A)^2} < F(q^A)$ holds such that there is an interior solution, we must have $\delta^* > \frac{F(q^A)}{F(q^h-\overline{p})+F(q^A)}$. Evaluating (8) at $\delta^* = \frac{F(q^A)}{F(q^h-\overline{p})+F(q^A)}$, we show that the left hand side is greater than the right hand side:

$$\frac{\gamma q^h}{\gamma + (1-\gamma)\frac{F(q^A)}{F(q^h)+F(q^A)}} > F(q^A)(\frac{\gamma F(q^h-\overline{p})q^h}{\gamma F(q^h-\overline{p}) + (1-\gamma)(1-\frac{F(q^A)}{F(q^h)+F(q^A)})F(q^A)} - q^A)$$
$$\gamma q^h(F(q^A)+F(q^h-\overline{p}))(1-F(q^A)) > -q^A F(q^A)(\gamma F(q^h-\overline{p}) + F(q^A))$$

which is always true. Recall that the left hand side is decreasing in δ^* and the right hand side increasing. Therefore, it must be that $\delta^* > \frac{F(q^A)}{F(q^h-\overline{p})+F(q^A)}$.

Next, we show that the interval where $\delta^* \in (\frac{F(q^A)}{F(q^h-\overline{p})+F(q^A)}, \frac{\gamma(q^h-q^A)}{(1-\gamma)q^A})$ can exist. This is the case if $\frac{F(q^A)}{F(q^h-\overline{p})+F(q^A)} < \frac{\gamma(q^h-q^A)}{(1-\gamma)q^A}$. Since F is linear, we can rewrite this as $\frac{q^A}{q^h-\overline{p}+q^A} < \frac{\gamma(q^h-q^A)}{(1-\gamma)q^A}$.

To see existence, note that $\overline{p} > 0$ implies that $\frac{q^A}{q^h-\overline{p}+q^A} < \frac{q^A}{q^h+q^A}$. Furthermore, $\frac{q^A}{q^h+q^A} < \frac{\gamma(q^h-q^A)}{(1-\gamma)q^A}$ holds if $(q^A)^2 < \gamma(q^h)^2$, and therefore the range can exist if q^h is sufficiently large.

Next, if (7) holds but $\overline{p} \leq 0$, from Lemma 5 we know firm B plays $\overline{p}$ regardless of it's type. In other words, the low-quality firm B never mixes and $\delta^* = 1$.

Next, if $\frac{(q^A)^2}{\gamma(q^h)^2-(q^A)^2} \geq F(q^A)$, then low-quality firm strictly prefers to mimic prices and we get $\delta^* = 1$.

Finally, we have already shown above that in the mixed-strategy equilibrium, newcomers sell and therefore enter. If $\delta^* = 1$, (1) ensures that newcomers attract strictly positive demand and enter. Thus, newcomers enter with probability one. This concludes the proof. □

We can now use the above results to prove each statement in Proposition 1 .

Proof of Proposition 1.
Suppose (1), (7), and (4) and (6) hold. It remains to show that there exists a unique $\underline{\delta} \in (0,1)$ such that newcomers enter if and only if $\delta^* > \underline{\delta}$. We know already from Lemma 8 that either both types of newcomers enter or none. By our Selection Assumption 1, newcomers enter whenever an equilibrium exists where they enter. By Lemma 11, they enter if $\delta^* > \max\{0, 1 - \frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A}\}$, i.e. if newcomers with a good rating sell in period 2. Clearly, if they do not sell after a good rating, they never sell. Thus, they enter if and only if $\delta^* > \max\{0, 1 - \frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A}\}$.

To see that $\underline{\delta} > 0$, note that for $\delta^* = 0$, $1 - \frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A} > 0$ if and only if $q^A > \gamma q^A$, which holds by assumption. Thus, the condition is violates for $\delta^* = 0$, implying no entry and $\underline{\delta} > 0$. Next, we know from (1) that even l earns weakly positive profits and attracts demand for $\delta^* = 1$. Since h must earn strictly larger profits than l, both types enter, implying that $\underline{\delta} < 1$. Finally, note that the left-hand-side of $\delta^* > \max\{0, 1 - \frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A}\}$ strictly increases in δ^*, while the right-land-side decreases in δ^*, implying that $\underline{\delta}$ is unique.

Next, note that Lemma 11 shows that conditional on entry, strategies are unique up to off-path beliefs. Additionally, Selection Assumption 1 implies that the same holds conditional on no entry.

We can now prove each statement about the newcomer entry in turn:

- Statement 1 follows directly from Lemma 9.
- Statement 2 follows directly from Corollary 12.
- Statement 3 follows directly from Corollary 13 and 14.
- Statement 4 follows directly from Corollaries 11 and 9 and Lemma 7.
- The conditions in statement 5 follow from Lemma 11 together with our result that newcomers firms enter if and only if $\delta^* > \underline{\delta}$.
- The prices in statement 5 follow from Corollary 14 and the ratings of the low-quality firm from Lemma 5.
- The equilibrium level of δ^* and its support comes from Lemma 11 and our result that newcomers firms enter if and only if $\delta^* > \underline{\delta}$.

This concludes the proof. □

Proof of Corollary 1.
We define the informativeness of ratings as a good rating being able to identify high-quality firms. This way, a good rating becomes more informative if $E[q_2^B|R=1]$ increases in δ^* when $\delta^* > \underline{\delta}$. To see this is true, first consider the case where $\overline{p} > 0$ then

$$E[q_2^B|R=1] = \frac{\gamma F(q^h - \overline{p})q^h}{\gamma F(q^h - \overline{p}) + (1-\gamma)(1-\delta^*)F(q^A)}$$

then note an increase in δ^* decreases $\overline{p}$ which means $\gamma F(q^h - \overline{p})$ increases. Hence, the expectation increases in δ^* and good ratings become more informative.

Suppose instead $\overline{p} \leq 0$, i.e. that δ^* is sufficiently large, and consider the more general beliefs where the low-quality firm may choose to mix between $\overline{p}$ and $\underline{p}$, then we have

$$E[q_2^B|R=1] = \frac{\gamma F(q^h - \overline{p})q^h}{\gamma F(q^h - \overline{p}) + (1-\gamma)\left[\delta^* F(|\overline{p}|) + (1-\delta^*)F(q^A)\right]}.$$

Observe that $F(q^A) > F(|\overline{p}|)$ because $-(\frac{\gamma q^h}{\gamma+(1-\gamma)\delta^*} - q^A) < q^A \Leftrightarrow 0 < \frac{\gamma q^h}{\gamma+(1-\gamma)\delta^*}$ which is always true. Then it must be that any increase in δ^* reduces $\delta^* F(|\overline{p}|) + (1-\delta^*)F(q^A)$ and increases $F(q^h - \overline{p})$. Therefore, $E[q_2^B|R=1]$ is increasing in δ^*. Overall, good ratings become more informative in δ^*. □

Proof of Corollary 2.

To show this, recall that the indifference condition for the low-quality firm must hold in a mixed-strategy equilibrium, define

$$G = \frac{\gamma q^h}{\gamma + (1-\gamma)\delta^*} - F(q^A)\left(\frac{\gamma F(q^h - \overline{p})q^h}{\gamma F(q^h - \overline{p}) + (1-\gamma)(1-\delta^*)F(q^A)} - q^A\right).$$

Then applying the uniform distribution, G becomes

$$\frac{\gamma q^h}{\gamma + (1-\gamma)\delta^*} - \frac{q^A}{\overline{e}}\left[\frac{\gamma(q^h - \overline{p})q^h}{\gamma(q^h - \overline{p}) + (1-\gamma)(1-\delta^*)q^A} - q^A\right].$$

We know from the proof of Lemma 11 that G is strictly decreasing in δ^*. Next, we consider the derivative of G with respect to $\overline{e}$, which is clearly strictly increasing. Then, using the implicit-function Theorem, it follows that $\frac{\partial \delta^*}{\partial \overline{e}} = -\frac{\frac{\partial G}{\partial \overline{e}}}{\frac{\partial G}{\partial \delta^*}} > 0$. This concludes the proof. □

Proof of Corollary 3.
First, we show that $\underline{\delta}$ is independent of $\overline{e}$. We know from the proof of Proposition 1 that (i) $\underline{\delta} \in (0,1)$, and (ii) that newcomers enter if and only if $\delta^* > \max\{0, 1 - \frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A}\}$. Thus, $\underline{\delta}$ is implicitly defined by $\underline{\delta} = 1 - \frac{(q^h-q^A)\gamma F(q^h-\overline{p})}{(1-\gamma)F(q^A)q^A}$, where also $\overline{p} = \frac{\gamma q^h}{\gamma+(1-\gamma)\underline{\delta}} - q^A$. Using that on its support, $F(x) = \frac{x}{\overline{e}}$, it follows that $\underline{\delta}$ is independent of $\overline{e}$.

Second, we know from Corollary 2 that $\frac{\partial \delta^*}{\partial \overline{e}} > 0$. Together with our results of Proposition 1 that newcomers enter if and only if $\delta^* > \underline{\delta}$, and since $\underline{\delta}$ is independent of $\overline{e}$, this implies that newcomers enter if and only if $\overline{e}$ is above some constant (which has to be strictly positive since we focus on $\overline{e}$ where newcomers get no rating with strictly positive probability). The result follows. □

Proof of Corollary 4.
First suppose $\delta^* \leq \underline{\delta}$. From Proposition 1 we know firm B is inactive and equivalently makes the profit $\pi^B = 0$. Hence, firm A charges monopoly prices, allowing it to extract the full surplus from consumers, q^A, in each period, making a total profit of $\pi^A = 2q^A$.

Now suppose $\delta^* > \underline{\delta}$. Firm B sells and it's expected profit is

$$\gamma\left[\overline{p} + F(q^h - \overline{p})\pi_2(R=1)\right] + (1-\gamma)\left[\delta^*\overline{p} - (1-\delta^*)q^A + (1-\delta^*)F(q^A)\pi_2(R=1)\right],$$

where π_2 represents firm B's period 2 profit following the rating $R = 1$. Then substituting $\overline{p}$ and $\pi_2(R=1)$,

$$\gamma q^h(1 + F(q^h - \overline{p})) - q^A\left[1 + \gamma F(q^h - \overline{p}) + (1-\gamma)(1-\delta^*)F(q^A)\right].$$

Note that $\overline{p}$ is decreasing in δ^*, which means $F(q^h - \overline{p})$ is increasing in δ^*. Then increases in δ^* increases $\gamma F(q^h - \overline{p})(q^h - q^A)$ and decreases $(1-\gamma)(1-\delta^*)F(q^A)$. Therefore, for increases in δ^*, the expected profits of firm B is increasing.

Firm A's expected profits are

$$\left[\gamma(1-F(q^h-\overline{p}))+(1-\gamma)\left[\delta^*(1-F(\overline{p}))+(1-\delta^*)(1-F(q^A))\right]\right]\left[q^A-E[q_2^B|R=0]\right]+ \\ (1-\gamma)\delta^*F(\overline{p})\left[q^A-E[q_2^B|R=-1]\right],$$

and substituting the expectations from Lemma 9, we get

$$\gamma(1-F(q^h-\overline{p}))(q^A-q^h)+(1-\gamma)\left[1-F(q^A)(1-\delta^*)\right]q^A.$$

Observing that an increase in δ^* decreases $\overline{p}$, it must be that $\gamma(1-F(q^h-\overline{p}))(q^A-q^h)$ becomes larger (since $q^A-q^h<0$), and also $(1-F(q^A)(1-\delta^*))$ becomes larger. Therefore the profits of firm A increase in δ^*.

Note that firm A's profits are strictly below monopoly level when firm B sells.

$$2q^A>\gamma(1-F(q^h-\overline{p}))(q^A-q^h)+(1-\gamma)\left[1-F(q^A)(1-\delta^*)\right]q^A \Leftrightarrow \\ q^A(\gamma F(q^h-\overline{p})+(1-\gamma)(1-F(q^A)(1-\delta^*)))>-\gamma(1-F(q^h-\overline{p}))q^h$$

which is always true.

Therefore the profits of firm A is first flat, then discontinuously decreases in δ^* as firm B begins to sell, and then increasing but remains strictly lower than when it was a monopolist. This concludes the proof. □

Proof of Corollary 5.
First suppose $\delta^*>\underline{\delta}$. To derive consumer surplus, note that total surplus is

$$\gamma q^h+\gamma\left[F(q^h-\overline{p})q^h+(1-F(q^h-\overline{p}))q^A\right]+(1-\gamma)\left[\delta^*q^A+(1-\delta^*)(1-F(q^A))q^A\right].$$

Then consumer surplus is given by total surplus minus the expected profits of A and B from the proof of Corollary 4. Rearranging leads to the consumer surplus

$$q^A+\left[\gamma F(q^h-\overline{p})+(1-\gamma)(1-\delta^*)F(q^A)\right]q^A+\gamma(1-F(q^h-\overline{p}))q^h.$$

We can further simplify this to

$$q^A+\gamma q^h+\gamma F(q^h-\overline{p})(q^A-q^h)+(1-\gamma)(1-\delta^*)F(q^A)q^A.$$

Note that an increase in δ^* leads to a decrease in $\overline{p}$. Thus, since $(q^A-q^h)<0$, it is immediate to see that consumers are worse off when δ^* increases.

Suppose now that $\delta^*\leq\underline{\delta}$. Then firm B does not enter and firm A is a monopolist. This way firm A is able to extract all surplus and consumer surplus is zero. □

Proof of Corollary 6.

Suppose $\delta^* > \underline{\delta}$ and consider an increase in $\overline{e}$ such that there is a first order stochastic dominant shift in the uniform rating cost distribution.

We first show the effect of a change in $\overline{e}$ on π^B, recall from the previous corollary that the profit function is $\gamma q^h(1+\frac{q^h-\overline{p}}{\overline{e}}) - q^A$. Then its derivative w.r.t. $\overline{e}$ is $-\gamma q^h \left[\frac{q^h-\overline{p}}{\overline{e}^2} + \frac{\frac{\partial \overline{p}}{\partial \delta^*}\frac{\partial \delta^*}{\partial \overline{e}}}{\overline{e}}\right]$. Since the first term in squared brackets is positive and the second one negative, the effect on π^B is ambiguous.

We next look at the effect on π^l. Recall that the low-quality firm B is indifferent between the payoff from setting $\overline{p}$ and $\underline{p}$. Hence, it suffice to show that the profits $\frac{\gamma q^h}{\gamma+(1-\gamma)\delta^*} - q^A$ is decreasing in $\overline{e}$. Notice that the derivative is $-\frac{\gamma(1-\gamma)q^h}{(\gamma+(1-\gamma)\delta^*)^2}\frac{\partial \delta^*}{\partial \overline{e}} < 0$.

We now look at the effect on π^h. Observe that the profits of the high-quality firm B is

$$\frac{\gamma q^h}{\gamma + (1-\gamma)\delta^*} - q^A + \frac{q^h - \overline{p}}{\overline{e}}\left[\frac{\gamma(q^h-\overline{p})q^h}{\gamma(q^h-\overline{p}) + (1-\gamma)(1-\delta^*)(q^A)} - q^A\right].$$

We can see that the term in squared brackets increases in $\overline{e}$ since it increases δ^*. But a larger $\overline{e}$ also decreases the probability that h gets a rating $\frac{q^h-\overline{p}}{\overline{e}}$. Thus, the overall effect is ambiguous.

We now argue that a change in $\overline{e}$ has an ambiguous effect on consumer surplus. To see this, observe that consumer surplus, using the term from the proof of Corollary 5, is

$$q^A + \gamma q^h + \gamma F(q^h - \overline{p})(q^A - q^h) + (1-\gamma)(1-\delta^*)F(q^A)q^A.$$

Then recall from Corollary 2 that $\frac{\partial \delta^*}{\partial \overline{e}} > 0$ and from above note $\frac{\partial \overline{p}}{\partial \delta^*}\frac{\partial \delta^*}{\partial \overline{e}} < 0$. Then the first and second terms are constant in $\overline{e}$. In the third term, $q^h - \overline{p}$ increase in $\overline{e}$, but $F(q^h - \overline{p})$ decreases in $\overline{e}$, so the effect is ambiguous. In the final term, an increase in $\overline{e}$ decreases $1-\delta^*$ and $F(q^A)$. Therefore, any increase in $\overline{e}$ can have an ambiguous effect on consumer surplus.

Finally, we show $\overline{e}$ has an ambiguous effect on π^A. To see this, consider firm A's profit

$$\gamma(1 - F(q^h - \overline{p}))(q^A - q^h) + (1-\gamma)[\delta^* + (1-\delta^*)(1 - F(q^A))]q^A$$

Again apply that $\frac{\partial \delta^*}{\partial \overline{e}} > 0$ and $\frac{\partial \overline{p}}{\partial \delta^*}\frac{\partial \delta^*}{\partial \overline{e}} < 0$. Then we know the first term increases in $q^h - \overline{p}$, but $\overline{e}$ has a direct negative effect in F, so the overall effect is ambiguous. The second term, second term becomes more positive as δ^* increases, but also via the direct effect of $\overline{e}$ on $F(q^A)$. Hence, the overall effect is ambiguous. □

Proof of Corollary 7.

By Corollary 3, newcomers enter if and only if $\overline{e}$ is sufficiently large. Additionally, by Corollary 5 consumer surplus is zero without entry and strictly positive with entry, the result follows. □