

Reputational Underpricing

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Question

★★★★★ Great quality for the price!

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Research Question: How do reputational incentives affect prices?

Motivation

(1) Lower prices → better reviews

“...price increase of 1% leads to a decrease of 3%-5% in the average rating.” Luca and Reshef (2021)

(2) Better reviews → higher demand & revenue

“...a one-star increase in Yelp rating leads to a 5-9 % increase in revenue.” Luca (2011)

Firm's tradeoff

- ▶ Lowering price improves reputation and increases future profits
- ▶ Lowering price decreases current profit

*When do firms **underprice** their product below the myopic optimum?*

Model Overview

Single long-lived firm

- ▶ Firm strategically prices its product
- ▶ Exogenous product quality privately observed by the firm

Multiple short-lived consumers

- ▶ Rational consumers observe past reviews and the current price
 - Past prices are unobserved
- ▶ Reviews depend on the utility of consumption of experience good:
 - Perfect good news
 - Price
 - Product quality (vertical differentiation)
 - IID taste shock (horizontal differentiation)

Results Preview

Main results

- (1) Underpricing occurs iff ratio of $\underbrace{\text{marginal}}_{\text{review if underpriced}}$ to $\underbrace{\text{inframarginal}}_{\text{review w/o underpricing}}$ reviewers is high.
- **Does not occur** if consumer's tastes are too diverse (uniform case)
 - **Occurs** if vertical quality differentiation $>$ horizontal taste differentiation
- (2) Underpricing can only happen at low current “reputation”.
- The high-quality firm prices lower than the low-quality firm.
- (3) Underpricing increases consumer surplus and speeds up learning.
- Rational consumers are not misled by UP & they pay less.

Literature

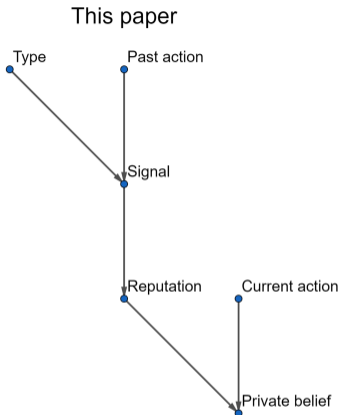
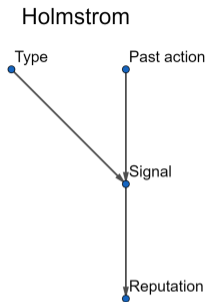
▶ Consumer Reviews Depending on Prices

- Static models: Feng, Li, and Zhang (2019); Martin and Shelegia (2021); **Huang, Li, and Zuo (2022)**;
- Boundedly-rational consumers: He and Chen (2018); Carnehl, Stenzel, and Schmidt (2021);

▶ Reputation

- Reputation for quality: **Holmström (1999)**; Mailath and Samuelson (2001);
- Dynamic signaling: Fudenberg and Levine (1989); Pei (2020); Ekmekci et al. (2022);

Literature



Reputation model with strategic pricing:

1. Prices affect reviews (*signal jamming*)
2. Price signals quality today (*repeated static signaling*)

Model

Firm

- ▶ **Long-lived Firm** sells a single product
 - Chooses $p_t \in [0, 1]$ over $t \in \mathbb{R}_+$
- ▶ Product quality is exogenous: $\theta \in \{L, H\}$, $0 < L < H = 1$
 - $\theta = H$, w/p q_0
 - In the paper, θ_t is redrawn at rate $\chi \geq 0$

Consumers

- ▶ **Short-lived Consumers** arrive at rate λ
 - Unit demand
- ▶ Utility of consumption

$$u_t = \theta - p_t + \varepsilon_t$$

- ε_t is IID ex-post taste shock, w/ $f_\varepsilon(x) = f_\varepsilon(-x)$
- Outside option is 0

Model

Reviews: Perfect Good News

- ▶ A consumer leaves a review iff $\theta = H$ AND $u_t > \bar{u}$ ($\bar{u} \geq 1$)
 - $\lambda_g(p_t) := \lambda \cdot \Pr(H - p_t + \varepsilon_t > \bar{u})$

Information

- ▶ $h^{t-} = \langle t, \{\tau_1, \dots, \tau_n\} \rangle$ is a **public** history of past reviews
- ▶ Firm observes θ and h^{t-}
 - $p_t = p(\theta, h^{t-})$
- ▶ Consumer observes p_t and h^{t-}
 - Expectations about firm's quality $\tilde{\theta}(p_t, h^{t-}) \in [L, H]$ (buy iff $\tilde{\theta} - p_t \geq 0$)

Firm's Problem

- ▶ Production is **costless** and payoffs are discounted at rate r

$$\max_{p_t} \mathbb{E} \left[\int_0^{+\infty} e^{-rt} \mathbf{1}_{\{\tilde{\theta}(p_t, h^{t-}) \geq p_t\}} p_t \lambda dt \right]$$

Markov Perfect Bayesian Equilibrium

Markov State and Beliefs

Firm's Reputation is the public belief that the quality is high:

$$q(h^{t-}) := (\tilde{\theta}(h^{t-}) - L)/(H - L) \in [0, 1]$$

Strategies, beliefs, and values depend on history only via $q(h^{t-})$

- ▶ Firm's prices $p(\theta, q)$
- ▶ Consumers' beliefs about prices $\tilde{p}(\theta, q)$
- ▶ Consumers' expectations about firm's quality $\tilde{\theta}(p, q) \in [L, H]$
- ▶ Firm's value function $V(\theta, q) \in \mathbb{R}_+$

Markov Perfect Bayesian Equilibrium

Equilibrium

MPBE is $\{p(\theta, q), V(\theta, q), \tilde{p}(\theta, q), \tilde{\theta}(p, q)\}$, s.t.

(1) $V(\theta, q)$ and $p_\theta(q)$ solve **HJB** (Static, Reputation)

$$\begin{aligned} rV(H, q) &= \max_{p \in \mathcal{P}_q} \left\{ \lambda p + \lambda_g(p) \cdot [V(H, 1) - V(H, q)] + "V_q(H, q) \cdot \frac{dq,}" \right\} \\ rV(L, q) &= \max_{p \in \mathcal{P}_q} \left\{ \lambda p + "V_q(L, q) \cdot \frac{dq,}" \right\} \end{aligned}$$

- $\frac{dq}{dt} = -\lambda_g(\tilde{p}(H, q)) \cdot q(1 - q)$ (w/o good news)
- $\mathcal{P}_q := \{p \in [0, 1] \mid \tilde{\theta}(p, q) \geq p\}$ (Acceptable Prices)

(2) Beliefs about prices are correct

- $\tilde{p}(\theta, q) = p(\theta, q)$

(3) Consumer expectations are **Bayesian** on path

- $\tilde{\theta}(p_\theta(q), q) = \mathbb{E}[\theta \mid p_\theta(q), q]$

Continuity Refinement

Continuity Refinement

Belief function $\tilde{\theta}(p, q)$ is continuous in p .

Equilibrium is an MPBE that satisfies *continuity refinement*.

No Underpricing & Underpricing

Equilibrium dichotomy:

(1) No Underpricing (**NUP**) is pricing at the consumers' willingness to pay:

$$\tilde{\theta}(q) := qH + (1 - q)L$$

(2) Underpricing (**UP**) is pricing below the consumers' willingness to pay.

*Remark: there is **NUP** in the myopic benchmark; $\tilde{\theta}(q)$ is the standard price in reputation models.*

Main Result

Theorem 1

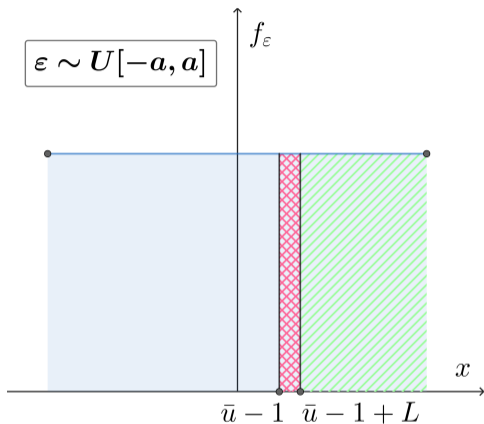
An equilibrium exists.

1. If $h_\varepsilon < \frac{1}{1-L}$, then **no underpricing** is the unique equilibrium ($\forall q p(\theta, q) = \tilde{\theta}(q)$).
2. If $h_\varepsilon > \frac{1}{1-L}$, then $\exists 0 < q^* < q^{**} \leq 1$, s.t. in every equilibrium
 - (a) there is **underpricing** $\forall q \leq q^*$: $p(H, q) = 0$, $p(L, q) = L$
 - (b) there is **no underpricing** $\forall q \geq q^{**}$.

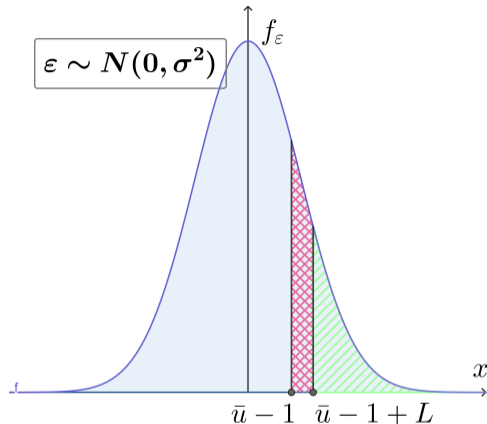
Adjusted hazard rate (of taste shock distribution) is

$$h_\varepsilon := \frac{(F_\varepsilon(\bar{u} - 1 + L) - F_\varepsilon(\bar{u} - 1))/L}{1 - F_\varepsilon(\bar{u} - 1 + L) + r/\lambda}$$

Adjusted Hazard Rate



(a) Low adjusted hazard rate



(b) High adjusted hazard rate

Inframarginal reviewers (NUP: $p = L$) v.s. Marginal reviewers (from UP $\rightarrow p = 0$) at $q = 0$

Proof: Part 1

UP Condition

Theorem 1 (restated)

1. $h_\varepsilon < \frac{1}{1-L} \Rightarrow$ **NUP** is the unique equilibrium ($\forall q$).
2. $h_\varepsilon > \frac{1}{1-L} \Rightarrow$ there is **UP** in every equilibrium:

$\exists 0 < q^* < q^{**} \leq 1$, s.t.

(a) **UP** $\forall q \leq q^*$: $p(H, q) = 0$, $p(L, q) = L$

(b) **NUP** $\forall q \geq q^{**}$.

Pricing Incentives

Lemma

$\lambda_g(p)$ and H 's objective function ($\lambda p + \lambda_g(p)(V(H, 1) - V(H, q))$) are **convex** and

$$p(H, q) \in \{0, \max \mathcal{P}(q)\}$$

Intuition: Reviews are sufficiently selective ($\bar{u} \geq 1$) \Rightarrow
there are more typical consumers than extreme consumers \Rightarrow
further underpricing adds higher density of reviewers

Motivation: Only 1 out of 1000 consumers leaves a review (Hu, Pavlou, and Zhang 2017).

Empirical Evidence

Underpricing Condition at $q = 0$

$$h_\varepsilon > \frac{1}{1-L} \Leftrightarrow \lambda \cdot (F_\varepsilon(\bar{u} - 1 + L) - F_\varepsilon(\bar{u} - 1)) \cdot \frac{1-L}{\lambda \cdot (1 - F_\varepsilon(\bar{u} - 1 + L)) + r} > L$$

- ▶ $\lambda \cdot (F_\varepsilon(\bar{u} - 1 + L) - F_\varepsilon(\bar{u} - 1))$ is the increase of good news arrival rate from underpricing (from $p = L$ to $p = 0$)
- ▶ $\frac{1-L}{\lambda \cdot (1 - F_\varepsilon(\bar{u} - 1 + L)) + r}$ is the value of an additional good review at $q = 0$.
- ▶ L the static profit loss from underpricing (from $p = L$ to $p = 0$)

Equilibrium Dichotomy

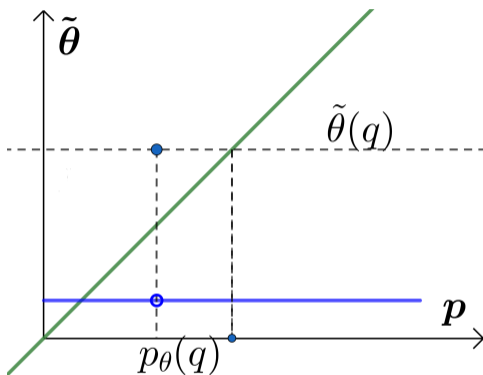
1. If $h_\varepsilon < \frac{1}{1-L}$, then **NUP** is the unique equilibrium.
2. If $h_\varepsilon > \frac{1}{1-L}$, then there is some **UP** in every equilibrium.

Sketch of the proof:

- ▶ Show that there are no underpricing incentives only at $q = 0$
- ▶ Show that there are no underpricing incentives only at any q ■

Unreasonable Underpricing

Both types underprice: $p(H, q) = p(L, q) < \tilde{\theta}(q)$



Continuity Refinement

Belief function $\tilde{\theta}(p, q)$ is continuous in p .

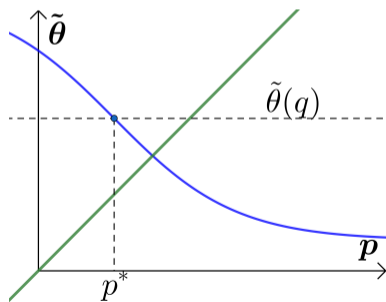
No-Underpricing Equilibrium

Proposition

If H prefers $p = L$ to $p = 0$ at a given q , then **NUP** is the unique equilibrium.

$$p(\theta, q) = \tilde{\theta}(q) = qH + (1 - q)L$$

Proof by contradiction:



Both types can increase their prices.

Proof: Part 2

Theorem 1 (restated)

1. $h_\varepsilon < \frac{1}{1-L} \Rightarrow$ **NUP** is the unique equilibrium ($\forall q$).
2. $h_\varepsilon > \frac{1}{1-L} \Rightarrow$ there is **UP** in every equilibrium:

$\exists 0 < q^* < q^{**} \leq 1$, s.t.

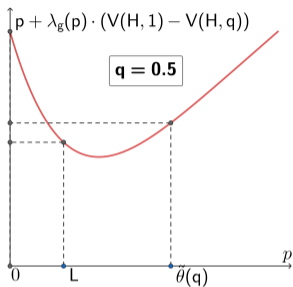
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(b) **NUP** $\forall q \geq q^{**}$.

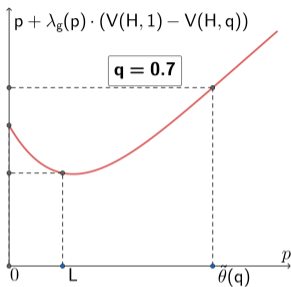
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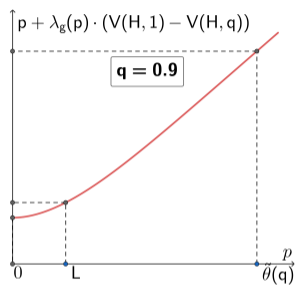
Underpricing Equilibrium Structure



Unique signaling
equilibrium is **UP**
($\forall q \leq q^*$)



Multiple signaling
equilibria
($\forall q^* < q < q^{**}$)



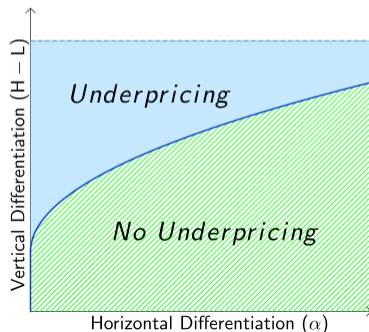
Unique signaling
equilibrium is **NUP**
($\forall q \geq q^{**}$)

Comparative Statics

Proposition

For any ε and λ/r and $\bar{u} = 1$, there exists a weakly increasing function $\alpha^*(H - L) : (0, 1) \rightarrow [0, +\infty)$, s.t.

1. If $\alpha < \alpha^*(H - L)$ and $\varepsilon' = \alpha\varepsilon$, there is underpricing in equilibrium.
2. If $\alpha > \alpha^*(H - L)$ and $\varepsilon' = \alpha\varepsilon$, there is no underpricing in equilibrium.



Welfare and Learning Effects of Underpricing

- ▶ If the firm is myopic, L and H prefer the highest price \Rightarrow **NUP** $\Rightarrow CS = 0$
- ▶ **UP** $\Rightarrow CS > 0$.
- ▶ High-quality firm underprices more, but the low-quality firm loses the surplus.
- ▶ Underpricing speeds up learning and makes both ratings and prices more informative.
- ▶ Platform transparency and observable past prices may harm consumers.

Summary

- ▶ Price-dependent reviews can but need not induce underpricing.
 - Underpricing depends on the ratio of the density of marginal reviewers to the mass of the inframarginal ones, who leave reviews without underpricing.
- ▶ If underpricing happens, it must occur at low-reputation levels in every equilibrium.
 - High-quality firm underprices more than low-quality firm.
- ▶ Underpricing hurts low-quality firm, increases CS, and speeds up social learning.

Thank you!

Empirical Motivation

- ▶ Firms' ratings affect their revenue

Luca (2011); Chevalier and Mayzlin (2006)

- ▶ Higher prices negatively affect product reviews/ratings

Luca and Reshef (2021); Cabral and Li (2015)

- ▶ Firms take these reputational incentives into account when setting prices

"...firms close to upgrading their tier are 4-9% more likely to discount." Sorokin (2021)

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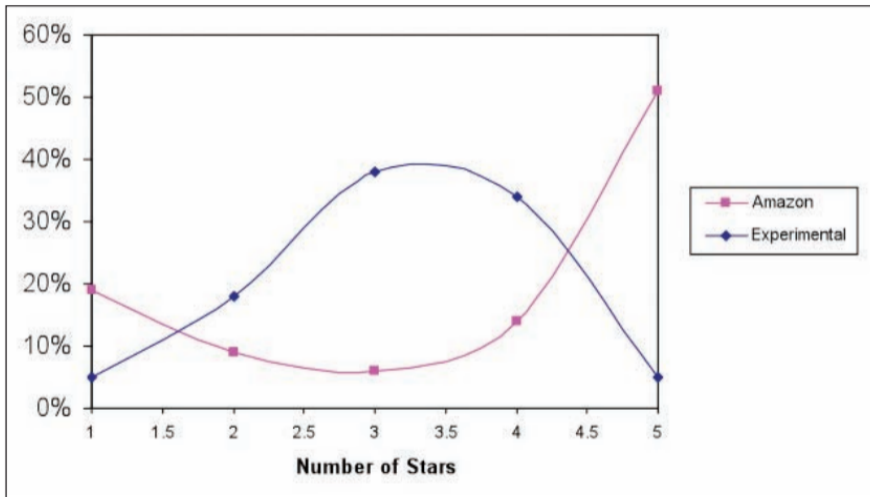
Extreme Reviews Empirical Evidence

- ▶ Across 25 platforms and 280 million reviews, there are extreme or polarized reviews (Schoenmüller, Netzer, and Stahl 2019)
- ▶ But experimental reviews are uni-modal (Hu, Zhang, and Pavlou 2009, Schoenmüller, Netzer, and Stahl 2019)
- ▶ Medium quality products are not rated possibly due to a cost of leaving a rating (Lafky 2014)
- ▶ Compensated reviews on Glassdoor are less extreme (Marinescu et al. 2021)

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Extreme Reviews

Figure 2. Distribution of Experimental versus Amazon's Ratings for a Music CD



Source: Hu, Zhang, and Pavlou (2009)

Price Dynamics

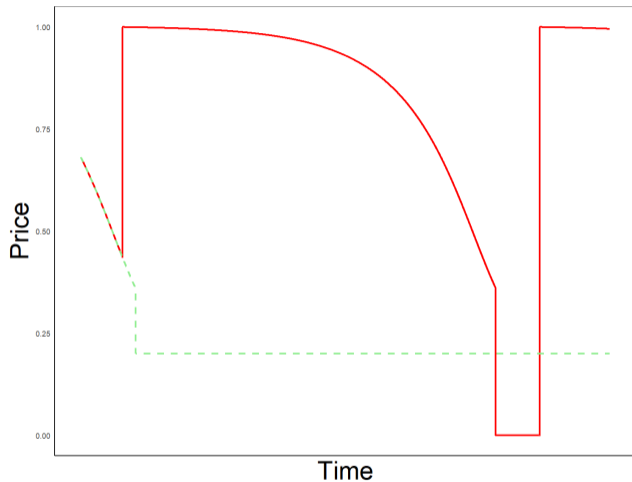


Figure: Price Dynamics with Underpricing