Personalized Pricing, Network Effects, and Corporate Social Responsibility

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Network Effects and Personalized Pricing

- Modern businesses heavily influenced by network effects
  - The product value to each consumer increases with the number of consumers
  - E.g., platforms, info technologies, video games

$\Rightarrow$ Coordination is relevant

$\Rightarrow$ Transparent prices can play a role here

- Technology and big data facilitate personalized pricing
  - E.g., individual coupons; different UBER fares
  - Benefit = price discrimination
  - Any cost? Especially in the presence of network effects.

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Price Unobservability

Each consumer can only see her own personalized price, but not others':

- Technology wise, not feasible
  - Personalized coupons; different UBER fares
- Privacy concerns + unfairness
- Regulation concerns
  - In July 2021, China issued draft rules to punish personalized pricing practice
  - Debates in EU and US

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Can a Firm Alleviate the Cost?

- Corporate social responsibility is a partial solution.
  - via CSR, the firm commits to $\downarrow$ prices, and thus $\uparrow\uparrow$ consumer base and profits
  - When the firm cannot commit prices, it can commit CSR
- "Doing well by doing good"
  - With optimal CSR commitment, both the firm and consumers are better off.

CSR as Commitment

- Feasibility / credibility:
  - Compensate management team with CSR
  - Hire socially conscious board members / management teams
  - Albuquerque and Cabral (21): "mission" statements
  - Principles for Responsible Investing (PRI)
- CSR commitment in practice:
  - Allbirds advertised maintaining ESG rating
  - Exxon activist installed directors to reduce carbon footprint
  - Huawei RuralStar Pro solution; Xiaomi profit cap
  - New players in CSR: gaming industries
    - Riot Games: matched millions in donations made by their global eSports community

Literature review

The use of CSR:

- long-termism, delegated/insider-initiated: Bénabou and Tirole (10)
- strategic CSR: Baron (01), Albuquerque and Cabral (21),
- increase in production function: Besley and Ghatak (05)
- Bond and Levit (23)

Strategic delegation:

- Fershtman and Judd (87), Bova and Yang (17)

Network products/ personalized pricing:

- Farrell and Saloner (85), Katz and Shapiro (85, 94)

Model

Setup

One firm & two consumers; network product.

$t = 0$

Firm chooses social responsibility.

$t = 1$

- Firm chooses prices for each consumer;
- Consumers make purchase decisions simultaneously.

$t = 2$

Firm profit and consumer utilities are realized

Consumer Preference

- The firm sells network product to consumer L and H
  - Personalized pricing: $p_L \neq p_H$
  - Uniform pricing: $p_L = p_H$

- Utility derived by consumer i

$$\mathcal{U}_i = v_i + \lambda \cdot 1(\text{consumer } j \text{ makes a purchase})$$

  - v_i: basic willingness to pay: $v_L \sim U[0,1]$ and $v_H \sim U[0,a]$, where $a > 1$; consumer i's private information

- $\lambda < 1$: network value
  - E.g., communication technologies (telephone, data networks), platforms (LinkedIn), video games

Firm Behavior

- Firm = Owner + Manager
- On date 1, manager chooses prices to maximize

$$\Pi = \pi + \gamma \cdot CS$$

  - $\pi = p_L \alpha_L + p_H \alpha_H$, where α_i is purchase probability
  - γ: firm's concern for consumer surplus
- On date 0, owner chooses γ to maximize profit π evaluated at date-1 equilibrium

Sequential Equilibrium (Backward Induction)

The equilibrium is characterized by the firm's socially responsible consciousness γ, product prices p_i and p_j, and consumers' purchasing strategies such that:

(1) γ maximizes the firm's expected profit;

(2) given γ, prices p_i and p_j maximize the firm's stated objective function;

(3) given γ and her own price p_i, consumer i's purchasing strategy maximizes her expected utility.

Analysis Outline

1. Two benchmarks of observable prices
   - Uniform pricing: $p_L = p_H = p$
   - Transparent pricing: $p_L \neq p_H$ but observable
2. Main model of personalized pricing:
   - $p_L \neq p_H$ and unobservable
3. Extensions
   - Sequential purchases
   - Multiple consumers
   - Socially conscious owner

Uniform Pricing ($p_L = p_H = p$)

- Denote consumer i's (j's) purchase probability α_i (α_j)
- Consumer i buys iff $v_i + \lambda\alpha_j \geq p \Leftrightarrow v_i \geq \bar{v}_i^U \equiv p - \lambda\alpha_j \Rightarrow$

$$\begin{cases} \alpha_L = 1 - (p - \lambda\alpha_H) \\ \alpha_H = 1 - \frac{1}{a}(p - \lambda\alpha_L) \end{cases} \Rightarrow \begin{cases} \alpha_L = \frac{a + a\lambda - p(a+\lambda)}{a - \lambda^2} \\ \alpha_H = \frac{a + \lambda - p(1+\lambda)}{a - \lambda^2} \end{cases}$$

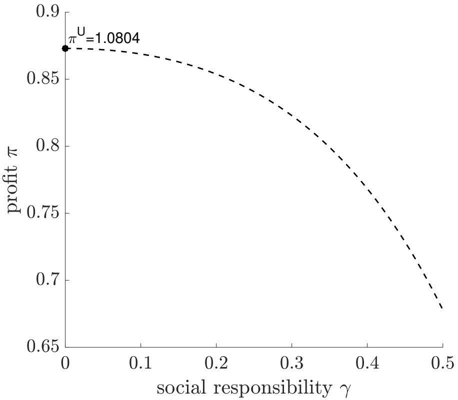
- Firm manager chooses p to max $\Pi = \pi + \gamma \cdot CS$, where

$$\pi = p(\alpha_L + \alpha_H),$$

$$\text{and } CS = \underbrace{\int_{\bar{v}_L^U}^{1} (v - p)dv + \alpha_L\alpha_H\lambda}_{\text{consumer } L\text{'s utility}} + \underbrace{\int_{\bar{v}_H^U}^{a} \frac{1}{a}(v - p)dv + \alpha_L\alpha_H\lambda}_{\text{consumer } H\text{'s utility}}.$$

- Firm owner chooses γ to max π

Under uniform pricing, the optimal $\gamma^U = 0$.



Transparent Pricing ($p_L \neq p_H$, Observable)

- Denote consumer i's (j's) purchase probability α_i (α_j).
- L buys iff $v_L + \lambda\alpha_H \geq p_L \Leftrightarrow v_L \geq \bar{v}_L^T \equiv p_L - \lambda\alpha_H$
- H buys iff $v_H + \lambda\alpha_L \geq p_H \Leftrightarrow v_H \geq \bar{v}_H^T \equiv p_H - \lambda\alpha_L$

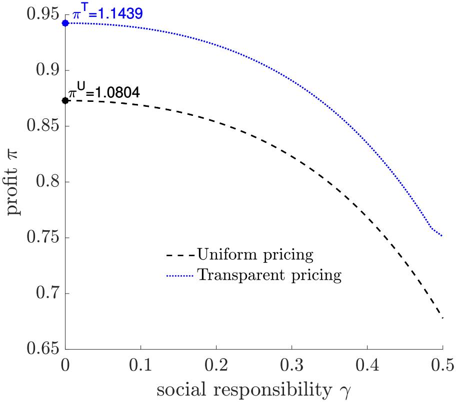
$$\begin{cases} \alpha_L = 1 - (p_L - \lambda\alpha_H) \\ \alpha_H = 1 - \frac{1}{a}(p_H - \lambda\alpha_L) \end{cases} \Rightarrow \begin{cases} \alpha_L = \frac{a(1-p_L)+\lambda(a-p_H)}{a-\lambda^2} \\ \alpha_H = \frac{a-p_H+\lambda(1-p_L)}{a-\lambda^2} \end{cases}$$

- Manager chooses p_L and p_H to max $\Pi = \pi + \gamma \cdot CS$, where

$$\pi = p_L\alpha_L + p_H\alpha_H.$$

- Owner chooses γ to max π

Under transparent pricing, the optimal $\gamma^T = 0$.



Personalized Pricing ($p_L \neq p_H$, Unobservable)

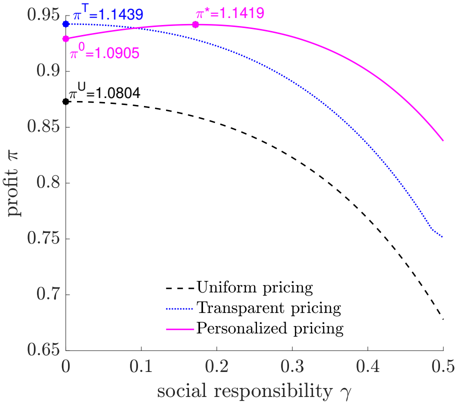
- Sequential equilibrium = Perfect Bayesian Nash Equilibrium + Passive Beliefs off Equilibrium
- Suppose that consumer i (j) believes that consumer j (i) buys with probability $\hat{\alpha}_j$ ($\hat{\alpha}_i$)
- Consumer i buys iff $v_i + \lambda \hat{\alpha}_j \geq p_i \Leftrightarrow v_i \geq \bar{v}_i \equiv p_i - \lambda \hat{\alpha}_j \Rightarrow$

$$\begin{cases} \alpha_L = \Pr(v_L \geq p_L - \lambda \hat{\alpha}_H) = 1 - (p_L - \lambda \hat{\alpha}_H) \\ \alpha_H = \Pr(v_H \geq p_H - \lambda \hat{\alpha}_L) = 1 - \frac{1}{a}(p_H - \lambda \hat{\alpha}_L) \end{cases}$$

  * α_i does not respond to p_j

- In equilibrium, consumers must hold consistent beliefs: $\alpha_L = \hat{\alpha}_L$ and $\alpha_H = \hat{\alpha}_H$

Under personalized pricing: $\gamma^* > 0$.



Intuitions

- Under both transparent and personalized pricing:

$$\pi(p_L, p_H, \hat{\alpha}_L, \hat{\alpha}_H) = p_L \alpha_L(p_L, \hat{\alpha}_H) + p_H \alpha_H(p_H, \hat{\alpha}_L),$$

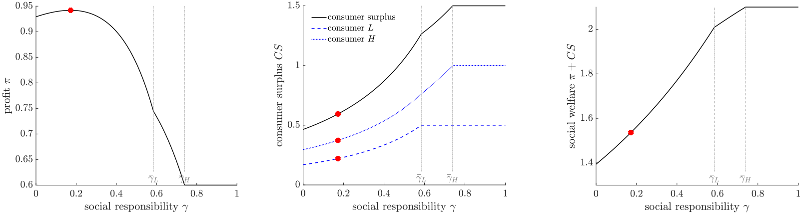
  with $\alpha_L(p_L, \hat{\alpha}_H) = 1 - (p_L - \lambda\hat{\alpha}_H), \alpha_H(p_H, \hat{\alpha}_L) = 1 - \frac{(p_H - \lambda\hat{\alpha}_L)}{a}$.
- Difference:
  - transparent pricing: $\hat{\alpha}_i = \alpha_i(p_L, p_H)$
  - personalized pricing: $\hat{\alpha}_i$ fixed

$$\frac{\partial \pi(p_i, p_j, \hat{\alpha}_i, \hat{\alpha}_j)}{\partial p_i} = \underbrace{\alpha_i(p_i, \hat{\alpha}_j) + p_i \frac{\partial \alpha_i(p_i, \hat{\alpha}_j)}{\partial p_i}}_{\text{standard trade-off}} + \underbrace{\left(p_i \frac{\partial \alpha_i(p_i, \hat{\alpha}_j)}{\partial \hat{\alpha}_j} \frac{\partial \hat{\alpha}_j}{\partial p_i} + p_j \frac{\partial \alpha_j(p_j, \hat{\alpha}_i)}{\partial \hat{\alpha}_i} \frac{\partial \hat{\alpha}_i}{\partial p_i} \right)}_{\substack{\text{– transparent pricing: } (<0) \\ \text{– personalized pricing: } (=0)}}$$

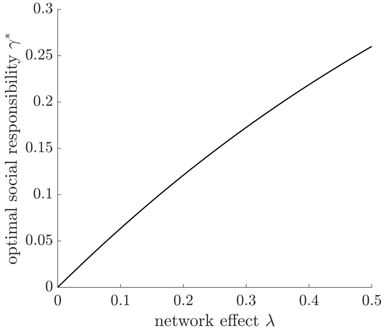
Doing Well by Doing Good

Proposition (Doing well by doing good)

Compared to the case in which the firm commits no CSR (i.e., $\gamma = 0$), both the firm and consumers are better off in equilibrium when the firm commits CSR (i.e., $\gamma = \gamma^*$).



Network Effects



- When $\lambda = 0$, we have $\gamma^* = 0$
- Firms/industries featured with a higher network effect have higher level of CSR

Extensions

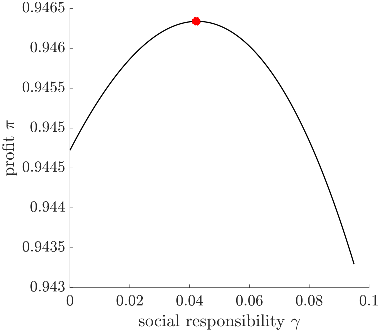
Sequential Purchases

$t = 0$ — Firm chooses social responsibility.

$t = 1$ —
- Firm chooses p_L for consumer L, and L makes purchase decision;
- Firm chooses p_H for consumer H, and H makes purchase decision.

$t = 2$ — All uncertainty realized

- Consumer L moves first and then consumer H



- While H can observe L's purchase decision, L cannot observe H's

Multiple Consumers

- A continuum type of consumers: $t \sim U[0, a]$
- Type-t's basic willingness to pay: $v_t \sim U[0, 1 + t]$
- Firm can charge different prices to different consumer types and each consumer cannot observe the others' prices
- Baseline model: two types

Result: $\gamma^* > 0$

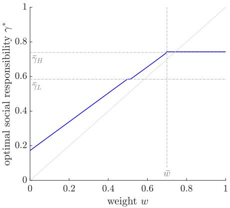
Socially Conscious Owner

- Firm owner's objective:

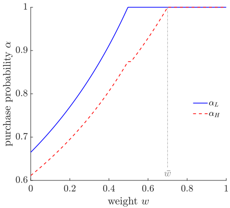
$$Z = \pi + w \cdot CS,$$

  where $w \geq 0$ is an exogenous constant.
- Baseline model: $w = 0$
- When $w = 1$, social planner

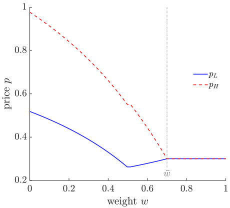
Result: in general, $\gamma^* > w$



(a) γ



(b) α_L, α_H



(c) p_L, p_H

Conclusion

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- We provide a product-based theory of CSR
  - CSR as a commitment device for low product prices and helps max shareholder value
  - Doing well by doing good
- CSR is positively correlated with product network value
- The joint rise of big data and CSR