Competitive Product Tests with Minimum Quality Standards

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Introduction

Two firms compete in quality disclosure and price under policy interventions

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Vertical oligopoly:

- Firms sort in quality and each serves a segment of the market
- Firms max differentiation and under-provide quality

Policy intervention: minimum quality standard (MQS)

- mitigate excessive differentiation and raise quality provision

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Competitive disclosure via Bayesian persuasion:

- *ex ante*: firms do not always know the exact quality, e.g., medical tests
- flexibility: increasing availability of various channels, e.g., IncoTest, *Consumer Reports*, lab or field experiments, etc.
- credibility: firms prefer credibility if possible

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Related Literature

Vertical differentiation and quality disclosure

- Shaked and Sutton, 1982; Board, 2009; Levin et al., 2009

Minimum quality standard

- Leland, 1979; Ronnen, 1991; Crampes and Hollander, 1995; Buehler and Schuett, 2014

(Competitive) information design

- KG, 2011; Dworczak and Maritini, 2019; Kleiner et al., 2020; Arieli et al., 2020
- Gill and Sgroi, 2012; Zapechelnyuk, 2020; Roesler and Szentes, 2018
- KG, 2016; Boleslavsky et al., 2019; Yang, 2020

Model

Market environment

- Two firms, qualities $q_i \sim F = U[\underline{q}, \bar{q}]$ i.i.d.
- Unit mass of consumers, taste $\theta \sim H = U[\underline{\theta}, \bar{\theta}]$
- Consumer's utility if purchase from i: $u = \theta q_i - p_i$
- Covered duopoly assumptions $\bar{\theta} \geq 2\underline{\theta}$, $\dfrac{\bar{q} - \underline{q}}{\underline{q}} \leq \dfrac{3\underline{\theta}}{\bar{\theta} - 2\underline{\theta}}$.

Model

Timing

- A minimum quality standard s_0 is imposed
- Firms choose public tests $\tau_i = (\beta_i, S_i)$
- Scores $s_i = E(q_i|s_i)$ are publicly generated
- Firm i exits iff $s_i < s_0$
- Remaining firm(s) decide price
- Consumers choose products

Price Equilibrium

Monopoly:

- Consumers purchase if $s\theta - p \geq 0$
- Monopolist: $\max_p p(1 - H(p/s))$
- Equilibrium

$$p^m = \frac{\bar{\theta}}{2}s, \quad \pi^m(s_i) = \frac{\bar{\theta}^2}{4(\bar{\theta} - \underline{\theta})}s$$

Price Equilibrium

Duopoly:

- Consumers purchase from i if $s_i\theta - p_i \geq \max\{s_j\theta - p_j, 0\}$
- The cutoff type X: $s_iX - p_i = s_jX - p_j$
- High (low) score firm serves $\theta \geq X$ $(\theta < X)$

Price Equilibrium

Duopoly:

- Consumers purchase from i if $s_i\theta - p_i \geq \max\{s_j\theta - p_j, 0\}$
- The cutoff type X: $s_iX - p_i = s_jX - p_j$
- High (low) score firm serves $\theta \geq X$ ($\theta < X$)
- Equilibrium $X^* = \frac{\bar{\theta}+\underline{\theta}}{3}$

$$p_h^d = \frac{(2\bar{\theta} - \underline{\theta})}{3}(s_h - s_l),\ p_l^d = \frac{(\bar{\theta} - 2\underline{\theta})}{3}(s_h - s_l).$$

$$\pi_h^d = \frac{(2\bar{\theta} - \underline{\theta})^2}{9(\bar{\theta} - \underline{\theta})}(s_h - s_l),\ \pi_l^d = \frac{(\bar{\theta} - 2\underline{\theta})^2}{9(\bar{\theta} - \underline{\theta})}(s_h - s_l).$$

Information Game

- In equilibrium each firm i chooses τ_i such that

$$\tau_i^* \in \text{argmax}_{\tau_i} E_{\tau_i} E_{\tau_{-i}} [\pi_i] \ \forall \ i$$

- Equivalently

$$\max_{G_i \in MPC(F)} \int_{\underline{q}}^{\bar{q}} \int_{\underline{q}}^{\bar{q}} \pi_i(s_i, s_{-i}) dG_{-i}(s_{-i}) dG_i(s_i) \ \forall \ i$$

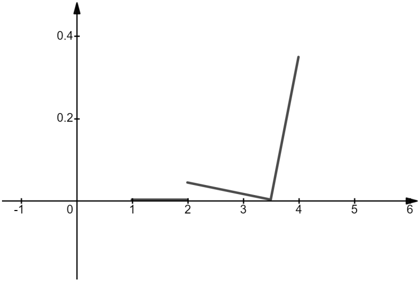

Figure 1: $\pi_1(s_1, s_2)$ when $s_0 = 2, s_2 = 3.5$

Information Equilibrium

Theorem

For any s_0 there exists an essentially unique symmetric equilibrium such that:

1. *when $s_0 < s_0^l$, each firm pools all states in $[\underline{q}, 2s_0 - \underline{q}]$ at s_0*
2. *when $s_0^l \leq s_0 < s_0^u$, each firm pools all states in $[s_0 - \delta, s_0 + \delta]$ at s_0 and reveals all states $s_i > s_0 + \delta$*
3. *when $s_0 > s_0^u$, each firm pools all states $s_i > 2s_0 - \bar{q}$ at s_0*

where δ, s_0^l, s_0^u are uniquely determined.

Information Equilibrium

Softening competition

- Both firms enjoy maximal differentiation
- Toward full revelation

Increasing pass probability

- Both firms hate exclusion
- Toward concealment around s_0

Proof of Equilibrium Characterization

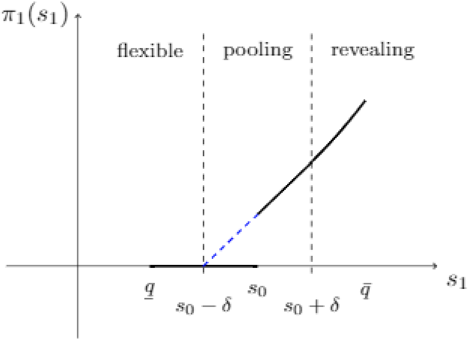

Figure 2: Equilibrium interim payoff $\int \pi_1(s_1, s_2) dG^*(s_2)$

Proof of Equilibrium Characterization

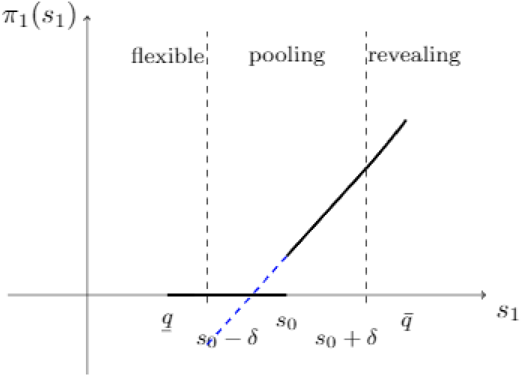

Figure 3: Non-equilibrium interim payoff $\delta_2 > \delta^*$

Proof of Equilibrium Characterization

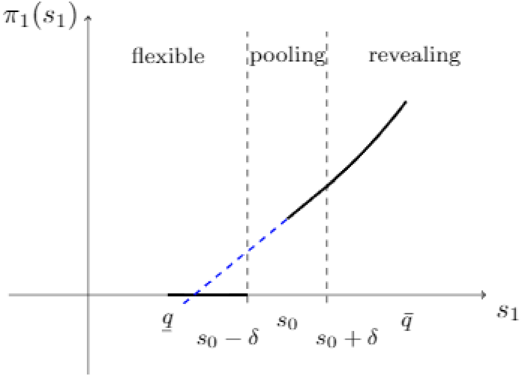

Figure 4: Non-equilibrium interim payoff $\delta_2 < \delta^*$

Proof of Equilibrium Uniqueness

$$\max_{G \in MPC(F)} \int \pi(s) dG(s)$$

All possible best responses (Kleiner, Moldovanu and Strack, 2020)

- Interval partitions with separating, uni-pooling, bi-pooling
- Arbitrary when $\pi(s)$ is linear (indifferent)

Proof by contradiction

- Full separation is not eqm
- No mass points other than s_0
- No "matching-pennies" equilibrium

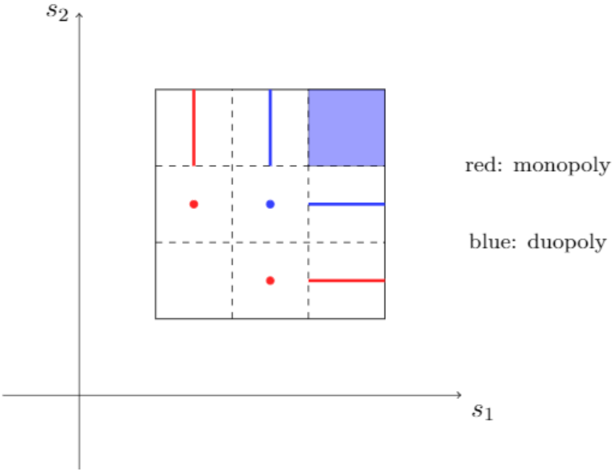

Figure 5: Equilibrium distribution of scores and market structure

Welfare Implication

Nontrivial MQS hurts firms

- $(-)$ Intensify price competition
- $(-)$ Induce exclusion when $s_0 > s_0^l$
- $(+)$ Creates monopoly but dominated when $s_0 > s_0^l$

Nontrivial MQS hurts total welfare (PS+CS)

- $(-)$ Induce mismatch
- $(-)$ Induce exclusion when $s_0 > s_0^l$
- Price is pure transfer

Welfare Implication

Nontrivial MQS benefits consumers

- $(+)$ Intensify price competition
- $(-)$ Induce mismatch
- $(-)$ Induce monopoly and no trade when $s_0 > s_0^l$

A nontrivial MQS increases CS when it's low

$$\frac{d}{ds_0} CS > 0 \text{ when} s_0 \in (\underline{q}, s_0^l)$$

Extensions?

- General q distribution? No problem
- General θ distribution? No problem
- Uncovered market? Maybe
  - Additional concern: demand effect
  - Additional reason for introducing MQS

(Un-)Related Open Questions

Who controls the test?

- Regulator designs test/certification
- A self-interested intermediary
- Firms can always disclose more? (Terstiege and Wasser, 2020)

Quality provision and certification design

- How firms invest in quality improvement in response to different tests?
- Bayesian persuasion with moral hazard (Boleslavsky and Kim, 2018; Zapechelnyuk, 2020 AERI)

Thanks!