Competitive Product Tests with Minimum Quality Standards

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Two firms compete in quality disclosure and price under policy interventions
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
Introduction

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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
Market environment

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

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

\[
p^m = \frac{\bar{\theta}}{2} s, \quad \pi^m(s_i) = \frac{\bar{\theta}^2}{4(\bar{\theta} - \bar{\theta})} s
\]
Duopoly:

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

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

\[
\begin{align*}
    p_h^d &= \frac{(2\bar{\theta} - \theta)}{3} (s_h - s_l), \quad p_l^d = \frac{(\bar{\theta} - 2\theta)}{3} (s_h - s_l).
    \\
    \pi_h^d &= \frac{(2\bar{\theta} - \theta)^2}{9(\bar{\theta} - \theta)} (s_h - s_l), \quad \pi_l^d = \frac{(\theta - 2\theta)^2}{9(\bar{\theta} - \theta)} (s_h - s_l).
\end{align*}
\]
In equilibrium each firm $i$ chooses $\tau_i$ such that

$$\tau_i^* \in \arg\max_{\tau_i} \mathbb{E}_{\tau_i} \mathbb{E}_{\tau_{-i}} [\pi_i] \ \forall \ i$$
Equivalently

\[
\max_{G_i \in MPC(F)} \int_{\bar{q}} \int_{\bar{q}} \pi_i(s_i, s_{-i}) dG_{-i}(s_{-i}) dG_i(s_i) \quad \forall \ i
\]

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

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

1. when $s_0 < s^l_0$, each firm pools all states in $[q, 2s_0 - q]$ at $s_0$

2. when $s^l_0 \leq s_0 < s^u_0$, 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 $s_0 > s^u_0$, each firm pools all states $s_i > 2s_0 - \bar{q}$ at $s_0$

where $\delta, s^l_0, s^u_0$ are uniquely determined.
Softening competition

- Both firms enjoy maximal differentiation
- Toward full revelation

Increasing pass probability

- Both firms hate exclusion
- Toward concealment around $s_0$
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

red: monopoly
blue: duopoly
Welfare Implication

Nontrivial MQS hurts firms

- (−) Intensify price competition
- (−) Induce exclusion when $s_0 > s^l_0$
- (+) Creates monopoly but dominated when $s_0 > s^l_0$

Nontrivial MQS hurts total welfare (PS+CS)

- (−) Induce mismatch
- (−) Induce exclusion when $s_0 > s^l_0$
- Price is pure transfer
Nontrivial MQS benefits consumers

- (+) Intensify price competition
- (−) Induce mismatch
- (−) Induce monopoly and no trade when $s_0 > s^l_0$

A nontrivial MQS increases CS when it’s low

$$\frac{d}{ds_0} CS > 0 \text{ when } s_0 \in (q, s^l_0)$$
Extensions?

- General $q$ distribution? No problem
- General $\theta$ distribution? No problem
- Uncovered market? Maybe
  - Additional concern: demand effect
  - Additional reason for introducing MQS
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!