The Economics of Predation: What Drives Pricing When There Is Learning-by-Doing?

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Predatory Pricing or Competition for Efficiency?

- Allegations of predation often surface in industries with learning-by-doing:
  - Semiconductor wars in 1970s and 1980s.
  - Intel vs. AMD in mid/late 2000s.
  - Chinese solar panels in 2012.
- How can we characterize exclusionary behavior when firms compete for a “positive-feedback” advantage?
Research Questions and Contributions

• When does predation-like behavior arise?
  • Routinely and under plausible conditions (generalize Cabral & Riordan 1994).
  • Coexist with non-predatory equilibria for same parameterization (formalize Edlin 2010).

• What drives pricing?
  • Isolate predatory incentives by decomposing equilibrium pricing condition.
  • Decomposition provides coherent and flexible way to define predatory incentives.

• What is the impact of predatory incentives (however defined) on industry structure, conduct, and performance?
  • Less severe conduct restrictions have small impact “on average.”
  • More severe conduct restrictions have large impact by eliminating equilibria with predation-like behavior.
  • But they reduce competition for the market.
Dynamic Pricing Model with Learning-by-Doing

- State \( e_n = 0 \) denotes firm \( n \in \{1, 2\} \) as potential entrant.
- State \( e_n \in \{1, \ldots, M\} \) indicates cumulative experience of incumbent firm. By winning sale, incumbent firm adds to cumulative experience and lowers production cost through learning-by-doing.
- Within-period timing:
  - Price-setting phase (transitions from state \( e \) to state \( e' \));
  - Exit-entry phase (transitions from state \( e' \) to state \( e'' \)).
Decisions and State-to-State Transitions

Decisions and State-to-State Transitions

\[ e \xrightarrow{\text{price-setting phase}} e' \xrightarrow{\text{exit-entry phase}} e' ' \]

- **neither wins sale**: \((e_1, e_2)\)
  - 1 exits, 2 stays in: \((0, e_2)\)
  - 1 stays in, 2 exits: \((e_1, 0)\)
  - both exit: \((0, 0)\)

- **1 wins sale**: \((e_1 + 1, e_2)\)
  - 1 exits, 2 stays in: \((0, e_2)\)
  - 1 stays in, 2 exits: \((e_1 + 1, 0)\)
  - both exit: \((0, 0)\)

- **2 wins sale**: \((e_1, e_2 + 1)\)
  - 1 exits, 2 stays in: \((0, e_2 + 1)\)
  - 1 stays in, 2 exits: \((e_1, 0)\)
  - both exit: \((0, 0)\)
Pricing Decision of Incumbent Firm

- **Value functions:** Expected NPV of future cash flows to firm 1...
  - ... in state $e$ at beginning of period $\rightarrow V_1(e)$;
  - ... in state $e'$ after pricing decisions but before exit and entry decisions are made $\rightarrow U_1(e')$.

- **Bellman equation:**
  $$V_1(e) = \max_{p_1} (p_1 - c(e_1)) D_1(p_1, p_2(e)) + D_0(p_1, p_2(e)) U_1(e)$$
  $$+ D_1(p_1, p_2(e)) U_1(e_1 + 1, e_2)$$
  $$+ D_2(p_1, p_2(e)) U_1(e_1, e_2 + 1).$$

- **Pricing decision:**
  $$mr_1(p_1, p_2(e)) - c(e_1) + \left[ U_1(e_1 + 1, e_2) - U_1(e) \right]$$
  $$+ Y(p_2(e)) \left[ U_1(e) - U_1(e_1, e_2 + 1) \right] = 0,$$
  where $Y(p_2(e))$ is conditional probability of firm 2 making sale.
Aggressive Equilibrium: Predation-Like Behavior

Pricing decision of firm 1, non-operating probability of firm 2, and time path of probability distribution over industry structures.
Accommodative Equilibrium

Pricing decision of firm 1, non-operating probability of firm 2, and time path of probability distribution over industry structures.
## Competition for and in the Market

<table>
<thead>
<tr>
<th></th>
<th>aggressive equilibrium</th>
<th>accommod. equilibrium</th>
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<tbody>
<tr>
<td><strong>structure:</strong></td>
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<tr>
<td>expected long-run Herfindahl index $HHI^\infty$</td>
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<td><strong>performance:</strong></td>
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Predation-Like Behavior Arises Routinely

Equilibrium correspondence.
Sacrifice Standard

- Legal standard of predation revolves around sacrifice of current profit in exchange for future profit.
- Determine whether derivative of suitably defined profit function at actual price is positive. “In principle this profit function should incorporate everything except effects on competition...” (Edlin & Farrell 2004).
- Profit function = everything-except-for-effects-on-competition profit function + remainder:

\[ \Pi_1(p_1) = \Pi_{1EEC}^E(p_1) + \Omega_1(p_1). \]

- In equilibrium:

\[ \frac{\partial \Pi_{1EEC}^E(p_1(e))}{\partial p_1} > 0 \iff \frac{\partial \Omega_1(p_1(e))}{\partial (-p_1)} > 0. \]
Isolating Predatory Incentives

- **Short-run profit.** “...but in practice sacrifice tests often use short-run data, and we will often follow the conventional shorthand of calling it short-run profit” (Edlin & Farrell 2004):

\[
\Pi_1^{EEEC}(p_1) = (p_1 - c(e_1)) D_1(p_1, p_2(e)).
\]

**Definition:** Predatory incentives are the advantage-building and advantage-denying motives

\[
[U_1(e_1 + 1, e_2) - U_1(e)] + Y(p_2(e)) [U_1(e) - U_1(e_1, e_2 + 1)].
\]

- **Dynamic competitive vacuum.** An action is predatory to the extent that it weakens the rival (Farrell & Katz 2005):

\[
\Pi_1^{EEEC}(p_1) = (p_1 - c(e_1)) D_1(p_1, p_2(e)
\]
\[
+ U_1(e) + D_1(p_1, p_2(e) [U_1(e_1 + 1, e_2) - U_1(e)].
\]

**Definition:** Predatory incentives are the advantage-denying motive

\[
[U_1(e) - U_1(e_1, e_2 + 1)].
\]
Isolating Predatory Incentives

- **Rival exit I.** Economic definitions of predation focus on impact of price cut on rival exit (Ordover & Willig 1981, Cabral & Riordan 1997).
  - **Advantage-building/exit motive** $\Gamma_1^2(e)$: If firm wins sale and moves down its learning curve, then firm increases rival’s exit probability.
  - **Advantage-denying/exit motive** $\Theta_1^2(e)$: If firm wins sale and moves down its learning curve, then firm prevents rival’s exit probability from decreasing.

**Definition:** Predatory incentives are the advantage-building/exit and advantage-denying/exit motives

$$\Gamma_1^2(e) + \Upsilon(p_2(e))\Theta_1^2(e).$$

- **Rival exit II.** Truly exclusionary effect is the one aimed at inducing exit by preventing rival from winning sale.

**Definition:** Predatory incentives are the advantage-denying/exit motive

$$\Theta_1^2(e).$$
Conduct Restrictions

- Definitions of predatory incentives correspond to conduct restrictions of decreasing severity.
- Impose constraint $\Xi(p_1, p_2(e), e) = 0$ on firm’s profit-maximization problem:

$$mr_1(p_1, p_2(e)) - c(e_1) + \left[ \sum_{k=1}^{5} \Gamma_k^1(e) \right] + \left[ \sum_{k=1}^{4} \Theta_k^1(e) \right] = 0,$$

with predatory incentives “switched off.”
Less Severe Conduct Restrictions: Small Impact “on Average”

Equilibrium and counterfactual correspondence for REI predatory incentives.
More Severe Conduct Restrictions: Large Impact by Eliminating Equilibria

Equilibrium and counterfactual correspondence for DCV predatory incentives.
What Happens After Conduct Restriction is Enforced?

• Compare counterfactuals to equilibria over wide range of parameterizations.
• Difficulty: Multiple counterfactuals.
• Use homotopy method where possible to connect equilibrium to nearby counterfactual and assume random selection where necessary.
## Impact of Conduct Restrictions

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Conclusions and Policy Implications

- Predation-like behavior arises routinely and under plausible conditions in dynamic pricing models.
- Aggressive equilibria with predation-like behavior typically coexist with accommodative equilibria: Predatory pricing can arise “if business folk think so” (Edlin 2010).
- Conduct restrictions may eliminate equilibria with predation-like behavior, but they reduce competition for the market.
  - Judge Breyer’s “bird-in-hand”: Price of making future consumers better off is making current consumers worse off.
- DCV and REII conduct restrictions are closest to unambiguously beneficial.
  - Exclusion of opportunity may be sensible dividing line between predatory pricing and competition for efficiency.
- Defining predatory pricing is hard, but we can usefully isolate and measure predatory incentives by decomposing equilibrium pricing condition.