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.
    - Japanese color televisions in 1960s and 1970s.
    - 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?

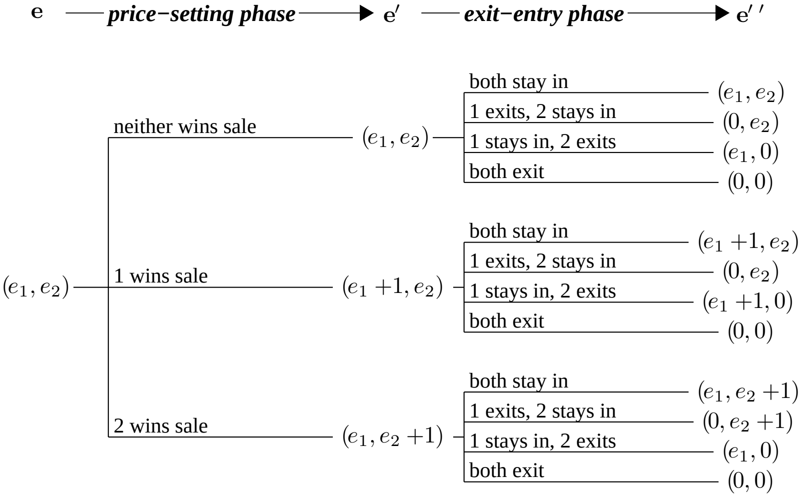
Research Questions and Contributions

- 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

- Markov-perfect-equilibrium framework (Ericson & Pakes 1995).
- 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 $\mathbf{e}$ to state $\mathbf{e}'$);
  - Exit-entry phase (transitions from state $\mathbf{e}'$ to state $\mathbf{e}''$).

Decisions and State-to-State Transitions



Pricing Decision of Incumbent Firm

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

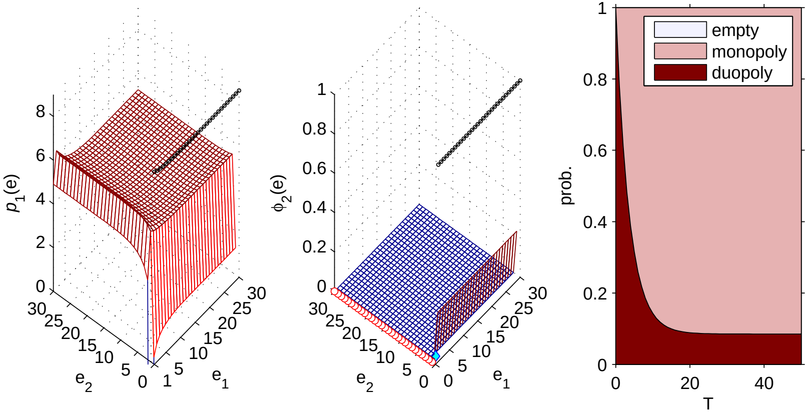
$$
\begin{aligned}
V_1(\mathbf{e}) \quad = \quad & \max_{p_1} (p_1 - c(e_1)) D_1(p_1, p_2(\mathbf{e})) + D_0(p_1, p_2(\mathbf{e})) U_1(\mathbf{e}) \\
& + D_1(p_1, p_2(\mathbf{e})) U_1(e_1 + 1, e_2) \\
& + D_2(p_1, p_2(\mathbf{e})) U_1(e_1, e_2 + 1).
\end{aligned}
$$

- Pricing decision:

$$
\begin{aligned}
\overbrace{mr_1(p_1, p_2(\mathbf{e})) - c(e_1)}^{\text{static profit}} + \overbrace{[U_1(e_1 + 1, e_2) - U_1(\mathbf{e})]}^{\text{advantage-building motive}} & \\
+ \Upsilon(p_2(\mathbf{e})) \underbrace{[U_1(\mathbf{e}) - U_1(e_1, e_2 + 1)]}_{\text{advantage-denying motive}} & \quad = \quad 0,
\end{aligned}
$$

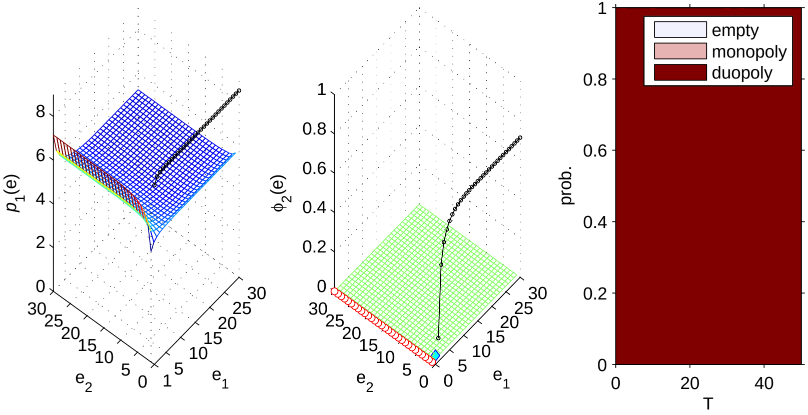
where $\Upsilon(p_2(\mathbf{e}))$ is conditional probability of firm 2 making sale.

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

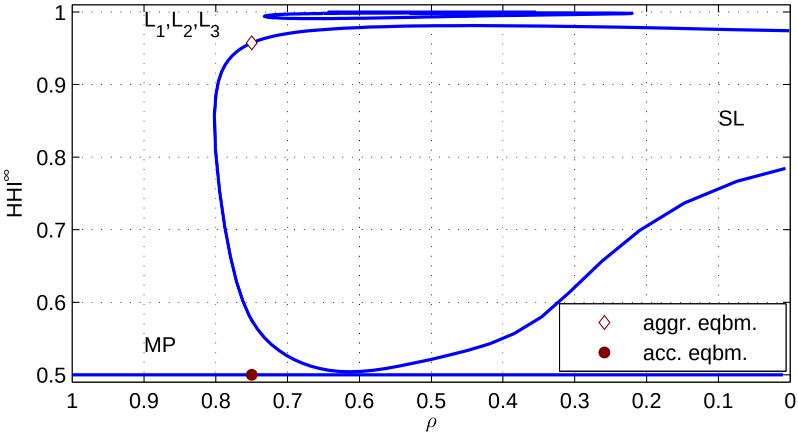


Pricing decision of firm 1, non-operating probability of firm 2, and time path of probability distribution over industry structures.

Competition for and in the Market

	aggressive equilibrium	accommod. equilibrium
<u>structure:</u>		
expected long-run Herfindahl index HHI^{∞}	0.96	0.50
<u>conduct:</u>		
expected long-run average price $\overline{p}^{\infty}$	8.26	5.24
<u>performance:</u>		
expected long-run consumer surplus CS^{∞}	1.99	5.46
expected long-run total surplus TS^{∞}	6.09	7.44
discounted consumer surplus CS^{NPV}	104.17	109.07
discounted total surplus TS^{NPV}	110.33	121.14

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:

$$\Pi_1(p_1) = \Pi_1^{EEEC}(p_1) + \Omega_1(p_1).$$

- In equilibrium:

$$\frac{\partial \Pi_1^{EEEC}(p_1(\mathbf{e}))}{\partial p_1} > 0 \Leftrightarrow \frac{\partial \Omega_1(p_1(\mathbf{e}))}{\partial(-p_1)} > 0.$$

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):

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

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

  $$\left[U_1(e_1+1, e_2) - U_1(\mathbf{e})\right] + \Upsilon(p_2(\mathbf{e}))\left[U_1(\mathbf{e}) - U_1(e_1, e_2+1)\right].$$

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

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

  Definition: Predatory incentives are the advantage-denying motive

  $$\left[U_1(\mathbf{e}) - U_1(e_1, e_2+1)\right].$$

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* $\Gamma_1^2(\mathbf{e})$: If firm wins sale and moves down its learning curve, then firm increases rival's exit probability.
  - *Advantage-denying/exit motive* $\Theta_1^2(\mathbf{e})$: 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

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

- *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

$$\Theta_1^2(\mathbf{e}).$$

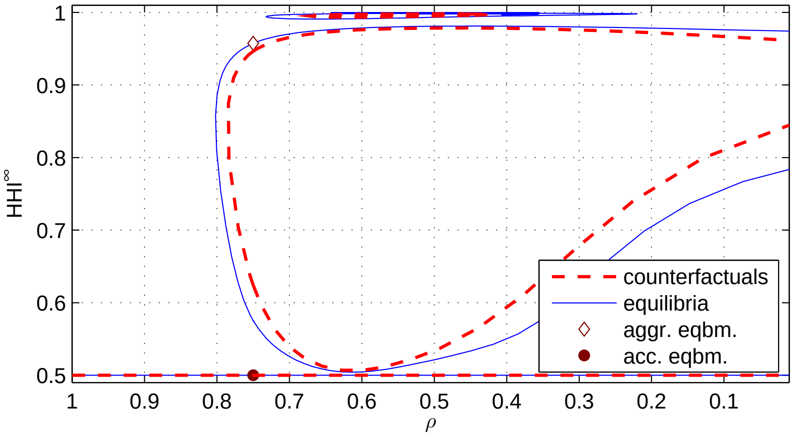
Conduct Restrictions

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

$$\overbrace{mr_1(p_1, p_2(\mathbf{e})) - c(e_1)}^{\text{static profit}} + \overbrace{\left[\sum_{k=1}^{5} \Gamma_1^k(\mathbf{e})\right]}^{\text{decomposed AB motives}} + \Upsilon(p_2(\mathbf{e})) \underbrace{\left[\sum_{k=1}^{4} \Theta_1^k(\mathbf{e})\right]}_{\text{decomposed AD motives}} = 0,$$

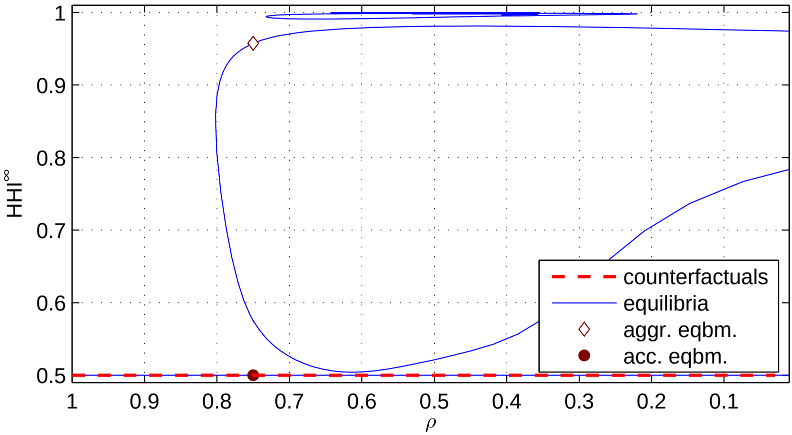
with predatory incentives "switched off."

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

	avg.		SRP	DCV	REI	REII
			definition			
HHI^{∞}	0.70	change	-0.11	-0.11	-0.02	-0.02
		up	6%	2%	10%	11%
		down	40%	40%	21%	19%
$\overline{p}^{\infty}$	6.71	change	-1.17	-1.23	-0.23	-0.18
		up	6%	2%	12%	13%
		down	39%	40%	22%	20%
CS^{∞}	3.97	change	1.27	1.33	0.24	0.20
		up	41%	41%	28%	26%
		down	6%	4%	14%	15%
TS^{∞}	7.73	change	0.32	0.30	0.05	0.05
		up	40%	38%	9%	10%
		down	0%	0%	1%	0%
CS^{NPV}	119.88	change	-64.94	-1.80	-1.38	-0.09
		up	0%	14%	0%	5%
		down	95%	60%	40%	7%
TS^{NPV}	139.16	change	-12.72	2.19	0.32	0.40
		up	1%	35%	8%	9%
		down	93%	0%	4%	2%

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.