# Consumer Privacy in Oligopolistic Markets

## Winners, Losers, and Welfare

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# Motivating Questions

- Is there a demand for privacy without taste for privacy?
- Which Consumers benefit from privacy and which do not?
- What is the impact of consumer privacy on firm profits?
- What are the efficiency implications of consumer privacy?

# The Linear City Model (LCM)

- Firm $A$ is located at 0 and $B$ at 1.
- Both firms' unit costs are $c$
- Consumer locations (addresses) $\alpha \in [0, 1]$ are uniformly distributed.
- Consumers value 1 unit at $v$ and pay transportation cost $t$ per "kilometer."
- Parameters: $v > c + \frac{3t}{2}$

# Equilibrium in LCM with Privacy

Consumer at $\alpha^*$ is indifferent iff:

$$v - p_A - t\alpha^* = v - p_B - t(1-\alpha^*)$$
$$\Rightarrow \alpha^* = \frac{1}{2} + \frac{p_B - p_A}{2t}$$

- $\max_{p_A} \pi_A = \alpha^*(p_A - c)$
- $\max_{p_B} \pi_B = (1-\alpha^*)(p_B - c)$
- Prices: $p_A = p_B = c + t$
- Marginal Type: $\alpha^* = \frac{1}{2}$

# Welfare in LCM with Privacy

- Firms: $\pi_A + \pi_B = t$
- Consumers: $CS = v - c - \frac{5t}{4}$
- Efficiency: $DWL = 0$
- Worst Off: $U(\frac{1}{2}) = v - c - \frac{3t}{2}$
- Best Off: $U(0 = U(1) = v - c - t$

# Equilibrium in LCM without Privacy

If addresses are common knowledge and arbitrage is infeasible, then firms compete for each consumer.

| | $P_A(\alpha)$ | $p_B(\alpha)$ |
|---|---|---|
| $\alpha \leq 0.5$ | $c + t(1 - 2\alpha)$ | $c$ |
| $\alpha \geq 0.5$ | $c$ | $c + t(2\alpha - 1)$ |

# Welfare in LCM without Privacy

- Firms: $\pi_A + \pi_B = \frac{t}{2}$
- Consumers: $CS = v - c - \frac{3t}{2}$
- Efficiency: $DWL = 0$
- Best Off: $U(\frac{1}{2}) = v - c - \frac{t}{2}$
- Worst off: $U(0) = U(1) = v - c - t$
- All consumers prefer no privacy!

# The Vertical Differentiation Model (VDM)

- Firms $H$ and $L$ produce qualities $q_H$ and $q_L$
- Both firms' unit costs are $c$
- Consumer types, $\theta \in [1, 5]$, are uniformly distributed.
- Utility is $U(q_i, p_i; \theta) = \theta q_i - p_i$
- Parameters satisfy $2q_L \geq q_H + c$

# Equilibrium in VDM with Privacy

Consumer with *theta*$^*$ is indifferent iff:

$$\theta^* q_H - p_H = \theta^* q_L - p_L$$
$$\Rightarrow \theta^* = \frac{p_H - p_L}{q_H - q_L}$$

- $\max_{p_H} \pi_H = (5 - \theta^*)(p_H - c)$
- $\max_{p_L} \pi_L = (\theta^* - 1)(p_L - c)$
- prices: $p_H = c + 3\Delta q$ $p_L = c + \Delta q$
- marginal type: $\theta^* = 2$

# Welfare in VDM with Privacy

- Firms: $\pi_L = \Delta q \ \pi_H = 9\Delta q$
- Consumers: $CS_L = 1.5q_L - c - \Delta q$

$$CS_H = 10.5q_H - 3c - 9\Delta q$$

- Efficiency: $DWL = 1.5\Delta q$
- Worst Off: $U(q_L, p_L; 1) = 2q_L - c - Q_H$
- Best Off: $U(q_H, p_H; 5) = 2q_H + 3q_L - c$

# Equilibrium in VDM without Privacy

If types are common knowledge and arbitrage is infeasible, then firms compete for each consumer.

$$p_L(\theta) = c, \quad \theta \in [1, 5]$$

$$p_H(\theta) = c + \theta \Delta q, \quad \theta \in [1, 5]$$

All consumers buy from $H$.

# Welfare in VDM without Privacy

- Firms: $\pi_L = 0$ $\pi_H = 12\Delta q$
- Consumers: $CS = 12q_L - 4c$
- Efficiency: $DWL = 0$
- Best off: $U(q_H, p_H(5); 5) = 5q_L - c$
- Worst off: $U(q_H, p_H(1); 1) = q_L - c$
- Consumers with $\theta > 3$ prefer privacy.

# Cournot Duopoly

- Firms 1 and 2 simultaneously produce $x_1$ and $x_2$.
- Both firms have unit costs $c$.
- One consumer: $U(X, p; \gamma) = \gamma X - 0.5X^2 - pX$
- Distribution: $\gamma \sim F(\cdot)$
- Parameters: $0 \leq E[\gamma] - c \leq \frac{3\underline{\gamma}}{2}$

# Equilibrium in Cournot with Privacy

- Demand: $x^* = \gamma - p$
- Market clearing: $p = \gamma - x_1 - x_2$
- Program: $\max_{x_i} E[\pi_i] = (E[\gamma] - x_1 - x_2 - c)\, x_i$
- Outputs: $x_1 = x_2 = \frac{E[\gamma]-c}{3}$
- Price: $p = \gamma - \frac{2}{3}(E[\gamma] - c)$

# Welfare in Cournot with Privacy

- Firms: $E[\pi_1 + \pi_2] = \frac{2}{9}\left(E[\gamma] - c\right)^2$
- Consumers: $CS = \frac{2}{9}\left(E[\gamma] - c\right)^2$
- Efficiency: $E[DWL] = \frac{1}{2}E[(\gamma - c)^2] - \frac{4}{9}\left(E[\gamma] - c\right)^2$
- All consumer types equally well off.

# Equilibrium in Cournot without Privacy

- Demand: $x^* = \gamma - p$
- Market clearing: $p = \gamma - x_1 - x_2$
- Program: $\max_{x_i} \pi_i = (\gamma - x_1 - x_2 - c)\, x_i$
- Outputs: $x_1 = x_2 = \frac{\gamma - c}{3}$
- Price: $p = c + \frac{\gamma - c}{3}$

# Welfare in Cournot without Privacy

- Firms: $E[\pi_1 + \pi_2] = \frac{2}{9}E[(\gamma - c)^2]$
- Consumers: $CS = \frac{2}{9}(\gamma - c)^2$
- Efficiency: $E[DWL] = \frac{1}{18}E[(\gamma - c)^2]$

# Privacy Comparison in Cournot

- $E[(\gamma - c)^2] \geq (E[\gamma] - c)^2$
- Expected profit is higher without privacy.
- Expected Consumer surplus is higher without privacy.
- Dead-Weight Loss is lower without privacy
- Types $\gamma < E[\gamma]$ prefer privacy.

# Summary

Effects of privacy

| | LCM | VDM | Cournot |
|---|---|---|---|
| $\pi_1 + \pi_2$ | higher | higher | lower |
| $CS$ | lower | lower | lower |
| $DWL$ | same | higher | higher |
| Prefers | none | $\theta > 3$ | $\gamma < E[\gamma]$ |