

# Data, Product Targeting and Competition

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# Motivation

- Data can improve product quality and enable price discrimination
  - ▶ e.g., Belleflamme et al. (2019), Montes et al. (2019), Hagiu and Wright (2020), de Cornière and Taylor (2023)
- Data can also be used to improve product targeting, i.e. customized offerings for a better match with consumer taste
- We analyze outcomes and mechanisms when data-driven product customization is added as a dimension of competition
- Connects to several strands and debates in digital regulation
  - ▶ access and use of data, and privacy
  - ▶ data sharing and data sales
  - ▶ uneven playing field for multi-product platforms

# Product Targeting

- Product targeting is relevant in many digital markets where search dominates and customization is easy
  - ▶ online retailers: display of targeted product lists
  - ▶ digital platforms: search results, matches
  - ▶ digital advertising: effective ads that neither intrude nor annoy
  - ▶ digital subscription services (Netflix, Spotify): personalized menus
  - ▶ social networks: content suggestions
  - ▶ financial services: payments data enable targeted loan offer / asset management services (EU Open Banking Directive PSD2)
- In many digital markets, there is value in knowing customer perfectly, but also in knowing limits (privacy, respect, ...)
- Product targeting may become more prominent with Generative AI:
  - ▶ e.g., AI may try to engage in personalized conversation

*"I have been daydreaming during a long flight from India about chatbots building profiles of people's tastes, then recommending and buying clothes or electronics."*

*Manish Chandra, CEO of Poshmark, cited by New York Times, March 2023*

# Set-up and Research Questions

- Products can be customized to fit individual customers
  - ▶ every customer is a market with an unknown location = maximal market segmentation
  - ▶ standard spatial models: known distribution of customers
  - ▶ firms customize products for every customer and compete in prices
- A competitive edge is driven by access to data (from many sources) and processing ability to predict best match (algorithm)
  - ▶ called “data capabilities” or “information quality”
- Main questions:
  - ▶ Impact of data capabilities on consumer surplus and welfare?
  - ▶ Consequences when data capabilities are heterogeneous?
  - ▶ How do firms strategically choose about data capabilities?
  - ▶ Consequences for regulation: Entry? Data sharing and data sales?  
Multi-product platforms?

# Preview of Results

- In a monopoly, more information improves targeting and welfare, but ambivalent effect on consumer welfare
- Competition positive for consumers, but welfare may decrease (targeting degraded)
- Prices and profits are **non-monotonic in information quality**
- More information only facilitates entry if entrant can **leap-frog**
- Competing firms choose their data capabilities so as to obtain **strong asymmetry in their information positions**
  - ▶ Regulation encouraging data sharing needs to account for entrants' need to leap-frog, and for resistance to level playing field
- **Information spillovers** between markets may further exacerbate the incumbent advantage of multi-platform (multi-product) firms
- Firm may **overinvest** in information quality

# Literature Review

- Data and competition
  - ▶ Gu, Madio and Reggiani (2019); Montes, Sand-Zantmann and Valetti (2019); Belleflamme, Lam and Vergote (2019); Taylor, Wagman (2014): assume fixed locations of competing firms, data do not affect the average desirability of products
  - ▶ we add choice of product specification
- Role of data for consumer experience and belief on consumer values
  - ▶ effect of data on product quality (Prüfer and Schottmüller, 2017; Hagiü and Wright, 2020) or production costs (Farboodi, Mihet, Philippon, Veldkamp, 2019)
  - ▶ data collection by platforms and user experience (Casadesus-Masanell and Hervas-Drane, 2015; Jullien, Lefouilli and Riordan, 2020)
  - ▶ pricing and structure of information by data brokers (Bergemann and Bonatti, 2019)
  - ▶ we add dimension of how data influences product location and competition
- Competition-in-utility framework on link between data and competition
  - ▶ De Cornière and Taylor (2023) focus on data as revenue shifter and are agnostic on precise mechanism for consumer
  - ▶ our specific modeling yields different predictions, e.g. non-monotonicities
- Economics of privacy
  - ▶ Varian (1997); Acquisti, Taylor, and Wagman (2016)
  - ▶ we contribute that consumer data influences surplus via match and competition
- Competition on attention
  - ▶ Bordalo et al. (2016); Anderson, DePalma (2012); de Clippel et al. (2014)
  - ▶ we add dimension of product targeting in this competition

# The Model

- Consumer wants to buy a single unit of good. Zero production cost
- Consumer has preference for product specification
  - ▶ preferences and product specifications are ordered on real line
  - ▶ consumer's preferred specification (location):  $\eta$ , drawn from a (degenerate) uniform distribution on  $(-\infty, +\infty)$ .
- Consumer values a good with product specification  $l$  at  $v - |\eta - l|$
- Incumbent firm  $I$ , possible entrant  $E$ ,  $i = I, E$
- Each firm receives a private, noisy signal  $x_i = \eta + \tilde{\epsilon}_i$ , about consumer's preference, where  $\tilde{\epsilon}_i$  is uniformly distributed on  $[-\epsilon_i, \epsilon_i]$
- $\epsilon_i$  measures (inverse of) information quality. W.l.o.g. assume  $\epsilon_I \leq \epsilon_E$
- After observing signal, firms choose simultaneously product specification (location)  $l_i$  and price  $p_i$
- Consumer observes products & prices, makes choice

# Benchmark: Monopoly

- Only firm  $I$  operates. Optimal location choice  $l_I = x_I$ .
- Optimal price reflects information:
  - ▶ when specification poor, consumer's WTP is low:  $I$  is likely to sell only if price is low
  - ▶ when signal allows precise specification, sale likely even at higher price
  - ▶ uncertainty of sale introduces price-sensitive demand
- When signal noise is low ( $\varepsilon_I \leq \frac{v}{2}$ ), set  $p_I$  just low enough to cover the market fully,  $p_I = v - \varepsilon_I$  ("market fully covered")
- Otherwise ( $\varepsilon_I > \frac{v}{2}$ ),  $I$  prefers "high" price  $p_I = \frac{v}{2}$  and not selling much of the time
- With perfect info,  $\varepsilon_I = 0$ :  $CS = 0$ ,  $\pi_I = TS = v$

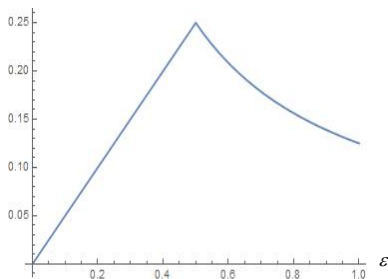
# Monopoly: Consumer Surplus and Profits

- Consumer surplus when incumbent's information quality varies:

- CS **non-monotonic**:

- ▶ increasing in  $\varepsilon_I$  while market covered
- ▶ decreasing beyond
- ⇒ consumer prefers intermediate info level (opt.  $\varepsilon_I = \frac{v}{2}$ )

Plot of consumer surplus;  $v = 1$ .



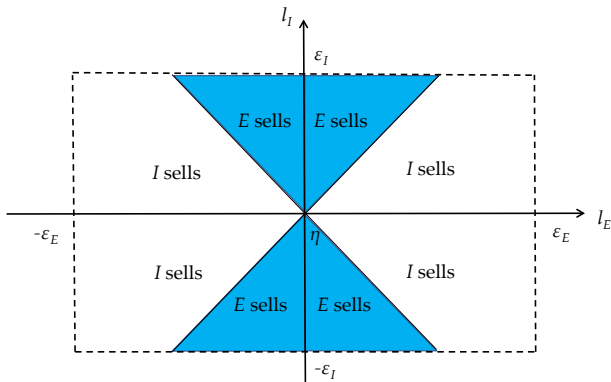
- Profit  $\pi_I$  and total surplus  $TS = CS + \pi_I$  increase in info quality

# Competition: Duopoly

- Each firm locates at its signal, i.e.,  $l_I = x_I$  and  $l_E = x_E$
- Consumer buys from firm  $i$  if she prefers  $i$ 's offer over  $j$ 's:  
 $v - p_i - |e_i| \geq v - p_j - |e_j|$ , and she prefers it over not buying at all:  
 $v - p_i - |e_i| \geq 0$
- Who sells? Depends on realized noise in  $I$ 's and  $E$ 's signals
- Sale by  $i$  more likely when  $i$  sets lower price and  $j$  a higher price.

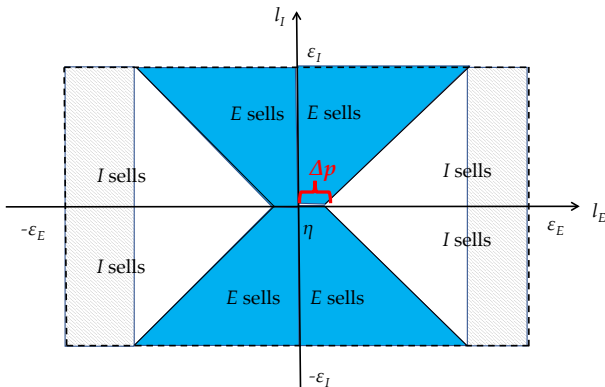
# Price and Location: A Graphical Illustration

- Let  $\Delta p = p_I - p_E = 0$ 
  - ▶  $I$  sells with higher probability as info quality higher



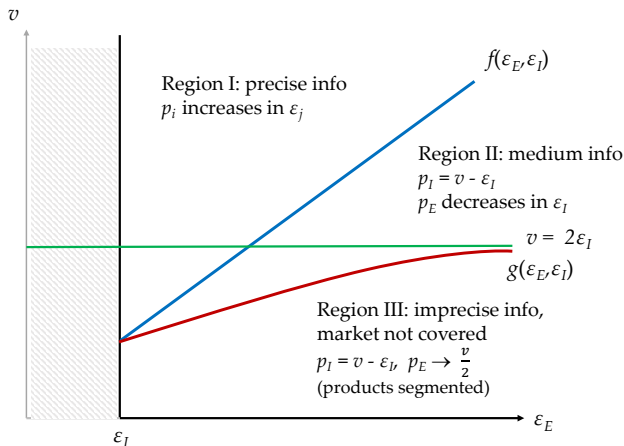
# Price Differentiation: A Graphical Illustration

- Let  $\Delta p = p_I - p_E > 0$ 
  - ▶  $E$  reduces price: increases market share & reduces capture
  - ▶ in equilibrium:  $p_I > p_E$



# Equilibrium with Duopoly

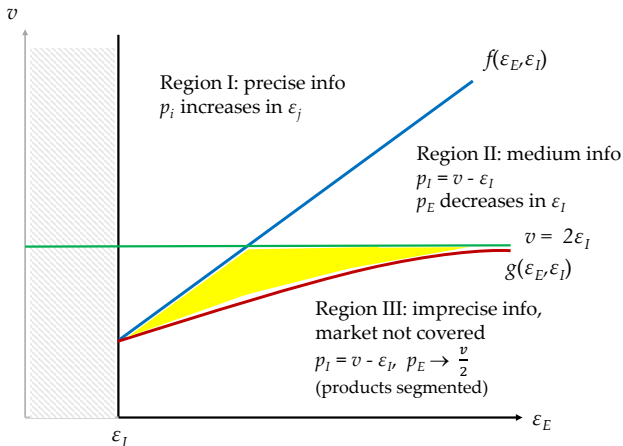
- Market covered in regions I and II, more often compared to monopoly
- If  $\varepsilon_E$  close to  $\varepsilon_I$ : market covered for wider range of values (Region II)



$$f(\varepsilon_E, \varepsilon_I) = \varepsilon_E + \frac{7}{4}\varepsilon_I - \sqrt{\left(\varepsilon_E - \frac{1}{4}\varepsilon_I\right)^2 + \varepsilon_I^2}, \quad g(\varepsilon_E, \varepsilon_I) = \frac{2}{3}\varepsilon_E + \frac{5}{6}\varepsilon_I$$

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# Duopoly and Welfare

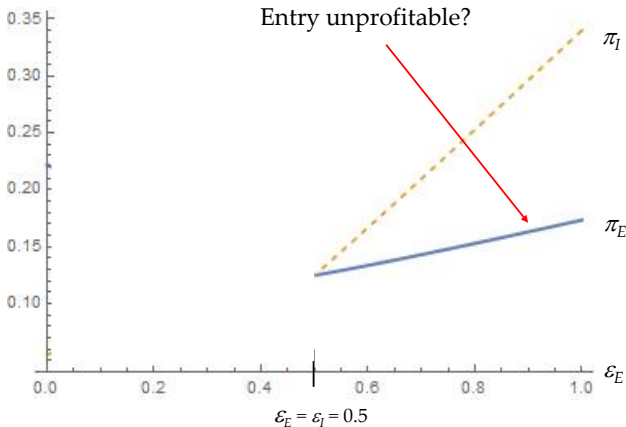
- Consumer surplus higher with two competing firms
  - ▶ price competition
  - ▶ improved product targeting on average (choice between two offers)
- Total surplus can be higher or lower in duopoly
- (+) Price competition improves market coverage
  - ▶ TS always higher when market covered in duopoly but not monopoly
- (+) Two firms each with own information offer better targeted product on average
- (—) Inefficient allocation: when  $\varepsilon_E > \varepsilon_I$  then  $p_E < p_I$  and consumer sometimes buys less preferred variety

## Competition: Effect of Information Quality

- Suppose entrant's information improves ( $\varepsilon_E \uparrow$ )
- Incumbent  $I$  competes more aggressively:  $p_I \downarrow$
- Prices are strategic complements  $\Rightarrow$  firm  $E$  also lowers price:  $p_E \downarrow$
- Better information makes market *more* competitive
  - ▶ unambiguously good for consumer surplus
  - ▶ better targeted products at lower prices
  
- Suppose incumbent's information improves ( $\varepsilon_I \uparrow$ )
- Entrant  $E$  competes more aggressively:  $p_E \downarrow$
- Information differential  $\uparrow$ : incumbent  $I$  with stronger market power, price  $p_I \uparrow$
- Better information makes market *less* competitive
  - ▶ consumer surplus is U-shaped: it decreases for low  $\varepsilon_I$  (region II) but increases for high  $\varepsilon_I$  (region I)
  - ▶ intuition: when signals relatively close (region II), price increases much stronger

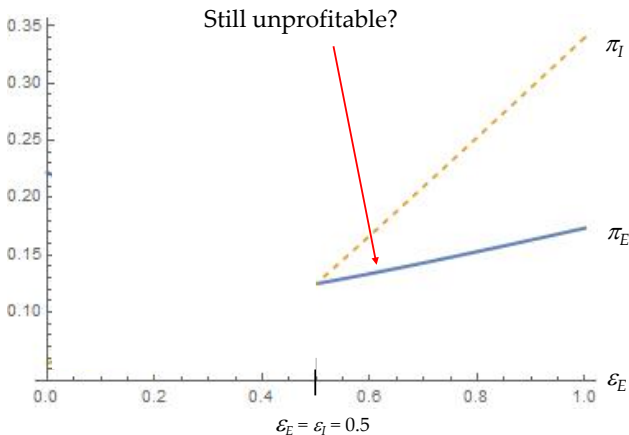
# Entry and Leap-Frogging

- Suppose we facilitate entry in monopolistic market via data access for entrant (e.g., data sharing)
- There is an entry cost  $F_E > 0$ . Can policy trigger entry?



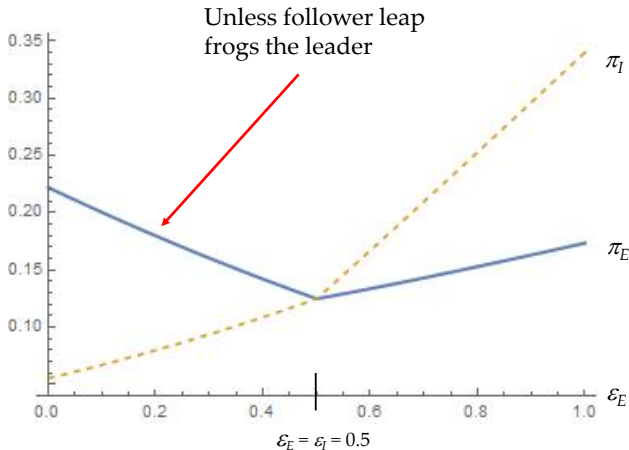
# Entry and Leap-Frogging

- A more accommodating data access policy?



# Entry and Leap-Frogging

- Data access policy can only succeed if it enables leap-frogging
- *Leap-frogging*: entrant overtakes incumbent in information quality



# Choice of Information Quality

- Suppose firms can freely choose information qualities  $\varepsilon_i$  at no cost
- First stage: firms decide sequentially on  $\varepsilon_i$  ( $I =$  Stackelberg leader).  
Second stage: firms choose simultaneously locations and prices
- Benchmark: monopolist would choose  $\varepsilon_I = 0$ , with monopoly price and profit of  $p_M = \pi_M = v$
- Unique duopoly equilibrium:
  - ▶  $I$  chooses  $\varepsilon_I = 0$ ,  $E$  chooses  $\varepsilon_E = \frac{3}{2}v$
  - ▶ Prices  $p_I = v$  and  $p_E = \frac{v}{2}$ .  $I$  makes sale with prob.  $\frac{2}{3}$ ,  $E$  with prob.  $\frac{1}{3}$
  - ▶  $I$  earns  $\pi_I = \frac{2}{3}v$ ,  $E$  earns  $\pi_E = \frac{1}{6}v$
  - ▶ Consumer Surplus  $CS_D = \frac{1}{12}v > CS_M$ . Welfare  $TS_D = \frac{11}{12}v < TS_M$
- Intuition:  $E$  opts for strongly asymmetric position to ease competition
  - ▶ picks price of (uninformed) monopolist:  $p_E = v/2$
  - ▶  $E$  stops raising  $\varepsilon_E$  at point where it no longer allows to higher raise  $p_E$
  - ▶ further decrease in info quality then only deteriorates  $E$ 's market share

# Choice of Information Quality

- Equilibrium reveals tendency to **strong information differentiation**
  - ▶ insight important for regulators and market participants
- When improving information and entry are cheap, entry will always occur and **welfare will always deteriorate**
- Extension to costly info improvement, with  $c(\varepsilon_i) > 0$ , convex:
  - ▶ structure of equilibrium generalizes to this case
  - ▶ incumbent  $I$  chooses  $\varepsilon_I > 0$  when cost  $c(\varepsilon_i) > 0$  large enough
  - ▶ entrant  $E$  responds with higher  $\varepsilon_E$ , so information differential is reduced

# Data Sharing

- Data sharing = regulatory policies giving entrants access to the information available to incumbent (or voluntary initiatives)
- Two insights from our analysis:
  - 1 Entry and leap-frogging: challenge for regulators
    - ★ reducing informational hurdles does not automatically facilitate entry
    - ★ regulator would need to enable leap-frogging ( $\Rightarrow$  big challenge). Small improvement will only deteriorate prospect for entry
  - 2 Choice of information quality: highlights tendency to strong info differentiation in equilibrium
    - ★ regulator's forcing of data access may not lead to intended effect
    - ★ risk of perverse effect: entrant could exploit data partially for entry strategy as a fringe supplier, with negative welfare effect

# Data Brokers

- 3rd party brokers' packaging and selling of data
- Assume broker offers data that reduce signal noise by factor  $\delta < 1$ , from  $\varepsilon_i$  to  $\delta\varepsilon_i$  (for either firm)
- *Result*: Exclusive data sale, incumbent always outbids entrant
- Exclusivity of sale bad for consumer, but optimal for data broker
- Intuition:
  - ▶ WTP of firm  $i$  depends on  $i$ 's own value of the data *and* value of denying access to the competitor
  - ▶ industry profits  $\downarrow$  when allocation of data becomes more homogeneous (if  $E$  acquires data) [Detail](#)
  - ▶  $I$  prices value differential of keeping monopoly.  $I$ 's WTP always higher than  $E$ 's, even  $E$  could leap-frog

# Entry Deterrence and Overinvestment

- Finally, consider strategic entry deterrence through information quality
- Potential entrant  $E$  faces entry cost  $F_E > 0$ , but entry is in principle profitable:  $\pi_E - F_E > 0$ .
- Consider investment in information quality by incumbent  $I$ :
  - ▶ consider costly investment in info quality,  $c(\varepsilon_I) > 0$
  - ▶  $I$  wants
- We find that there are values where  $I$  will overinvest to thwart entry,  
 $\hat{\varepsilon}_I < \varepsilon_{I,M}^*$
- where  $\varepsilon_{I,M}^*$  = optimal choice of uncontested incumbent
- Argument also applies to predatory strategies to induce exit

# Cross-Market Information Spillovers

- Big Tech as potential entrants in new services, e.g. financial services
- May be able to use information acquired in existing market to predict consumer preferences in new market (information spillover)
- Modifications to set-up:
  - ▶ Consider two markets  $j = a, b$ , with consumer valuations  $v_a$  and  $v_b$
  - ▶  $E$ 's home market is  $a$  and  $b$  its new (foreign) market;  $I$ 's home market is  $b$  and  $a$  its foreign market
  - ▶ Each firm observes  $\varepsilon_i$  in home market but not foreign market, but can acquire signal  $\hat{x}_{E,b}$  and  $\hat{x}_{I,a}$  about foreign market, at cost  $c_{E,b}$  and  $c_{I,a}$
  - ▶ Info spillover: consumer has identical preference  $\eta$  in both markets
  - ▶ firm  $I$ 's observation of  $\tilde{x}_{I,a} = \eta + \tilde{e}_{I,a}$ : additional signal on  $\eta$
  - ▶ Each firm retains an info advantage in home market: quality of additional signal less precise than signal from firm's home market Detail

# Cross-Market Information Spillovers

- We focus on  $I$ . In market  $b$ ,  $I$  remains a monopolist but now has two signals
- 2nd signal  $\tilde{x}_{I,a}$  only affects  $I$ 's price setting and product targeting decisions if it allows to rule out range of values of  $\eta$  [Details](#)
- Strategic learning via entry in new market  $a$ :
  - ▶ When  $I$ 's info in home market is weak, then additional signal in foreign market confers a stronger info improvement
  - ▶  $I$  willing to enter  $a$  even if info cost  $c_{I,a}$  exceeds its profit in  $a$
  - ▶ Reason: entry increases  $I$ 's profits in home market  $b$  via info spillover
- *Result*: firm  $I$  benefits from info spillover.
- Consumer surplus: consumer in  $I$ 's foreign market  $a$  better off when firm  $I$  enters, but consumer in home market  $b$  is worse off
- Total consumer surplus? Ambiguous, depends on sensitivity of price on both markets. Likely negative if  $v_a$  low.

Extension

# Conclusion

- Model of data-driven competition in product specification and price
- Better information quality
  - ▶ leads to hump-shaped consumer surplus in monopoly
  - ▶ increases consumer surplus in duopoly, but may reduce welfare
- Better information quality for
  - ▶ information follower makes market *more* competitive
  - ▶ information leader makes market *less* competitive
- Access to data facilitates entry only when entrant able to leap-frog
  - ▶ Entry deterrence may lead to overinvestment in information
- Firms prefer strong information asymmetry to ease competition
  - ▶ Data sharing policy needs to account for this preference
  - ▶ Data brokers will only increase advantage of information leader
- Multi-product platforms: cross-market spillovers may trigger excess entry in new market and harm consumers in current market