Data and Competition

A Simple Framework

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Roadmap

Introduction and motivating example

Competitive effects of data

Applications

Data-driven mergers

Introduction

Data is at the centre of the ongoing digital revolution.

- Much rhetoric about danger to competition.

Among concerns/questions:

- Exploitative behaviour: lack of privacy, (price-)discrimination.
- Data as barrier to entry / market tipping.
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In short: (when) is data a pro- or anti-competitive force?

- Many types of data, uses of data, and business models.

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- Two effects: quality effect and price effect.

We can answer this question by solving the firm's problem.

- But solution will be specific to this use of data/business model.
- Instead, let's look at another approach...

Motivating example, an alternative approach

Notice that

$$u = v(\delta) - p$$

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Plan:

1. study the effects of δ in this setup (depend on shape of r).
2. study how different types and uses of data influence the shape of r.

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- Profit:

$$r(u_i, \delta_i) D_i(u_i, \mathbf{u}_{-i}) - C(u_i)$$

Competitive effect of data

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Is data pro- or anti-competitive?

- Comparative statics exercise: how does increase in δ_i change i's choice of u_i?
- Firm i's best-response shifts up $\iff \frac{\partial^2 \pi_i}{\partial u_i \partial \delta_i} > 0$.

Competitive effect of data

$$\frac{\partial^2 \pi_i}{\partial u_i \partial \delta_i} > 0 \iff \frac{\partial r}{\partial \delta_i}\frac{\partial D_i}{\partial u_i} + \frac{\partial^2 r}{\partial u_i \partial \delta_i} D_i > 0$$

We say data is *unilaterally pro-competitive* (UPC) if this condition is satisfied.

Data is *unilaterally anticompetitive* (UAC) if the inequality is reversed.

Competitive effect of data

$$\frac{\partial r}{\partial \delta_i}\frac{\partial D_i}{\partial u_i} + \frac{\partial^2 r}{\partial u_i \partial \delta_i} D_i > 0$$

Interpretation, part 1: mark-up effect

- $\frac{\partial r_i}{\partial \delta_i}\frac{\partial D_i}{\partial u_i} > 0.$
- Data makes marginal consumer more valuable.
- $\implies$ Provides extra incentive to compete.

Competitive effect of data

$$\frac{\partial r}{\partial \delta_i}\frac{\partial D_i}{\partial u_i} + \frac{\partial^2 r}{\partial u_i \partial \delta_i} D_i > 0$$

Interpretation, part 2: surplus-extraction effect

- Sign of $\frac{\partial^2 r_i}{\partial u_i \partial \delta_i}$ is not *a priori* obvious.
- Reflects how data changes the opportunity cost of providing utility.
- E.g., more data $\implies$ better ad targeting $\implies$ more costly to reduce ad load.

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Observation: if $\frac{\partial^2 r_i}{\partial u_i \partial \delta_i} \geq 0$ then data is UPC (sufficient condition).

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UPC condition:

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Combining these two expressions eliminates the terms involving D and yields a new UPC condition:

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Combining these two expressions eliminates the terms involving D and yields a new UPC condition:

$$-\frac{\partial r}{\partial u_i} \frac{\partial r}{\partial \delta_i} + \frac{\partial^2 r}{\partial u_i \partial \delta_i} r > 0 \iff \frac{\partial^2 \ln[r(u_i, \delta_i)]}{\partial u_i \partial \delta_i} > 0$$

(a necessary and sufficient condition).

Competitive effects of data

Sufficient condition

Data is UPC if r is supermodular.

Necessary and sufficient condition ($C'(u_i) = 0$)

Data is UPC if and only if r is log-supermodular.

In many cases ($C'(u_i) = 0$, or $\frac{\partial^2 r_i}{\partial u_i \partial \delta_i} \geq 0$), no information about D required to check whether data is pro or anti-competitive.

- What matters is the technology by which revenue is extracted from data, summarised by r.

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Equilibrium: symmetric environment

If we assume firms are symmetric (including $\delta_i = \delta_{-i}$), these unilateral results extend to equilibrium.

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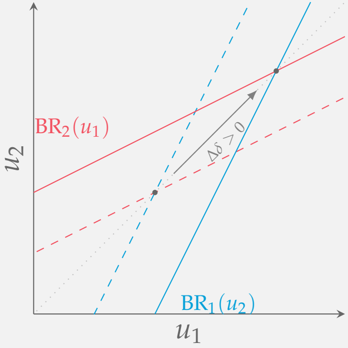
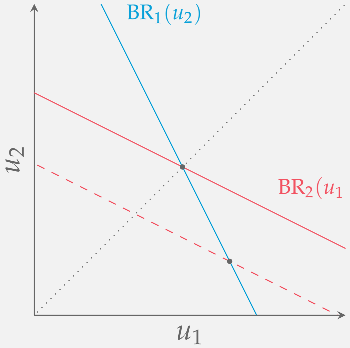


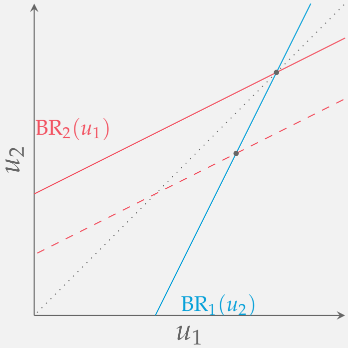
When $\delta_i \equiv \delta$, data increases equilibrium utility offers if and only if it is UPC.

Equilibrium with asymmetries

If firms are asymmetric, then

1. effect for focal firm given by UPC/UAC,
2. effect for its rivals determined by strategic complementarity/substitutability.





Equilibrium and congruence/conflict

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$$0 < \frac{\partial^2 \pi_i}{\partial u_i \partial u_j} = r(u_i)\frac{\partial^2 D(u_i, \mathbf{u}_{-i})}{\partial u_i \partial u_j} + \frac{\partial r(u_i)}{\partial u_i}\frac{\partial D(u_i, \mathbf{u}_{-i})}{\partial u_j}.$$

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Useful result in Hotelling duopoly: $D(u_i, u_{-i}) = \frac{t+u_i-u_J}{2t} \implies \frac{\partial^2 D(u_i, \mathbf{u}_{-i})}{\partial u_i \partial u_j} = 0.$

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- u_1 & u_2 are strategic complements iff $r'(u_i) < 0$ (*conflict*).

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If δ_i increases:

	Data	
Payoffs	UAC	UPC
Conflicting	$\downarrow u_i^*, \downarrow u_j^*$	$\uparrow u_i^*, \uparrow u_j^*$
Congruent	$\downarrow u_i^*, \uparrow u_j^*$	$\uparrow u_i^*, \downarrow u_j^*$

Taking stock

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Now let's look at some applications:

- Product improvement.
- Targeted advertising.
- Price-discrimination.
- Contract design.

Roadmap

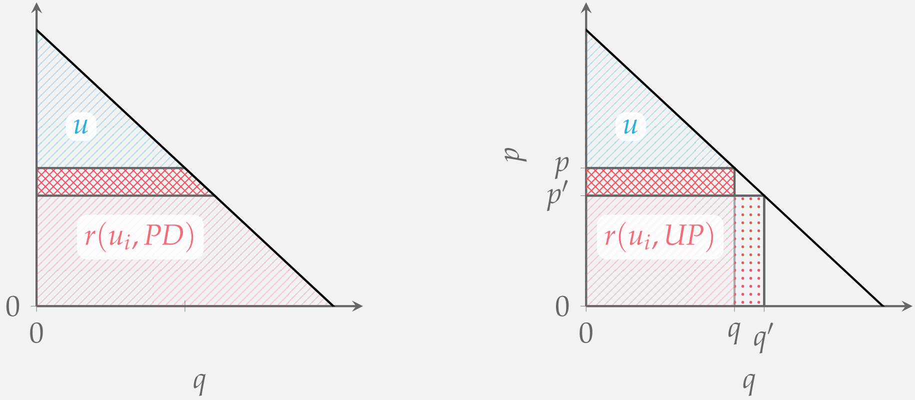
Product improvement

- In the motivating example we had $r(u,\delta) = v(\delta) - u$.
- It is immediate that $\frac{\partial^2 r}{\partial u \partial \delta} = 0 \implies$ data is UPC.
- This is an example where the surplus extraction effect is inactive because the firm can extract surplus efficiently through the price for any δ.

Price-discrimination

Multi-product firms, one-stop shoppers.

- Uniform list price, plus personalised discount for δ products.



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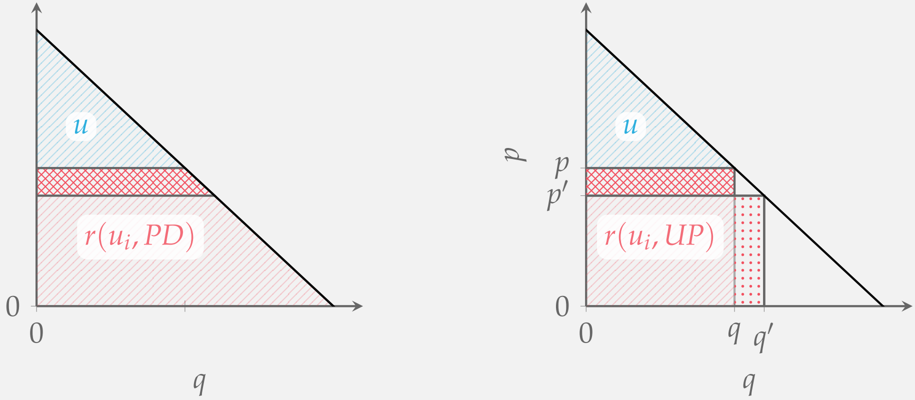

Surplus extraction effect is negative: we use the log supermodularity condition to show data is UAC in this kind of environment.

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- Firm's revenue:

$$r(u, \delta) = \max_{\mathcal{C}} \{p - (1-\alpha)(\delta X_+ + (1-\delta)X_-)\}$$

$$\text{s.t.} \quad U(\mathcal{C}, 1) = u \quad \text{and} \quad U(\mathcal{C}, 1) \geq U(\mathcal{C}, 0).$$

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$$\text{s.t.} \quad U(\mathcal{C},1) = u \quad \text{and} \quad U(\mathcal{C},1) \geq U(\mathcal{C},0).$$

- Can show that for CARA preferences, r is supermodular (surplus extraction effect is positive).
  - Data is UPC because it *reduces* the opportunity cost of utility.

Targeted advertising 1

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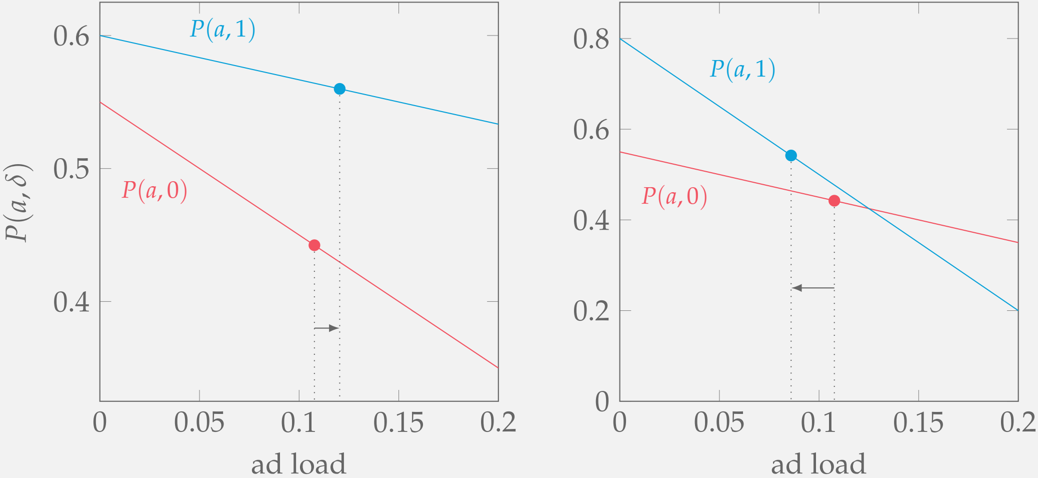
- $r(u, \delta) = a(u)P(a(u), \delta)$.
- Effects depend on the ad technology (i.e., how targeting affects P).
- Using the log-supermodularity condition, data is UPC if and only if it makes P more elastic.

Targeted advertising 2

Data can be informative about a category (left) or a brand's (right) match with a consumer.



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Data-driven mergers

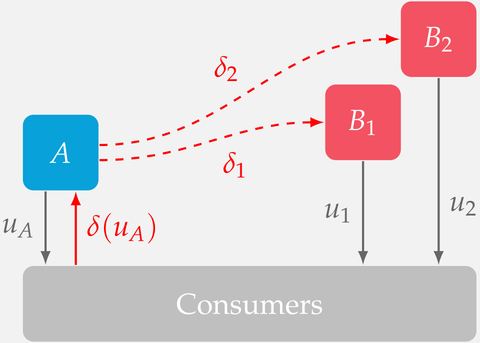
Several recent high-profile mergers:

- Facebook/Instagram/WhatsApp
- Microsoft/LinkedIn
- Google/Fitbit

Features

- Data obtained as by-product of activity in one market (IG, WA,LI)
- Used in other market (FB: targeted ads, Msft: personalized CRM software)

Data-connected markets



Data-driven mergers

In a companion paper (de Cornière and Taylor, forthcoming ManSci), we use our framework to study such mergers.

- UAC/UPC condition tells us the effect of data in market B.
- Merger also affects A's incentives to gather data, implying welfare effects in both markets.

Data-driven merger, no trade

Suppose that data trade is NOT possible absent merger.

- After merger, A internalises the value of data for $B1$: $\frac{\partial \pi_A(\delta)}{\partial \delta} + \frac{\partial \pi_{B1}(\delta,0)}{\partial \delta_1} = 0$.
- A thus collects more data: u_A must go up.
- Effect of merger in market B is positive if data is UPC, negative if UAC.

Data-driven merger, trade

Merger

- Marginal incentive to collect data: $\frac{\partial \pi_A(\delta)}{\partial \delta} + \frac{\partial \pi_{B1}(\delta,0)}{\partial \delta_1}$

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- Marginal incentive to collect data: $\frac{\partial \pi_A(\delta)}{\partial \delta} + \frac{\partial \pi_{B1}(\delta,0)}{\partial \delta_1} - \frac{\partial \pi_{B1}(0,\delta)}{\partial \delta_2}$

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- Marginal incentive to collect data: $\frac{\partial \pi_A(\delta)}{\partial \delta} + \frac{\partial \pi_{B1}(\delta,0)}{\partial \delta_1} - \frac{\partial \pi_{B1}(0,\delta)}{\partial \delta_2}$
- If data is UPC then $\frac{\partial \pi_{B1}(0,\delta)}{\partial \delta_2} < 0$.
  - Stronger incentive to collect data without merger.
  - The opposite if data is UAC.

Summary effects of the merger

	data is UPC	data is UAC
Pre-merger data trade	$\downarrow u_A, \downarrow u_B$	$\uparrow u_A, \downarrow u_B$
No pre-merger data trade	$\uparrow u_A, \uparrow u_B$	$\uparrow u_A, \downarrow u_B$

Conclusion

- Data is at the centre of a fierce policy debate in tech.
- But competitive implications are ambiguous.
- We show that these can be understood through a simple condition, often without knowing about demand.
- Applications to various markets.
- These insights can also inform our understanding of merger policy and market structure.

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Link to paper:
`https://drive.google.com/open?id=1p0mZDc5sEKa_Iz3tzA_wQJhiRK2zc5Pv`

Link to data-drive mergers companion paper:
`https://drive.google.com/file/d/1DqqtKiH8Vw-a7NGnaA-qH3SSix3JAkBt`