Competitive Markets for Personal Data

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Motivation

Consumers supply a crucial input for modern economy: their **personal data**

Yet, they often have **limited control** over how and by whom their data is used:

- This may lead to inefficiencies and inequality

New legislation gives consumers more control over their data

- Lays foundations upon which **data markets** could emerge

What properties would these markets have, and how should they be designed to promote desirable outcomes?

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- If full disclosure $\Rightarrow$ No Externalities $\Rightarrow$ Efficiency
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2. Propose three solutions to this market failure:

- Data unions; Data taxes; "Lindahl" pricing for the data

model

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Two periods: 1. Data markets are open 2. Product market is open

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The supply side:

- If a type-ω consumer sells her record to the platform, she is paid $p(\omega)$ and is later intermediated with merchant
- If she doesn't, she enjoys her outside option $r \sim F_\omega$

Period 2: Product Market

Given acquired database q, platform acts as **information designer**

- It sends signal to merchant about each consumer in its database
- Given signal, the merchant chooses an action $a \in A$ (finite)
- Together, a and ω determine period-2 payoffs:

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$$V(q) = \max_{x:\Omega \to \Delta(A)} \sum_{\omega, a} v(a, \omega) x(a|\omega) q(\omega)$$

$$\text{s.t. } \forall a, a': \; \sum_{\omega} \Big(\pi(a, \omega) - \pi(a', \omega) \Big) x(a|\omega) q(\omega) \geq 0$$

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(d). Data markets clear, i.e. $\quad q^*(\omega) = \bar{q}(\omega) F_{\omega}(r^*(\omega)) \qquad \forall \omega$

discussion

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Results extend to large class of **information-intermediation problems**:

- Multiple agents (e.g., competing merchants)
- Arbitrary downstream (finite) games (e.g., a second-price auctions, hotelling)
- More than information design (e.g., platform takes a enforceable action)

Leading applications: Online marketplaces and advertisement auctions

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Substantive assumptions we made:

- The data market is competitive
- Platform is a "gate keeper" — alt see BB '23
- A data record combines "access" and information — alt see ALV '22

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For this talk only: I'll focus on differentiable $V(q)$ and x_q

efficiency

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To illustrate inefficiency, less-demanding benchmark more desirable

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A high-level intuition:

- If type-ω consumer sells her record, she affects $q(\omega)$, which may change x_q, which affects other consumers' payoffs

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To formalize this intuition, let's compare:

– How records are allocated in equilibrium

– How records are allocated by social planner

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(Poor) Intuition. Exact mixture depends on q

Work in progress: "Only if" direction also holds under some additional conditions

an application

Mediated Price Discrimination

So far, minimal assumptions on the intermediation problem

Let's specialize setting to canonical application: Price discrimination *à la* BBM

Mediated Price Discrimination

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- Let $\omega \in \mathbb{R}_{++}$ be the consumer's WTP for merchant's product
- Let a denote price the merchant sets for his product
- Players payoffs are

$$\begin{aligned} &\text{Consumer's:} && u(a,\omega) = \max\{\omega - a, 0\} \\ &\text{Merchant's:} && \pi(a,\omega) = a\, \mathbb{1}(\omega \geq a) \\ &\text{Platform's:} && v(a,\omega) = \gamma_u\, u(a,\omega) + \gamma_\pi\, \pi(a,\omega) \end{aligned}$$

Equilibrium Characterization

$$v(a, \omega) = \gamma_u \, u(a, \omega) + \gamma_\pi \, \pi(a, \omega)$$

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Fix any equilibrium.

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That is, any "non-trivial" use of information by the platform will lead to inefficiencies

Intuition for Efficiency

If $\gamma_u < \gamma_\pi$

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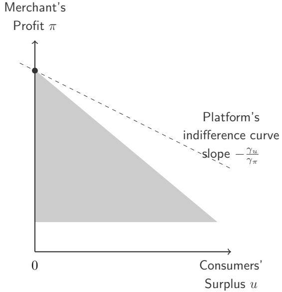

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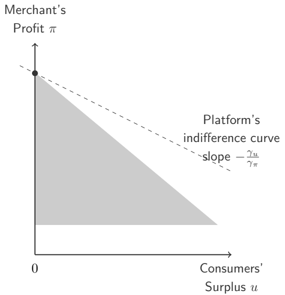

- At all q, **full disclosure** is optimal
- Merchant extracts surplus from all consumers

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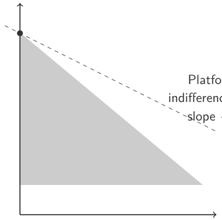

- At all q, **full disclosure** is optimal
- Merchant extracts surplus from all consumers
- Therefore, $x^*(a, \omega)$ does not depend on q
- Therefore, no externality! All equilibria are constrained efficient

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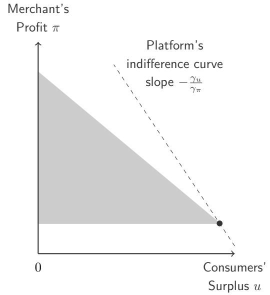

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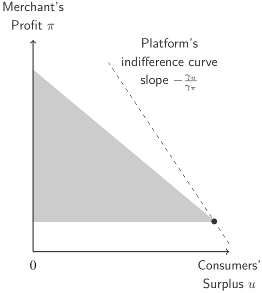

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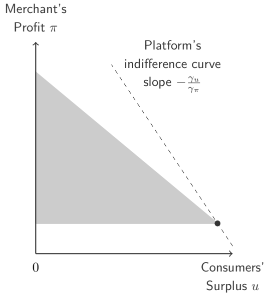

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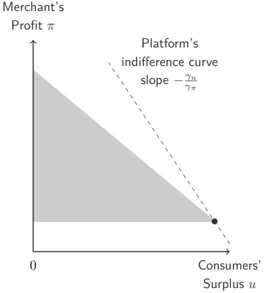

– Platform **withholds information** from merchant

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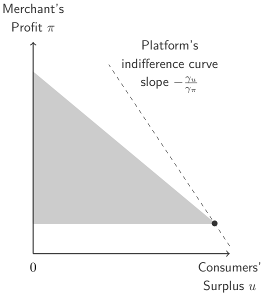

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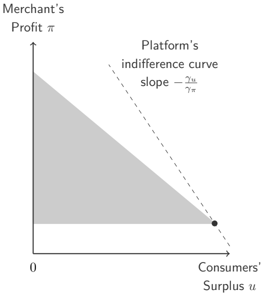

- Platform **withholds information** from merchant
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- Thus, x_q depends on q
- Thus, $\sum_{\omega'} q(\omega') \frac{\partial U(\omega', x^*)}{\partial q^*(\omega)}$ can be non-zero: data externality

Bigger Picture

Application highlights when there is **no conflict of interest** btw platform and merchant $\Rightarrow$ full disclosure is optimal $\Rightarrow$ data market is efficient

Special case: if platform is the merchant $\quad\Rightarrow\quad$ no intermediation

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Thus the source of the inefficiency is the role platforms play as **information intermediaries**

- Platforms typically balance conflicting interests, which they rarely resolve with full disclosure — otw, no info-design literature! :)
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This paper shows how this practice can lead to a failure of the first-welfare theorem in a competitive data market

example

A Simple Example to Illustrate

Suppose:

- $\gamma_u > \gamma_\pi = 0$, i.e. platform only cares about consumers' surplus
- Only two types of consumers: $\Omega = \{1, 2\}$ with $\bar{q}(1) < \bar{q}(2)$
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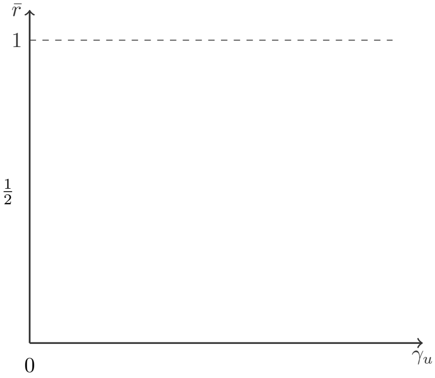
- Market unravels $\rightsquigarrow$ No trade $\rightsquigarrow$ Inefficiency

Example

Complete equilibrium characterization for this example:



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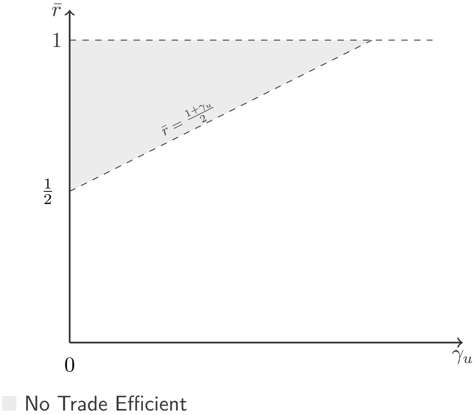

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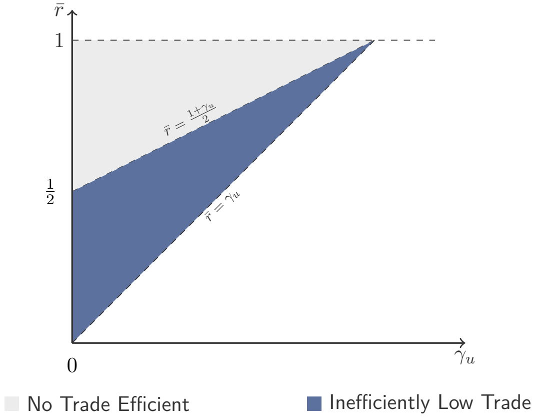

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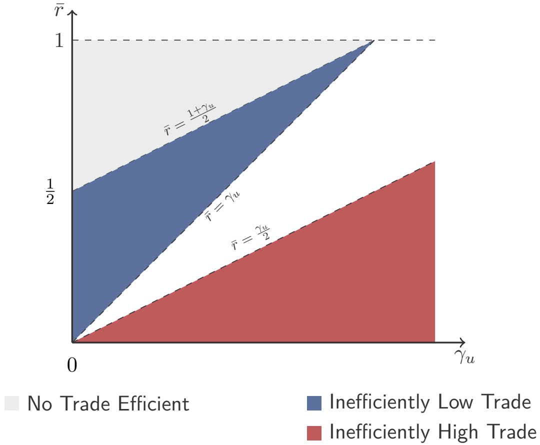

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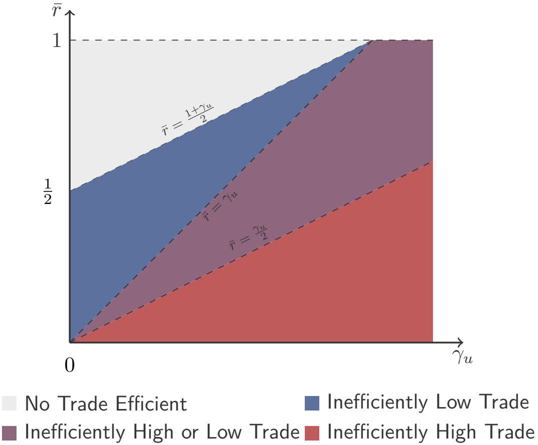

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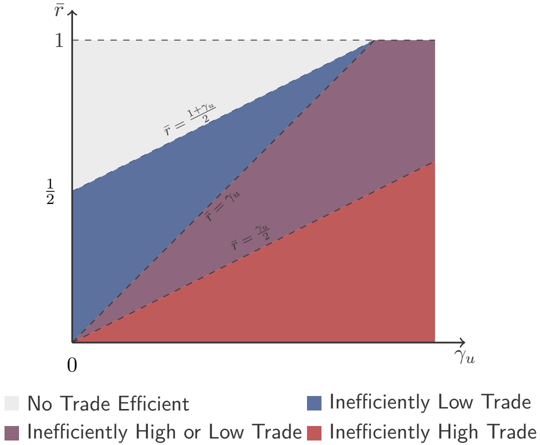

remedies

Remedies

How to fix this market failure?

We explore three alternative market designs:

1. Introducing a **data union**
2. Implementing **data taxes**
3. Making data markets more **complete**

data union

Data Unions

Recent policy proposals for the data economy (Posner-Weyl 18; Bergemann et al 23)

A data union would represent consumers by managing data on their behalf

We offer some theoretical support to these policy proposals

Data Union

How does a data union work?

- Consumers can participate in the union
- If they do, they relinquish their data to the union
- Union sells some of this data to the platform

  Consumers retain reservation utility unless record is sold to platform

- With the proceeds of sale, union compensates all participating consumers (to incentivize their participation)
- Union maximizes welfare of participating consumers

Data Union

Formally, the data union problem is:

$$
\begin{aligned}
\max_{(p,q,x)} \quad & \sum_{\omega} p(\omega)\bar{q}(\omega) + \sum_{a,\omega} u(a,\omega)x(a|\omega)q(\omega) + \sum_{\omega}(\bar{q}(\omega) - q(\omega))\bar{r} \\
\text{such that} \quad & q \leq \bar{q}, \\
\text{and} \quad & \textstyle\sum_{\omega} p(\omega)\bar{q}(\omega) = V(q), \\
\text{and} \quad & x \text{ solves } \mathcal{P}_q, \\
\text{and} \quad & p(\omega) + \tfrac{q(\omega)}{\bar{q}(\omega)} \textstyle\sum_{a} u(a,\omega)x(a|\omega) + \left(1 - \tfrac{q(\omega)}{\bar{q}(\omega)}\right)\bar{r} \geq \bar{r}.
\end{aligned}
$$

Data Union

Proposition

Equilibria of the data-union economy are constrained efficient and maximize consumers' welfare (and vice versa), regardless of the platform's objective

Some intuition:

Data union coordinates consumers by deciding which records to sell and how to compensate them

By doing so, data union acts as a substitute for the competitive market and avoids market failure

data taxes

Data Taxes

Enrich competitive economy by introducing a simple **data tax**:

- When selling her record, consumer pays tax $\tau(\omega) \in \mathbb{R}$ to the govt

When properly designed, data taxes force consumers to internalize effects that selling their records create on economy

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Proposition

Let (q°, x°) be a constrained-efficient allocation. There exists a profile of taxes τ^*, of prices p^*, and of consumer choices ζ^*, such that $(p^*, \zeta^*, q^\circ, x^\circ)$ is an equilibrium of the economy with taxation τ^* and the government does not run a deficit.

Sketch of the Proof

Let allocation (q°, x°) be constrained efficient

Let p^* be a supergradient of $V(q^\circ)$

Define $\boxed{\tau^*(\omega) \triangleq p^*(\omega) + \sum_a x^\circ(a|\omega) u(a,\omega) - \bar{r}}$

Notice that $U^*(\omega) - \tau^*(\omega) \equiv \bar{r}$

Therefore, all consumers indifferent $\rightsquigarrow$ choose ζ^* to implement q° $\square$

more-complete markets

Lindahl Economy

We let price of data depend not only on its type (i.e., ω) but also on its "intended use" (i.e., a)

> Platform and the consumer trade on **how** record will be used—i.e., which fee a platform will recommend to the merchant

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This is reminiscent of GDPR: "*The **specific purposes** for which personal data are used should be determined at the time of the collection*"

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A market for each (a, ω), where ω-records can be traded for use a at price $p(a, \omega)$

Our equilibrium definition extends naturally to this richer economy

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Proposition

Equilibria of this economy are (unconstrained) efficient and maximize consumers' welfare, regardless of platform's incentives

conclusion

Summary

1. A framework to study competitive markets for personal data

2. Identify novel inefficiency leading this otherwise perfectly competitive market to fail

   Show how inefficiency critically depends on platform's role as an information intermediary

3. Propose three alternative market designs that fix inefficiency: data unions, data taxes, richer data prices

Thank You!

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The Merchant of Venice, Gilbert (1873)

Efficiency Benchmark

To illustrate market failure, a less demanding efficiency benchmark is desirable:

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Bonus: In eqm, platform makes not profits. Thus, $W(q^*, x^*)$ equals consumer welfare. Thus, any constrained-efficient eqm maximizes consumer welfare

back