Competitive Markets for Personal Data

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Motivation

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

Yet, they often have **limited control** over who uses it and are **imperfectly compensated** in return

- Expropriation and barter, common practice in the industry (FTC '15)

This status quo may be source of market failures (Seim et al. '22)

Could a competitive market for data avoid these problems?

This Paper

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- Consumers own their data and can sell it to a platform
- Platform uses this data to interact consumers with a merchant

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Main Result.

- **Inefficiency**, despite competitive economy and property rights
- Inefficiency stems from an **externality** consumers exert on each other, enabled by how platform uses their data — Galperti, Levkun, Perego (2023)

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Solutions. Three alternative market designs to avoid inefficiency:

- Introducing **data taxes** on consumers
- Introducing a **data union**
- Making data markets **more complete**

Literature

This paper contributes to a growing literature on data markets

Bergemann, Bonatti 19

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This paper.

- Emphasizes a novel source of inefficiency Galperti et al. '23
- Explores novel designs for data markets

model

A Simple Data Economy

One merchant, one platform, a unit mass of consumers

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Each **consumer** has unit demand for widget and WTP $\omega \in \Omega$ (finite)

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Two periods: 1. Data is traded, 2. Data is used

Period 1: Data Trade

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Platform and consumers trade the data records

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Demand Side:

For each ω-record the platform buys, it pays price $p(\omega)$

Supply Side:

If type-ω consumer sells her record, she is paid price $p(\omega)$

(on top of the "service" offered by platform)

Notation: $\zeta(\omega) \in [0, 1]$ denotes probability of selling

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If consumer does not sell, she forgoes platform's "service" and obtain reservation utility $r(\omega)$

Period 2: Data Use

Given acquired database $q \in \mathbb{R}_+^\Omega$, platform acts as **information designer**:

- It sends merchant signal about each consumer in database
- Given signal, merchant charges each consumer a personal fee a
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The **payoffs** in period 2 are:

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

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I.e., Platform chooses recommendation mechanism $x : \Omega \to \Delta(A)$ to solve

$$\begin{aligned} V(q) = \max_{x:\Omega\to\Delta(A)} & \sum_{\omega,a} v(a,\omega)x(a|\omega)q(\omega) \\ \text{s.t. } \forall a, a'\colon & \sum_{\omega} \Big(\pi(a,\omega) - \pi(a',\omega)\Big)x(a|\omega)q(\omega) \geq 0 \end{aligned} \qquad (\mathcal{P}_q)$$

(ID problem with endogenous q)

Equilibrium

Definition

A profile (p^*, ζ^*, q^*, x^*)

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$$\zeta^*(\omega) \in \arg\max_{z \in [0,1]} z\Big(p^*(\omega) + \sum_a x^*(a|\omega) u(a, \omega)\Big) + (1 - z) r(\omega).$$

(d). Markets clear, i.e. $\quad q^*(\omega) = \zeta^*(\omega) \bar{q}(\omega) \qquad \forall \omega$

Discussion

A stylized competitive data economy:

- Fully revealing records (see Galperti, Levkun, Perego 23)
- Platform's payoff $v(a,\omega) = \gamma_u \; u(a,\omega) + \gamma_\pi \; \pi(a,\omega)$ (see Xu, Yang 22)
- A single platform + price taking behavior
- Exogenous $r(\omega)$ (e.g., no"showrooming", see Bergemann et al '22)
- Records bundles access and information

  No access without information

efficiency

Efficiency Benchmark

Goal. Study the efficiency of the market in which consumers and platform trade data records

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We call (q, x) a **data allocation**

Denote by $W(q, x)$ the total welfare of consumers and platform

$$W(q,x) = \sum_{a,\omega} \Big(v(a,\omega) + u(a,\omega)\Big) x(a|\omega) q(\omega) + \sum_{\omega} \Big(\bar{q}(\omega) - q(\omega)\Big) r(\omega)$$

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- When $\gamma_\pi < 1$, platform does not fully internalize merchant's payoff $\rightsquigarrow$ a source of inefficiency: not new, just distracting

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- Appendix shows how main result extends to "social" welfare

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Result is not off-the-shelf, since consumers behavior depends on p *and* x

- Suffice to show that solution correspondence of $\mathcal{P}_q$ is UHC in q

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Therefore, are equilibrium allocations constrained efficient?

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It depends on how platform uses data, which depends on its objective

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- If $\gamma_u < \gamma_\pi$, equilibria are constrained efficient and consumers' welfare is maximized
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Equilibrium maximizes consumers welfare when platform cares more about merchant's payoff $\rightsquigarrow$ **Why?**

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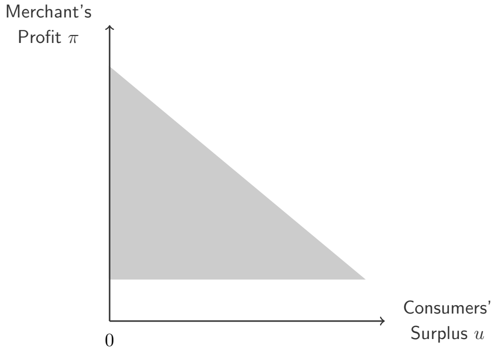
Idea. How platform's uses the data can enable externalities

Intuition for Inefficiency

Recall "surplus triangle" from Bergemann et al. (2015):



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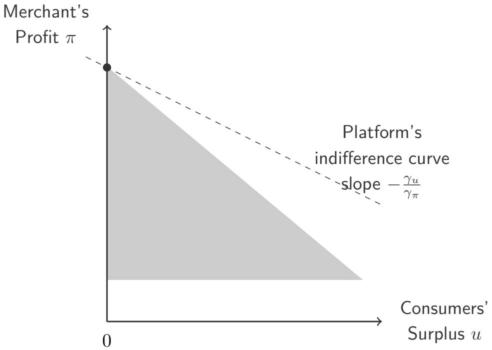

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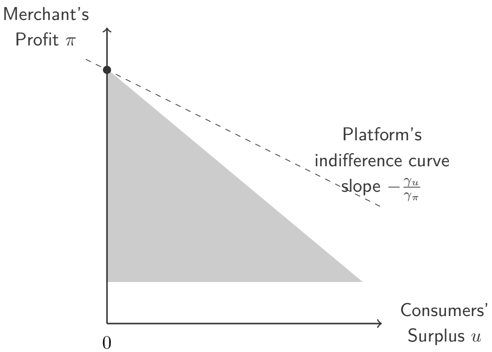

If $\gamma_u < \gamma_\pi$, optimal x^* involves "**full disclosure**," regardless of q.
Merchant learns consumers' types and extract their surplus

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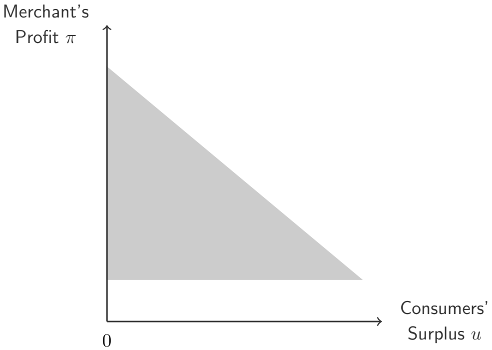

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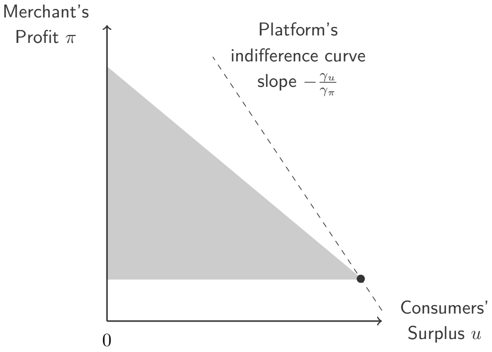

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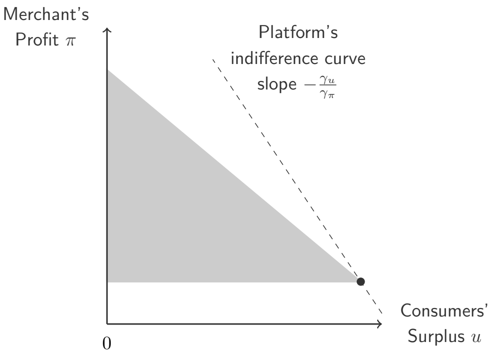

If $\gamma_u \geq \gamma_\pi$, optimal x^* involves **pooling**

It prevents merchant from extracting too much surplus

Intuition for Inefficiency

If $\gamma_u \geq \gamma_\pi$, platform pools consumers of diff types to prevent merchant learning their types

The composition of the pool determines merchant's beliefs, thus his fee

If one consumer does not sell her data, she affects pool composition and, thus, other consumers' payoff

Consumers exert **externality** on each other

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Consumers exert **externality** on each other

Build on Galperti et al (2023): from platform's values to consumers' payoffs

This paper: competitive economy enables this externality to a degree that leads to inefficiency

A Simple Example to Illustrate

Suppose:

- $\gamma_\pi = 0$ (i.e. platform maximizes consumers' surplus)
- Only two types: $\Omega = \{1, 2\}$ with $\bar{q}(1) < \bar{q}(2)$
- Same outside option: $r(\omega) = \bar{r} \in (0, 1)$, for all ω

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The constrained-efficient allocation (q°, x°) involves:

- All low-type consumers participate: $q^\circ(1) = \bar{q}(1)$
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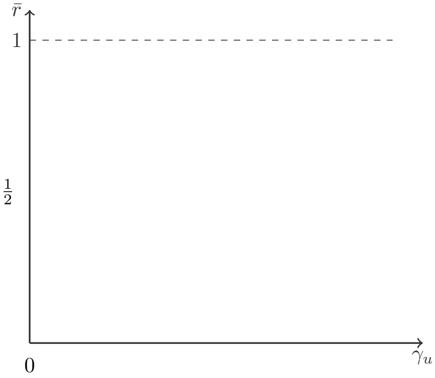
If $\gamma_u < \bar{r}$, any competitive equilibrium has $p^*(1) < \bar{r}$. Thus,

- Low-type consumers do not sell their records $\rightsquigarrow$ neg externality
- Hence, high-type consumer do not want to sell
- Market unravels $\rightsquigarrow$ No trade $\rightsquigarrow$ Inefficiency

Example

Complete equilibrium characterization for this example:



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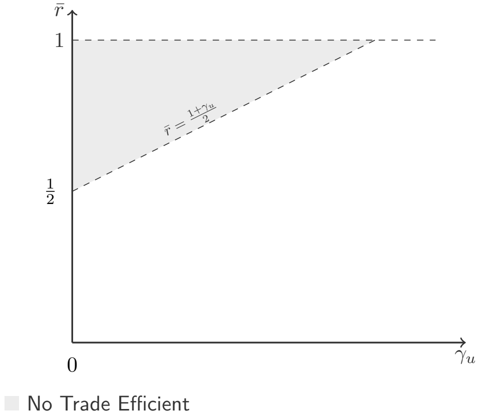

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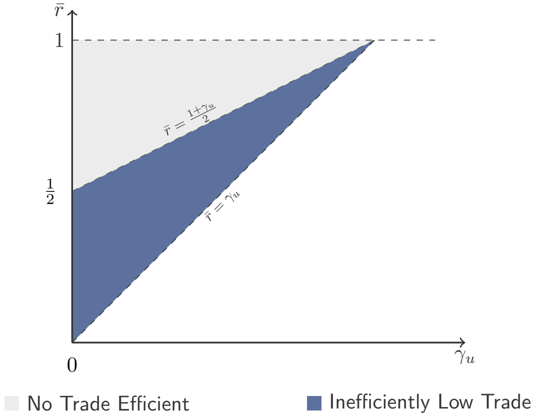

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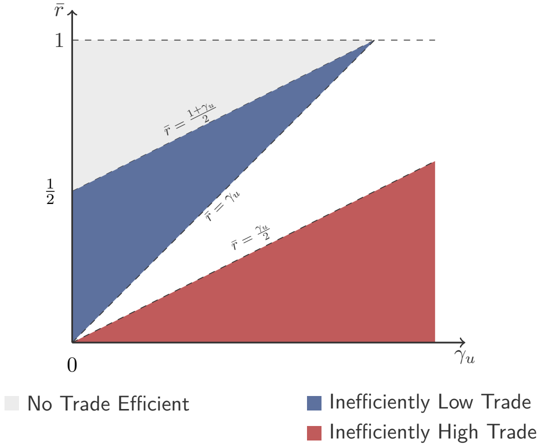

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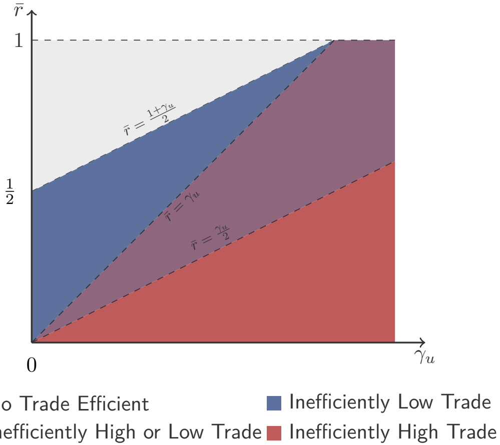

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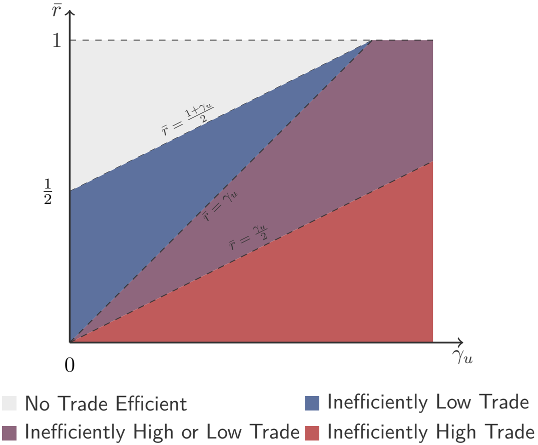

A Characterization of Inefficient Equilibria

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Denote by $\psi_q(\omega)$ the marginal **social value** of ω-records given q

- Marginal change in $W(q, x_q^*)$ if we allocate additional record ω to platform's database
- Galperti et al. '23 characterize such values

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Fixing q and letting the uninformed-merchant fee be a_q:

$$\psi_q(\omega) = \begin{cases} \gamma_\pi \omega & \text{if } \gamma_u < \gamma_\pi \\ (1+\gamma_u)\omega - (1+\gamma_u-\gamma_\pi) a_q \mathbb{1}(\omega \geq a_q) & \text{if } \gamma_u \geq \gamma_\pi \end{cases}$$

A Characterization of Inefficient Equilibria

Proposition

Fix an equilibrium data allocation (q^*, x^*) and let ψ_{q^*} be the associated social values of data. The allocation is constrained efficient if and only if

- $q^*(\omega) > 0 \quad \implies \quad \psi_{q^*}(\omega) \geq r(\omega)$
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Interpretation: $r(\omega)$ is the marginal social cost; $\psi_q(\omega)$ is the marginal social value

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Let $\underline{\omega} := \min_{\omega \in \Omega} \omega$. The characterization implies:

Corollary (A Sufficient Condition for Inefficiency)

Let $\gamma_u \geq \gamma_\pi$ and assume constrained efficiency requires $q \neq 0$.

If $\gamma_u \underline{\omega} < r(\underline{\omega}) < (1 + \gamma_u)\underline{\omega}$, all equilibria are inefficient

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Why? Take any allocation $q \neq 0$.

- $\gamma_u \underline{\omega} < r(\underline{\omega}) \implies$ no trade between the platform and type-$\underline{\omega}$ consumers
- $q \neq 0 \implies a_q > \underline{\omega} \implies \psi_q(\underline{\omega}) = (1 + \gamma_u)\underline{\omega}$
- If $r(\underline{\omega}) < (1 + \gamma_u)\underline{\omega} \implies$ social cost $<$ social value
- $\underline{\omega}$-consumers not selling is inefficient

Summary so far

The equilibrium of the competitive data economy can be inefficient

We characterized this inefficiency in two ways:

1. In terms of the social values of data records:

   We provide a tight characterization

2. In terms of the model primitives:

   We find sufficient conditions for efficiency ($\gamma_u < \gamma_\pi$)

   We find sufficient conditions for inefficiency ($\gamma_u > \gamma_\pi$ and more)

Underlying mechanism: platform's incentives $\rightsquigarrow$ induce some pooling $\rightsquigarrow$ enables externalities $\rightsquigarrow$ creates inefficiency remedies

Remedies

How to fix this market failure?

We explore three alternative market designs:

1. Introducing **data taxes**
2. Introducing **data unions**
3. Making data markets more **complete**

data taxes

Data Taxes

Introduce a simple **data tax** on consumers:

- When selling her record, consumer pays tax / receive subsidy $t(\omega) \in \mathbb{R}$

We show that any constrained-efficient allocation can be supported as an equilibrium of the competitive economy with taxation

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Fix any constrained-efficient data allocation (q^*, x^*).

There exists an equilibrium of the competitive economy (p^*, ζ^*, q^*, x^*) and taxes

$$t^*(\omega) := \sum_a u(a, \omega) x^*(a|\omega) + p^*(\omega) - \psi_{q^*}(\omega) \qquad \forall \omega$$

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Moreover, the budget is balanced.

Data Taxes

Proposition

Fix any constrained-efficient data allocation (q^*, x^*).

There exists an equilibrium of the competitive economy (p^*, ζ^*, q^*, x^*) and taxes

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supporting the constrained-efficient data allocation. Thus, consumer welfare is maximized, regardless of platform's preferences.

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Idea: with data tax, consumers internalize social benefit of selling their data

data union

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Proposition

Equilibria of the data-union economy are constrained efficient and maximize consumers' welfare, regardless of platform's incentives

more-complete markets

Lindahl Economy

We allow consumers to trade **the way** their records are used by platform

More-complete markets:

- There is a market where type-ω records can be sold for "intended use a"
- The price of ω-records, $p(a, \omega)$, can now depend on how it is used

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Proposition

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

monopsonist platform

Monopsonist Economy

Drop competitive market assumption and suppose platform is **price maker**

- Platform sets data prices p by making take-it-or-leave-it offers to consumers

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Definition

(p^*, ζ^*, q^*, x^*) is an equilibrium of the **monopsonist economy** if it solves

$$\begin{aligned} \max_{(p,\zeta,q,x)} \quad & V(q) - \sum_{\omega} p(\omega) q(\omega) \\ \text{s.t.} \quad & \text{conditions } (b), (c), (d) \text{ satisfied} \end{aligned}$$

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Remark

In a monopsony equilibrium, allocations are constrained-efficient (and vice versa). Moreover, platform's payoff is maximal, while consumers' welfare is minimal

conclusion

Summary

1. A stylized framework to study competitive markets for personal data

   Rooted in GE tradition but leveraging recent progress in info-design literature

2. Emphasize a novel market failure

   Platform's role as an information intermediary enables an externality that leads to inefficiencies

3. We propose three alternative market designs that fix inefficiency: data taxes, data unions, more-complete data markets