Competitive Markets for Personal Data

Simone Galperti
UCSD

Jacopo Perego
Columbia

April 2023

Competitive Markets for Personal Data

Simone Galperti UCSD

Jacopo Perego Columbia

April 2023

Preliminary

Motivation

Personal data fuels multi-billion dollar industries and is essential input to the digital economy

Yet, consumers are **imperfectly compensated** for their data, and have **limited control** over their use

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

Motivation

Personal data fuels multi-billion dollar industries and is essential input to the digital economy

Yet, consumers are **imperfectly compensated** for their data, and have **limited control** over their use

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

Status quo may be source of "market failures:" (Seim et al. '22)

- Lack of compensation may affect incentives and equity
- Lack of control may facilitate market power (no trade)

Motivation

Personal data fuels multi-billion dollar industries and is essential input to the digital economy

Yet, consumers are **imperfectly compensated** for their data, and have **limited control** over their use

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

Status quo may be source of "market failures:" (Seim et al. '22)

- Lack of compensation may affect incentives and equity
- Lack of control may facilitate market power (no trade)

A "well-functioning market for data" would correct these problems

Motivation

Personal data fuels multi-billion dollar industries and is essential input to the digital economy

Yet, consumers are **imperfectly compensated** for their data, and have **limited control** over their use

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

Status quo may be source of "market failures:" (Seim et al. '22)

- Lack of compensation may affect incentives and equity
- Lack of control may facilitate market power (no trade)

A "well-functioning market for data" would correct these problems **?**

This Paper

In this paper,

1. We introduce a framework to study **competitive** markets for data and characterize their equilibria

   Unrealistic yet natural benchmark we should know about

This Paper

In this paper,

1. We introduce a framework to study **competitive** markets for data and characterize their equilibria

   Unrealistic yet natural benchmark we should know about

2. Show that **pooling externality** (GLP22) can lead to market failure

   So severe that consumers may be better off under expropriation

This Paper

In this paper,

1. We introduce a framework to study **competitive** markets for data and characterize their equilibria

   Unrealistic yet natural benchmark we should know about

2. Show that **pooling externality** (GLP22) can lead to market failure

   So severe that consumers may be better off under expropriation

3. Show that "more complete" markets restore efficiency

This Paper

In this paper,

1. We introduce a framework to study **competitive** markets for data and characterize their equilibria

   Unrealistic yet natural benchmark we should know about

2. Show that **pooling externality** (GLP22) can lead to market failure

   So severe that consumers may be better off under expropriation

3. Show that "more complete" markets restore efficiency

Basic Idea

Basic idea in the paper

Platform as an information designer:

- It uses personal data to intermediate consumers and merchants
- Platform often finds it optimal to **withhold** some information

Basic Idea

Basic idea in the paper

Platform as an information designer:

- It uses personal data to intermediate consumers and merchants
- Platform often finds it optimal to **withhold** some information

When info is withheld, data of different consumers are pooled together

Basic Idea

Basic idea in the paper

Platform as an information designer:

- It uses personal data to intermediate consumers and merchants
- Platform often finds it optimal to **withhold** some information

When info is withheld, data of different consumers are pooled together

When consumers data are pooled, their payoff may depend on which other consumers have sold their data

Basic Idea

Basic idea in the paper

Platform as an information designer:

- It uses personal data to intermediate consumers and merchants
- Platform often finds it optimal to **withhold** some information

When info is withheld, data of different consumers are pooled together

When consumers data are pooled, their payoff may depend on which other consumers have sold their data

We build a competitive economy around this idea and show when it leads to market failure

Literature

We know exogenous correlation in consumers' data can lead to externalities

Choi et al. 19, Bergemann et al. 22, Acemoglu et al. 22

We explore novel externality and its consequences on competitive mkts

- It emerges endogenously from how platform uses data even when data are uncorrelated

Literature

We know exogenous correlation in consumers' data can lead to externalities

Choi et al. 19, Bergemann et al. 22, Acemoglu et al. 22

We explore novel externality and its consequences on competitive mkts

- It emerges endogenously from how platform uses data even when data are uncorrelated

Growing interest in studying these markets, avenue for econ theory

Literature

We know exogenous correlation in consumers' data can lead to externalities

Choi et al. 19, Bergemann et al. 22, Acemoglu et al. 22

We explore novel externality and its consequences on competitive mkts

- It emerges endogenously from how platform uses data even when data are uncorrelated

Growing interest in studying these markets, avenue for econ theory

Our approach: (GLP22, GP23, and this paper)

- Use tools from information-design literature

  Bergemann and Morris 19, Kamenica 19

- To answer questions about data markets

  Acquisti et al 16, Bergemann and Bonatti 19, Bergemann and Ottaviani 21

Plan for Talk

1. Leading example to illustrate main ideas and results
2. General model
3. Results

leading example

(many consumers, one platform, one merchant)

A Simple Data Economy

A **merchant** want to sell product to consumers and charge fee $a \in \{1, 2\}$

A Simple Data Economy

A **merchant** want to sell product to consumers and charge fee $a \in \{1, 2\}$

A **consumer**'s WTP for the product is $\omega \in \{1, 2\}$

A Simple Data Economy

A **merchant** want to sell product to consumers and charge fee $a \in \{1, 2\}$

A **consumer**'s WTP for the product is $\omega \in \{1, 2\}$

Type-ω consumers have mass $\bar{q}(1) = 1$ and $\bar{q}(2) = 2$, resp.

A Simple Data Economy

A **merchant** want to sell product to consumers and charge fee $a \in \{1, 2\}$

A **consumer**'s WTP for the product is $\omega \in \{1, 2\}$

Type-ω consumers have mass $\bar{q}(1) = 1$ and $\bar{q}(2) = 2$, resp.

The **platform** is an intermediary that provides the merchant with information about the consumers' ω

- By doing so, it influences the fee that merchant charges to consumer

A Simple Data Economy

A **merchant** want to sell product to consumers and charge fee $a \in \{1, 2\}$

A **consumer**'s WTP for the product is $\omega \in \{1, 2\}$

Type-ω consumers have mass $\bar{q}(1) = 1$ and $\bar{q}(2) = 2$, resp.

The **platform** is an intermediary that provides the merchant with information about the consumers' ω

- By doing so, it influences the fee that merchant charges to consumer
- **Examples:** full info $\rightsquigarrow$ discriminatory prices; no info $\rightsquigarrow$ uniform price

A Simple Data Economy

A **merchant** want to sell product to consumers and charge fee $a \in \{1, 2\}$

A **consumer**'s WTP for the product is $\omega \in \{1, 2\}$

Type-ω consumers have mass $\bar{q}(1) = 1$ and $\bar{q}(2) = 2$, resp.

The **platform** is an intermediary that provides the merchant with information about the consumers' ω

- By doing so, it influences the fee that merchant charges to consumer
- **Examples:** full info $\rightsquigarrow$ discriminatory prices; no info $\rightsquigarrow$ uniform price

A Simple Data Economy

If platform knew all consumers' ω, it would solve a very standard information-design problem

same as in GLP22

A Simple Data Economy

If platform knew all consumers' ω, it would solve a very standard information-design problem

same as in GLP22

platform's expected payoff

$$\overbrace{U(\bar{q})}$$

A Simple Data Economy

If platform knew all consumers' ω, it would solve a very standard information-design problem

same as in GLP22

$$\overbrace{U(\bar{q})}^{\substack{\text{platform's}\\ \text{expected payoff}}} = \max_{x: A\times\Omega\to\mathbb{R}_+} \sum_{\omega,a} u(a,\omega)x(a,\omega)$$

$$\text{such that:} \quad \sum_{\omega} \big(\pi(a,\omega) - \pi(\hat{a},\omega)\big)x(a,\omega) \geq 0 \qquad \forall\, a,\hat{a} \in A$$

$$\sum_{a} x(a,\omega) = \bar{q}(\omega) \qquad \forall\, \omega \in \Omega$$

A Simple Data Economy

If platform knew all consumers' ω, it would solve a very standard information-design problem

same as in GLP22

$$\overbrace{U(\bar{q})}^{\substack{\text{platform's}\\ \text{expected payoff}}} = \max_{x:A\times\Omega\to\mathbb{R}_+} \sum_{\omega,a} u(a,\omega)x(a,\omega)$$

$$\text{such that:} \quad \sum_{\omega} \big(\pi(a,\omega) - \pi(\hat{a},\omega)\big)x(a,\omega) \geq 0 \qquad \forall\, a,\hat{a} \in A$$

$$\sum_{a} x(a,\omega) = \bar{q}(\omega) \qquad \forall\, \omega \in \Omega$$

Main twist in this paper:

What data the platform has about consumers is **endogenous**

It has to acquire consumers' data in a **competitive market**

A Simple Data Economy

Each consumer owns a **data record** that reveals her type ω.

A Simple Data Economy

Each consumer owns a **data record** that reveals her type ω.

A **database** is a collection of data records, denoted by $q = (q(1), q(2))$

A Simple Data Economy

Each consumer owns a **data record** that reveals her type ω.

A **database** is a collection of data records, denoted by $q = (q(1), q(2))$

In a **competitive market** for data records:

1. Taking prices $p(1)$ and $p(2)$ as given,
   - Platform decides which database q to acquire

A Simple Data Economy

Each consumer owns a **data record** that reveals her type ω.

A **database** is a collection of data records, denoted by $q = (q(1), q(2))$

In a **competitive market** for data records:

1. Taking prices $p(1)$ and $p(2)$ as given,
   - Platform decides which database q to acquire
   - Consumers decide whether to sell their data records to platform or keep it an avoid intermediation

A Simple Data Economy

Each consumer owns a **data record** that reveals her type ω.

A **database** is a collection of data records, denoted by $q = (q(1), q(2))$

In a **competitive market** for data records:

1. Taking prices $p(1)$ and $p(2)$ as given,

- Platform decides which database q to acquire
- Consumers decide whether to sell their data records to platform or keep it an avoid intermediation

2. Given q, platform intermediates consumers in its database with the merchant

A Simple Data Economy

Payoffs:

	If a type-ω consumer: keeps her record	sells her record
Consumer	ε	
Merchant	0	
Platform	0	

A Simple Data Economy

Payoffs:

	If a type-ω consumer: keeps her record	sells her record
Consumer	ε	
Merchant	0	
Platform	0	

A Simple Data Economy

Payoffs:

	If a type-ω consumer: keeps her record	sells her record
Consumer	ε	
Merchant	0	
Platform	0	

A Simple Data Economy

Payoffs:

	If a type-ω consumer: keeps her record	sells her record
Consumer	ε	
Merchant	0	
Platform	0	

A Simple Data Economy

Payoffs:

	If a type-ω consumer: keeps her record	sells her record
Consumer	ε	
Merchant	0	
Platform	0	

A Simple Data Economy

Payoffs:

	If a type-ω consumer: keeps her record	sells her record
Consumer	ε	
Merchant	0	
Platform	0	

A Simple Data Economy

Payoffs:

	If a type-ω consumer: keeps her record	sells her record
Consumer	ε	
Merchant	0	
Platform	0	

A Simple Data Economy

Payoffs:

	If a type-ω consumer: keeps her record	sells her record	
Consumer	ε	$g(a,\omega) = \max\{\omega - a, 0\}$	consumer's surplus
Merchant	0		
Platform	0		

A Simple Data Economy

Payoffs:

	If a type-ω consumer: keeps her record	sells her record	
Consumer	ε	$g(a,\omega) = \max\{\omega - a, 0\}$	consumer's surplus
Merchant	0	$\pi(a,\omega) = a\mathbb{1}(\omega \geq a)$	merchant's profit
Platform	0		

A Simple Data Economy

Payoffs:

	If a type-ω consumer: keeps her record	sells her record	
Consumer	ε	$g(a,\omega) = \max\{\omega - a, 0\}$	consumer's surplus
Merchant	0	$\pi(a,\omega) = a\mathbb{1}(\omega \geq a)$	merchant's profit
Platform	0	$u(a,\omega) = \beta\ g(a,\omega) + \gamma\ \pi(a,\omega)$	platform's payoff

A Simple Data Economy

Payoffs:

	If a type-ω consumer: keeps her record	sells her record	
Consumer	ε	$g(a,\omega) = \max\{\omega - a, 0\}$	consumer's surplus
Merchant	0	$\pi(a,\omega) = a\mathbb{1}(\omega \geq a)$	merchant's profit
Platform	0	$u(a,\omega) = \beta\ g(a,\omega) + \gamma\ \pi(a,\omega)$	platform's payoff

Later: many platforms, many merchants, many types, arbitrary objectives, partially informative records

equilibrium

Competitive Equilibrium

A **competitive equilibrium** is: prices $(p^*(1), p^*(2))$; a database $q^* = (q^*(1), q^*(2))$; consumers' decisions $(\alpha^*(1), \alpha^*(2))$ such that

Competitive Equilibrium

A **competitive equilibrium** is: prices $(p^*(1), p^*(2))$; a database $q^* = (q^*(1), q^*(2))$; consumers' decisions $(\alpha^*(1), \alpha^*(2))$ such that

1. Given p^*, database q^* solves platform's problem

$$q^* \in \arg\max_q U(q) - \sum_\omega p^*(\omega) q(\omega)$$

Competitive Equilibrium

A **competitive equilibrium** is: prices $(p^*(1), p^*(2))$; a database $q^* = (q^*(1), q^*(2))$; consumers' decisions $(\alpha^*(1), \alpha^*(2))$ such that

1. Given p^*, database q^* solves platform's problem
$$q^* \in \arg\max_q U(q) - \sum_\omega p^*(\omega) q(\omega)$$
2. Given p^* and q^*, $\alpha^*(\omega)$ solves ω-consumer's problem
$$\alpha^*(\omega) \in \arg\max_{\alpha \in [0,1]} (1-\alpha)\varepsilon + \alpha\Big(p^*(\omega) + \mathbb{E}_{q^*}(g(a,\omega))\Big)$$

Competitive Equilibrium

A **competitive equilibrium** is: prices $(p^*(1), p^*(2))$; a database $q^* = (q^*(1), q^*(2))$; consumers' decisions $(\alpha^*(1), \alpha^*(2))$ such that

1. Given p^*, database q^* solves platform's problem
$$q^* \in \arg\max_q U(q) - \sum_\omega p^*(\omega) q(\omega)$$
2. Given p^* and q^*, $\alpha^*(\omega)$ solves ω-consumer's problem
$$\alpha^*(\omega) \in \arg\max_{\alpha \in [0,1]} (1-\alpha)\varepsilon + \alpha\Big(p^*(\omega) + \mathbb{E}_{q^*}(g(a,\omega))\Big)$$
3. Markets clear
$$q^*(\omega) = \alpha^*(\omega)\bar{q}(\omega), \quad \forall \omega$$

Competitive Equilibrium

A **competitive equilibrium** is: prices $(p^*(1), p^*(2))$; a database $q^* = (q^*(1), q^*(2))$; consumers' decisions $(\alpha^*(1), \alpha^*(2))$ such that

1. Given p^*, database q^* solves platform's problem
$$q^* \in \arg\max_q U(q) - \sum_\omega p^*(\omega) q(\omega)$$
2. Given p^* and q^*, $\alpha^*(\omega)$ solves ω-consumer's problem
$$\alpha^*(\omega) \in \arg\max_{\alpha \in [0,1]} (1-\alpha)\varepsilon + \alpha\Big(p^*(\omega) + \mathbb{E}_{q^*}(g(a,\omega))\Big)$$
3. Markets clear
$$q^*(\omega) = \alpha^*(\omega)\bar{q}(\omega), \quad \forall \omega$$

Efficiency Benchmark

Social planner maximizes **Consumers Welfare** by picking a data allocation and transfers:

$$\max_{q,T} \quad T + \sum_{\omega} (\bar{q}(\omega) - q(\omega))\varepsilon + q(\omega)\mathbb{E}_q(g(a,\omega))$$

$$\text{such that:} \quad q(\omega) \leq \bar{q}(\omega) \qquad \forall\, \omega \in \Omega$$

$$T \leq U(q)$$

Efficiency Benchmark

Social planner maximizes **Consumers Welfare** by picking a data allocation and transfers:

$$\begin{aligned} \max_{q,T} \quad & T + \sum_{\omega} (\bar{q}(\omega) - q(\omega))\varepsilon + q(\omega)\mathbb{E}_q(g(a,\omega)) \\ \text{such that:} \quad & q(\omega) \leq \bar{q}(\omega) \qquad \forall\, \omega \in \Omega \\ & T \leq U(q) \end{aligned}$$

Note: Merchant profit is excluded from welfare computation:

- In model, no way to transfer merchant profits to consumer
- This benchmark gives model a fair chance at efficiency (stronger negative result)

analysis

Towards the Equilibrium

What is the competitive equilibrium of this economy?

Towards the Equilibrium

What is the competitive equilibrium of this economy?

To illustrate, begin from the case $\gamma = 0$, i.e.,

$$u(a, \omega) = \beta \; g(a, \omega) + \gamma \; \pi(a, \omega)$$

Platform objective is to maximize consumer's gains from trade

Towards the Equilibrium (1): Expropriation

Imagine platform **expropriated** consumers of their records ($\approx$ status quo)

How would the platform use database $\bar{q}$?

Towards the Equilibrium (1): Expropriation

Imagine platform **expropriated** consumers of their records ($\approx$ status quo)

How would the platform use database $\bar{q}$?

Record Type	**Prices**	**Records Kept**	**Platform's Database**
$\omega = 1$	0	0	1
$\omega = 2$	0	0	2

Towards the Equilibrium (1): Expropriation

Imagine platform **expropriated** consumers of their records (≈ status quo)

How would the platform use database $\bar{q}$?

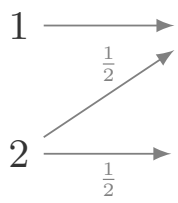
Record Type	Prices	Records Kept	Platform's Database	Use
$\omega = 1$	0	0	$1 \to s^L$	$\to a = 1$
$\omega = 2$	0	0	$2 \to s^H$ (each with prob. $\frac{1}{2}$)	$\to a = 2$

Towards the Equilibrium (1): Expropriation

Imagine platform **expropriated** consumers of their records (≈ status quo)

How would the platform use database $\bar{q}$?

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	0	0	$1 \to s^L \to a = 1$		1
$\omega = 2$	0	0	$2 \to s^H \to a = 2$		



Towards the Equilibrium (1): Expropriation

Platform withholds info from merchant (due to conflict of interest, $\gamma = 0$)

Platform withholds info by pooling data records

When data records are pooled, consumer' payoff depend on what other records platform has

Towards the Equilibrium (1): Expropriation

Platform withholds info from merchant (due to conflict of interest, $\gamma = 0$)

Platform withholds info by pooling data records

When data records are pooled, consumer' payoff depend on what other records platform has

Thus, consumer's payoff affected by who else sells her data

Towards the Equilibrium (1): Expropriation

Platform withholds info from merchant (due to conflict of interest, $\gamma = 0$)

Platform withholds info by pooling data records

When data records are pooled, consumer' payoff depend on what other records platform has

Thus, consumer's payoff affected by who else sells her data

Model "enables" this externality, which will lead to inefficiencies

Towards the Equilibrium (2): Planner's Solution

Does expropriation maximize consumer welfare?

Towards the Equilibrium (2): Planner's Solution

Does expropriation maximize consumer welfare? No

Towards the Equilibrium (2): Planner's Solution

Does expropriation maximize consumer welfare? No

Expropriation:

Record Type	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	0	$1 \to s^L \to a = 1$		
		$2 \xrightarrow{\frac{1}{2}} s^L \to a = 1$		1
$\omega = 2$	0	$2 \xrightarrow{\frac{1}{2}} s^H \to a = 2$		

Towards the Equilibrium (2): Planner's Solution

Does expropriation maximize consumer welfare? No

Planner's solution:

Towards the Equilibrium (2): Planner's Solution

Does expropriation maximize consumer welfare? No

Planner's solution:

Record Type	Records Kept	Platform's Database	Use
$\omega = 1$	0	1	$s^L \longrightarrow a = 1$
$\omega = 2$	1	1	

Towards the Equilibrium (2): Planner's Solution

Does expropriation maximize consumer welfare? No

Planner's solution:

Record Type	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	0	1	$s^L \longrightarrow a = 1$	$1 + \varepsilon + \beta$
$\omega = 2$	1	1		

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	Prices	Records Kept	Platform's Database
$\omega = 1$	β	1	0
$\omega = 2$	0	2	0

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)
$\omega = 1$	β	1	$0 \longrightarrow s^L$	$\longrightarrow a = 1$
$\omega = 2$	0	2	$0 \longrightarrow s^H$	$\longrightarrow a = 2$

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

1. Low-type consumers have no incentive to sell:
   Price $p^*(1) = \beta$ is too low $(\beta < \varepsilon)$

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

2. High-type consumers have no incentive to sell:
   Price $p^*(2) = 0$ is too low $(\varepsilon > 0)$

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

3. Platform has no strict incentive to buy.
   Equilibrium prices = marginal values

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

4. Equilibrium welfare is inefficiently low

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

5. If $\varepsilon < \frac{1}{3}$, equilibrium welfare is even lower than under expropriation!

Competitive Equilibrium: "Too Little Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: **"Too little data"**
2. $\beta > \varepsilon$: "Too much data"

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Trivial)	**Consumers Welfare**
$\omega = 1$	β	1	$0 \longrightarrow s^L \longrightarrow a = 1$		3ε
$\omega = 2$	0	2	$0 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

6. (Negative prices) – High-type consumers would want to subsidize low-type consumers to sell their data, but market is too incomplete

Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database
$\omega = 1$	β	0	1
$\omega = 2$	0	0	2

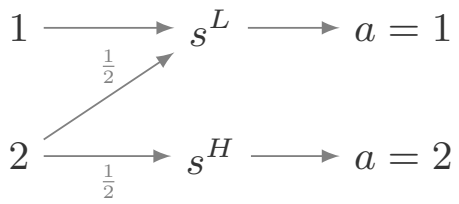
Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use
$\omega = 1$	β	0	$1 \to s^L$	$\to a = 1$
$\omega = 2$	0	0	$2 \to s^H$	$\to a = 2$



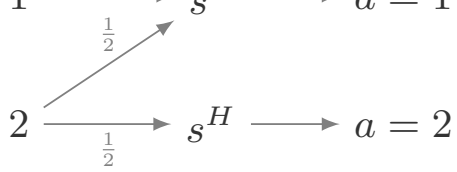
Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \to s^L \to a = 1$		$1 + \beta$
$\omega = 2$	0	0	$2 \to s^H \to a = 2$		



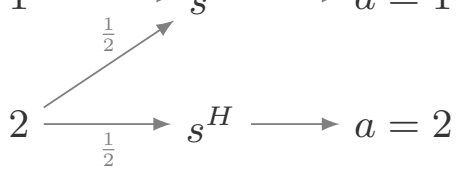
Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \to s^L \to a = 1$		$1 + \beta$
$\omega = 2$	0	0	$2 \to s^H \to a = 2$		



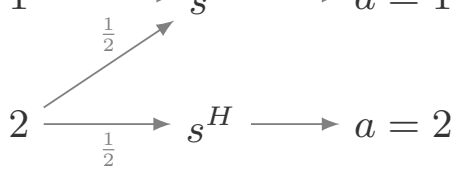
Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \to s^L \to a = 1$		$1 + \beta$
$\omega = 2$	0	0	$2 \to s^H \to a = 2$		



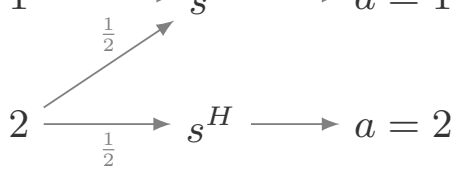
Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \to s^L \to a = 1$		$1 + \beta$
$\omega = 2$	0	0	$2 \to s^H \to a = 2$		



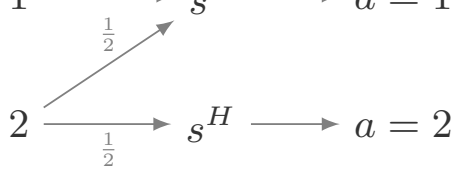
Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \to s^L \to a = 1$		$1 + \beta$
$\omega = 2$	0	0	$2 \to s^H \to a = 2$		



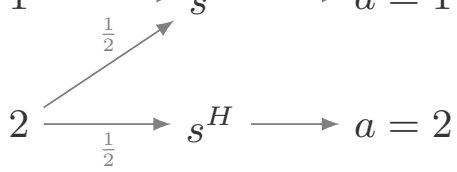
Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \to s^L \to a = 1$		$1 + \beta$
$\omega = 2$	0	0	$2 \to s^H \to a = 2$		



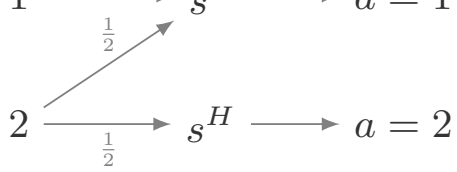
Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \to s^L \to a = 1$		$1 + \beta$
$\omega = 2$	0	0	$2 \to s^H \to a = 2$		



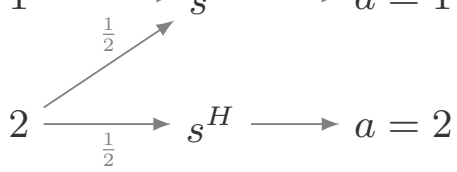
Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \to s^L \to a = 1$		$1 + \beta$
$\omega = 2$	0	0	$2 \to s^H \to a = 2$		



Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \longrightarrow s^L \longrightarrow a = 1$		$1 + \beta$
$\omega = 2$	0	0	$2 \xrightarrow{\frac{1}{2}} s^H \longrightarrow a = 2$		

Comments:

Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \longrightarrow s^L \longrightarrow a = 1$		$1 + \beta$
$\omega = 2$	0	0	$2 \xrightarrow{\frac{1}{2}} s^H \longrightarrow a = 2$		

Comments:

Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \longrightarrow s^L \longrightarrow a = 1$		$1 + \beta$
$\omega = 2$	0	0	$2 \xrightarrow{\frac{1}{2}} s^H \longrightarrow a = 2$		

Comments:

Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \xrightarrow{\frac{1}{2}} s^L \longrightarrow a = 1$		$1 + \beta$
$\omega = 2$	0	0	$2 \xrightarrow{\frac{1}{2}} s^H \longrightarrow a = 2$		

Comments:

1. Too many high-type consumers sell. Attracted by expected gain ($\frac{1}{2}$), they decrease each other payoffs

Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0	$1 \to s^L \to a = 1$ ($\frac{1}{2}$)		$1 + \beta$
$\omega = 2$	0	0	$2 \to s^H \to a = 2$ ($\frac{1}{2}$)		

Comments:

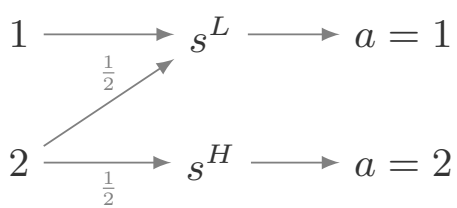
2. Welfare is inefficiently low

Competitive Equilibrium: "Too Much Data"

Let's compute the **competitive equilibrium** of this data economy:

Two cases to consider, leading to different market failures:

1. $\beta < \varepsilon$: "Too little data"
2. $\beta > \varepsilon$: **"Too much data"**

Record Type	Prices	Records Kept	Platform's Database	Use	Consumers Welfare
$\omega = 1$	β	0			$1 + \beta$
$\omega = 2$	0	0			

Comments:

3. Negative price on high-type consumers? Again, not an equilibrium...

Taking Stock

Taking Stock

The example illustrates that inefficiency can be generic (for all ε)

Also, inefficiency can be severe: Welfare higher under expropriation

- Perverse consequence of empowering consumers

Taking Stock

The example illustrates that inefficiency can be generic (for all ε)

Also, inefficiency can be severe: Welfare higher under expropriation

- Perverse consequence of empowering consumers

Example shows two kinds of failures:

- "Too little data:" When low-type consumer keeps her data, she decreases payoff of high types
- "Too much data:" When high-type consumer sells, she decreases payoff of other high types

Taking Stock

The example illustrates that inefficiency can be generic (for all ε)

Also, inefficiency can be severe: Welfare higher under expropriation

- Perverse consequence of empowering consumers

Example shows two kinds of failures:

- "Too little data:" When low-type consumer keeps her data, she decreases payoff of high types
- "Too much data:" When high-type consumer sells, she decreases payoff of other high types

Both failures originates from same source:

- Platform has incentives to withhold information

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\ g(a, \omega) + \gamma\ \pi(a, \omega)$$

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	Prices	Records Kept	Platform's Database
$\omega = 1$	γ	0	1
$\omega = 2$	2γ	0	2

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow$	$a = 1$
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow$	$a = 2$

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

1. Platform does not withhold information from the merchant $\rightsquigarrow$ price discrimination

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

2. Crucially, payoff of a consumer is independent of decisions of other consumers. No externalities

Competitive Equilibrium: No-Intermediation Case

What happens when platform has no incentive to withhold? $\rightsquigarrow$ **Efficiency**

Suppose that $\beta = 0$ and $\gamma > \varepsilon$:

$$u(a, \omega) = \beta\, g(a, \omega) + \gamma\, \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Platform's Database**	**Use** (Full Info)	**Consumer Welfare**
$\omega = 1$	γ	0	$1 \longrightarrow s^L \longrightarrow a = 1$		5γ
$\omega = 2$	2γ	0	$2 \longrightarrow s^H \longrightarrow a = 2$		

Comments:

3. Consumers get fully compensated: They get payoff that platform makes with their data. $\rightsquigarrow$ Equilibrium is efficient

general model

Model 1/3

There are I competing **platforms**

Model 1/3

There are I competing **platforms**

A **merchant** is active on platform i and sells product for a_i

Model 1/3

There are I competing **platforms**

A **merchant** is active on platform i and sells product for a_i

Consumers has preference type ω

Model 1/3

There are I competing **platforms**

A **merchant** is active on platform i and sells product for a_i

Consumers has preference type ω

Type-ω consumers are of mass $\bar{q}(\omega) \geq 0$

Model 1/3

There are I competing **platforms**

A **merchant** is active on platform i and sells product for a_i

Consumers has preference type ω

Type-ω consumers are of mass $\bar{q}(\omega) \geq 0$

When a ω-consumer transacts with platform i's vendor, payoffs realize

Model 1/3

There are I competing **platforms**

A **merchant** is active on platform i and sells product for a_i

Consumers has preference type ω

Type-ω consumers are of mass $\bar{q}(\omega) \geq 0$

When a ω-consumer transacts with platform i's vendor, payoffs realize

$$\begin{aligned} \text{consumer:} \quad & g_i(a_i, \omega) \\ \text{merchant:} \quad & \pi_i(a_i, \omega) \\ \text{platform:} \quad & u_i(a_i, \omega) \end{aligned}$$

Model 2/3: Data Records

Each consumer is uniquely identified by a **data record**, which provides:

1. Info about this consumer's WTP ω

Model 2/3: Data Records

Each consumer is uniquely identified by a **data record**, which provides:

1. Info about this consumer's WTP ω (e.g., age, gender, edu, etc.)

Model 2/3: Data Records

Each consumer is uniquely identified by a **data record**, which provides:

1. Info about this consumer's WTP ω (e.g., age, gender, edu, etc.)
2. Exclusive access to this consumer

Model 2/3: Data Records

Each consumer is uniquely identified by a **data record**, which provides:

1. Info about this consumer's WTP ω (e.g., age, gender, edu, etc.)
2. Exclusive access to this consumer (e.g., email, IP address, etc.)

Model 2/3: Data Records

Each consumer is uniquely identified by a **data record**, which provides:

1. Info about this consumer's WTP ω (e.g., age, gender, edu, etc.)
2. Exclusive access to this consumer (e.g., email, IP address, etc.)

Exclusivity is key: Data record is rival good

Model 2/3: Data Records

Each consumer is uniquely identified by a **data record**, which provides:

1. Info about this consumer's WTP ω (e.g., age, gender, edu, etc.)
2. Exclusive access to this consumer (e.g., email, IP address, etc.)

Exclusivity is key: Data record is rival good

Model 2/3: Data Records

Each consumer is uniquely identified by a **data record**, which provides:

1. Info about this consumer's WTP ω (e.g., age, gender, edu, etc.)
2. Exclusive access to this consumer (e.g., email, IP address, etc.)

Exclusivity is key: Data record is rival good

Model 2/3: Data Records

Each consumer is uniquely identified by a **data record**, which provides:

1. Info about this consumer's WTP ω (e.g., age, gender, edu, etc.)
2. Exclusive access to this consumer (e.g., email, IP address, etc.)

Exclusivity is key: Data record is rival good

Model 2/3: Data Records

Each consumer is uniquely identified by a **data record**, which provides:

1. Info about this consumer's WTP ω (e.g., age, gender, edu, etc.)
2. Exclusive access to this consumer (e.g., email, IP address, etc.)

Exclusivity is key: Data record is rival good

Model 2/3: Data Records

Each consumer is uniquely identified by a **data record**, which provides:

1. Info about this consumer's WTP ω (e.g., age, gender, edu, etc.)
2. Exclusive access to this consumer (e.g., email, IP address, etc.)

Exclusivity is key: Data record is rival good

A collection of data records is called a **database**: denoted $q_i \in \mathbb{R}_+^{\Omega}$

Model 3/3: Platforms

Suppose platform i has acquired database q_i

Model 3/3: Platforms

Suppose platform i has acquired database q_i

- i.e., i has exclusive access to consumers whose records belong to q_i

Model 3/3: Platforms

Suppose platform i has acquired database q_i

i.e., i has exclusive access to consumers whose records belong to q_i

Platform i is an **information designer**: It sends a signal about each consumers's ω to its vendor to influence his price a

Model 3/3: Platforms

Suppose platform i has acquired database q_i

i.e., i has exclusive access to consumers whose records belong to q_i

Platform i is an **information designer**: It sends a signal about each consumers's ω to its vendor to influence his price a

$$\max_{x_i : A \times \Omega \to \mathbb{R}_+} \quad \sum_{\omega, a} u_i(a, \omega) x_i(a, \omega)$$

$$\text{such that:} \quad \sum_{\omega} \big(\pi_i(a, \omega) - \pi_i(\hat{a}, \omega)\big) x_i(a, \omega) \geq 0 \qquad \forall\, a, \hat{a} \in A$$

$$\sum_{a} x_i(a, \omega) = q_i(\omega) \qquad \forall\, \omega \in \Omega$$

Model 3/3: Platforms

Suppose platform i has acquired database q_i

i.e., i has exclusive access to consumers whose records belong to q_i

Platform i is an **information designer**: It sends a signal about each consumers's ω to its vendor to influence his price a

$$\max_{x_i : A \times \Omega \to \mathbb{R}_+} \quad \sum_{\omega, a} u_i(a, \omega) x_i(a, \omega)$$

$$\text{such that:} \quad \sum_{\omega} \big(\pi_i(a, \omega) - \pi_i(\hat{a}, \omega)\big) x_i(a, \omega) \geq 0 \qquad \forall\, a, \hat{a} \in A$$

$$\sum_{a} x_i(a, \omega) = q_i(\omega) \qquad \forall\, \omega \in \Omega$$

Model 3/3: Platforms

Suppose platform i has acquired database q_i

i.e., i has exclusive access to consumers whose records belong to q_i

Platform i is an **information designer**: It sends a signal about each consumers's ω to its vendor to influence his price a

$$\overbrace{U_i(q_i)}^{\substack{\text{platform's} \\ \text{exptd payoff}}} = \max_{x_i : A \times \Omega \to \mathbb{R}_+} \sum_{\omega, a} u_i(a, \omega) x_i(a, \omega)$$

$$\text{such that:} \quad \sum_{\omega} \big(\pi_i(a, \omega) - \pi_i(\hat{a}, \omega)\big) x_i(a, \omega) \geq 0 \qquad \forall\, a, \hat{a} \in A$$

$$\sum_{a} x_i(a, \omega) = q_i(\omega) \qquad \forall\, \omega \in \Omega$$

Model 3/3: Platforms

Suppose platform i has acquired database q_i

i.e., i has exclusive access to consumers whose records belong to q_i

Platform i is an **information designer**: It sends a signal about each consumers's ω to its vendor to influence his price a

$$\overbrace{U_i(q_i)}^{\substack{\text{platform's} \\ \text{exptd payoff}}} = \max_{x_i : A \times \Omega \to \mathbb{R}_+} \sum_{\omega, a} u_i(a, \omega) x_i(a, \omega)$$

$$\text{such that:} \quad \sum_{\omega} \big(\pi_i(a, \omega) - \pi_i(\hat{a}, \omega)\big) x_i(a, \omega) \geq 0 \qquad \forall\, a, \hat{a} \in A$$

$$\sum_{a} x_i(a, \omega) = q_i(\omega) \qquad \forall\, \omega \in \Omega$$

Denote by $x^*_{q_i}$ a solution (note: it depends on the entire database)

Model 3/3: Platforms

Suppose platform i has acquired database q_i

i.e., i has exclusive access to consumers whose records belong to q_i

Platform i is an **information designer**: It sends a signal about each consumers's ω to its vendor to influence his price a

$$\overbrace{U_i(q_i)}^{\substack{\text{platform's} \\ \text{exptd payoff}}} = \max_{x_i : A \times \Omega \to \mathbb{R}_+} \sum_{\omega, a} u_i(a, \omega) x_i(a, \omega)$$

$$\text{such that:} \quad \sum_{\omega} \big(\pi_i(a, \omega) - \pi_i(\hat{a}, \omega)\big) x_i(a, \omega) \geq 0 \qquad \forall\, a, \hat{a} \in A$$

$$\sum_{a} x_i(a, \omega) = q_i(\omega) \qquad \forall\, \omega \in \Omega$$

Denote by $x^*_{q_i}$ a solution (note: it depends on the entire database)

Summing Up

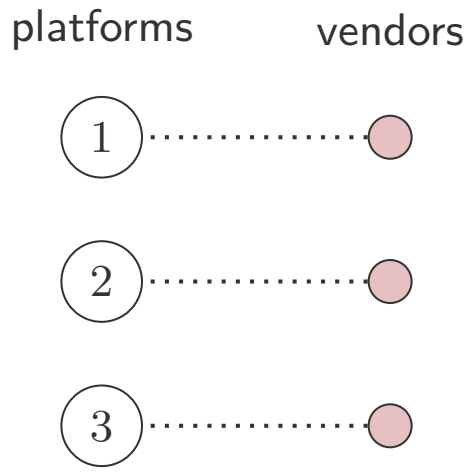
platforms

1

2

3

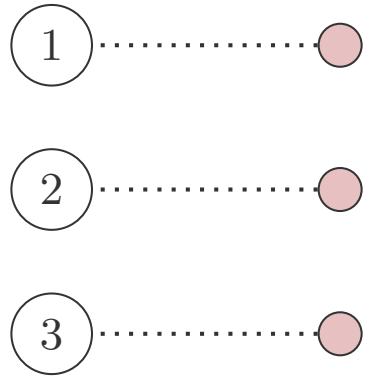
Summing Up



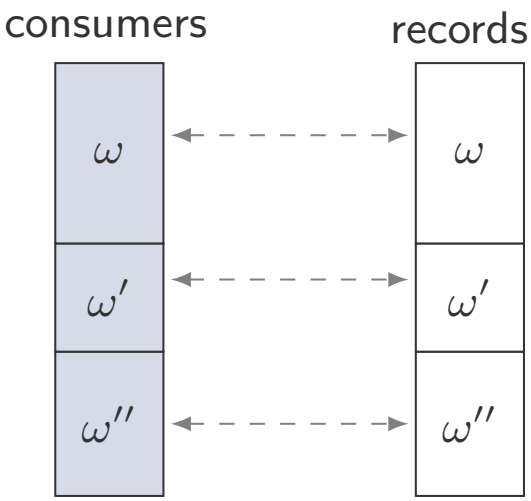
Summing Up

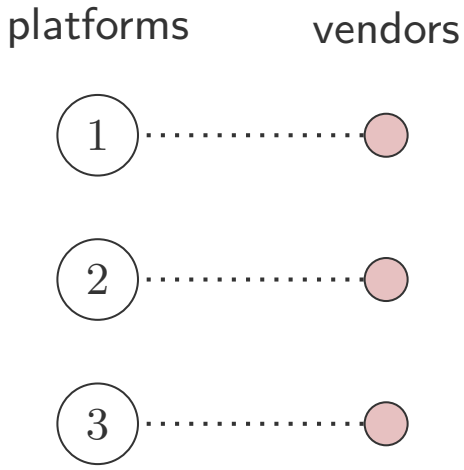
consumers

platforms vendors

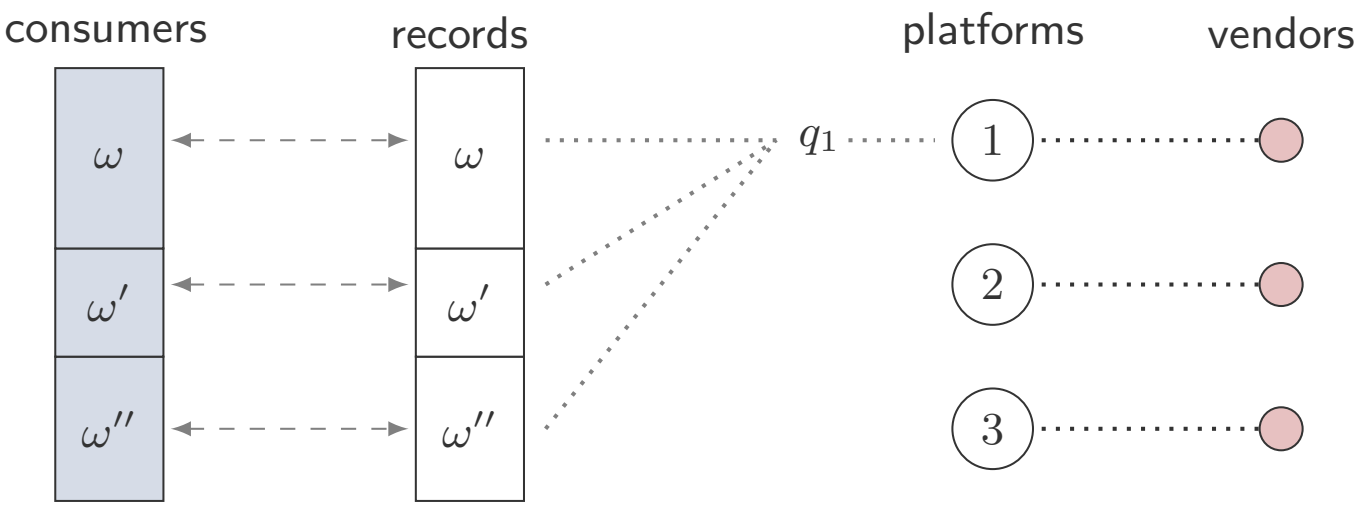


Summing Up


consumers
records
ω
ω'
ω''
ω
ω'
ω''


platforms
vendors
1
2
3

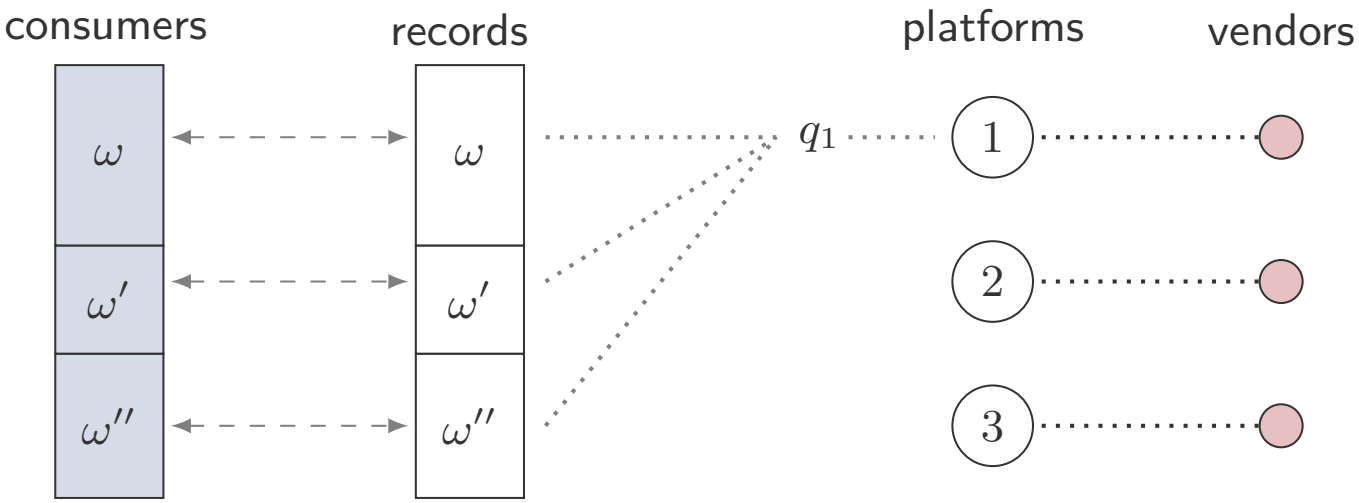
Summing Up



Timing:

1. Platform i acquires q_i in a **competitive market** for data records

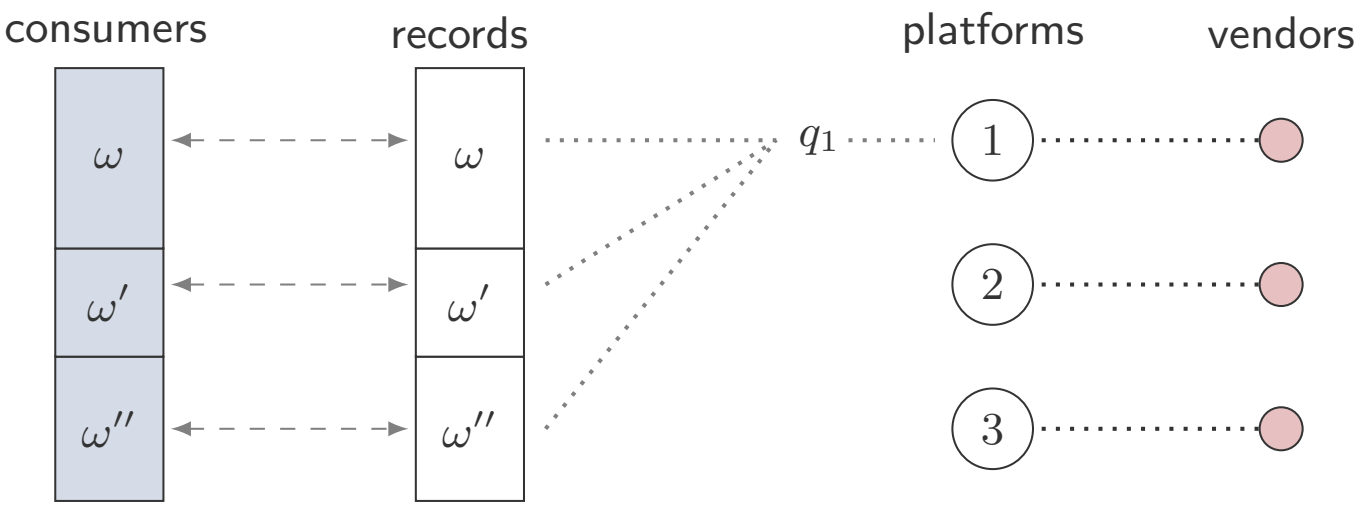
Summing Up



Timing:

1. Platform i acquires q_i in a **competitive market** for data records
2. Given database q_i, platform i chooses $x^*_{q_i}$

Summing Up



Timing:

1. Platform i acquires q_i in a **competitive market** for data records
2. Given database q_i, platform i chooses $x^*_{q_i}$
3. Payoffs realize

results

Three Economies

We study the welfare properties of three different economies:

$\mathcal{E}_1$ An economy with expropriation

Platforms own consumers data and can trade

$\mathcal{E}_2$ An economy with data ownership

Consumers own their data and can trade

$\mathcal{E}_3$ An economy with data ownership and Lindhal prices

Data are priced conditional on how it is used

$\mathcal{E}_1$ – An Economy with Expropriation

In this economy:

- Consumers "expropriated" of their records: no control, imperfect compns
- Platforms trade records among each other, taking prices as given

$\mathcal{E}_1$ – An Economy with Expropriation

In this economy:

- Consumers "expropriated" of their records: no control, imperfect compns
- Platforms trade records among each other, taking prices as given

Definition. Equilibrium in $\mathcal{E}_1$

Prices $p^* \in \mathbb{R}^{\Omega}$ and a feasible data allocation $q^* \in \mathbb{R}_+^{\Omega \times I}$ are an equilibrium of $\mathcal{E}_1$ if:

1. Platforms maximize given prices $\quad q_i^* \in \arg\max_{q_i} U_i(q_i) - \sum_{\omega} p^*(\omega) q_i(\omega)$
2. All markets clear $\quad$ for all ω, $p^*(\omega)\left(\bar{q}(\omega) - \sum_i q_i^*(\omega)\right) = 0$

$\mathcal{E}_1$ – An Economy with Expropriation

Platform i's payoff depends only on q_i, not on q_j (exclusivity)

$\mathcal{E}_1$ – An Economy with Expropriation

Platform i's payoff depends only on q_i, not on q_j (exclusivity)

Proposition. Equilibrium Characterization in $\mathcal{E}_1$

Equilibria of $\mathcal{E}_1$ exist and maximize the sum of platforms' payoffs

Every platform-optimal allocation can be supported as an equilibrium of $\mathcal{E}_1$

Equilibria are solutions of a grand-information design (LP) problem

$\mathcal{E}_1$ – An Economy with Expropriation

Platform i's payoff depends only on q_i, not on q_j (exclusivity)

Proposition. Equilibrium Characterization in $\mathcal{E}_1$

Equilibria of $\mathcal{E}_1$ exist and maximize the sum of platforms' payoffs

Every platform-optimal allocation can be supported as an equilibrium of $\mathcal{E}_1$

Equilibria are solutions of a grand-information design (LP) problem

$\mathcal{E}_1$ – An Economy with Expropriation

Platform i's payoff depends only on q_i, not on q_j (exclusivity)

Proposition. Equilibrium Characterization in $\mathcal{E}_1$

Equilibria of $\mathcal{E}_1$ exist and maximize the sum of platforms' payoffs

Every platform-optimal allocation can be supported as an equilibrium of $\mathcal{E}_1$

Equilibria are solutions of a grand-information design (LP) problem

$\mathcal{E}_2$ – An Economy with Data Ownership

$\mathcal{E}_2$ is the economy we analyzed earlier

$\mathcal{E}_2$ – An Economy with Data Ownership

$\mathcal{E}_2$ is the economy we analyzed earlier

Equilibrium in $\mathcal{E}_2$:

Prices $p^* \in \mathbb{R}^{\Omega}$, data allocation $q^* \in \mathbb{R}_+^{\Omega \times (I+1)}$, consumers' decisions $\alpha^* \in (\Delta(I))^{\Omega}$ are an equilibrium if:

1. Given p^*, database q_i^* solves platform i's problem

$$q_i^* \in \arg\max_{q_i} U_i(q_i) - \sum_{\omega} p^*(\omega) q_i(\omega)$$

2. Given p^* and q^*, $\alpha^*(\omega)$ solves ω-consumer's problem

$$\alpha^*(\omega) \in \arg\max_{\alpha(\omega) \in \Delta(I)} (1 - \alpha(0|\omega)) r(\omega) + \sum_i \alpha(i|\omega) \Big(p^*(\omega) + \mathbb{E}_{q_i^*}(g_i(a_i, \omega)) \Big)$$

3. Markets clear

$$q_i^*(\omega) = \alpha^*(i|\omega) \bar{q}(\omega), \quad \forall \omega, i$$

$\mathcal{E}_2$ – An Economy with Data Ownership

What We Know:

- Equilibrium *can* be inefficient $\rightsquigarrow$ our leading example
- Sufficient conditions for efficiency:

Proposition. No-Intermediation Case

When $u_i = \pi_i$ for all i, equilibria in $\mathcal{E}_2$ exist and are efficient

$\mathcal{E}_2$ – An Economy with Data Ownership

What We Know:

- Equilibrium *can* be inefficient $\rightsquigarrow$ our leading example
- Sufficient conditions for efficiency:

Proposition. No-Intermediation Case

When $u_i = \pi_i$ for all i, equilibria in $\mathcal{E}_2$ exist and are efficient

What We Don't Know (yet):

- Sufficient conditions for inefficiency beyond examples?
- Sufficient conditions for existence in the intermediation case?

$\mathcal{E}_3$ – An Economy with Lindhal prices

How can we fix inefficiencies discussed so far?

$\mathcal{E}_3$ – An Economy with Lindhal prices

How can we fix inefficiencies discussed so far?

We enrich our economy by opening "more complete" markets

following e.g. Arrow 69, Laffont 78

- Consumers can sell record for a **specific purpose** (i.e. an action a_i)
- A richer price system: prices $p_i(\omega, a_i)$ depend on record type, on platform identity, and on intended use a_i

$\mathcal{E}_3$ – An Economy with Lindhal prices

How can we fix inefficiencies discussed so far?

We enrich our economy by opening "more complete" markets

following e.g. Arrow 69, Laffont 78

- Consumers can sell record for a **specific purpose** (i.e. an action a_i)
- A richer price system: prices $p_i(\omega, a_i)$ depend on record type, on platform identity, and on intended use a_i

This presumes data use is contractible

$\mathcal{E}_3$ – An Economy with Lindhal prices

How can we fix inefficiencies discussed so far?

We enrich our economy by opening "more complete" markets

following e.g. Arrow 69, Laffont 78

- Consumers can sell record for a **specific purpose** (i.e. an action a_i)
- A richer price system: prices $p_i(\omega, a_i)$ depend on record type, on platform identity, and on intended use a_i

This presumes data use is contractible

Proposition. Equilibrium Characterization in $\mathcal{E}_3$

Equilibria in $\mathcal{E}_3$ exist and are (first-best) efficient.

Every (first-best) efficient data allocation can be supported in an eqm

Equilibria are solutions of a grand-information design (LP) problem

Back to Example

Illustrate functioning of economy $\mathcal{E}_3$ with our earlier example

Return to case of market unravelling ($\beta < \epsilon$, $\gamma = 0$):

$$u(a, \omega) = \beta\ g(a, \omega) + \gamma\ \pi(a, \omega)$$

Record Type
$\omega = 1$
$\omega = 2$

Back to Example

Illustrate functioning of economy $\mathcal{E}_3$ with our earlier example

Return to case of market unravelling ($\beta < \epsilon$, $\gamma = 0$):

$$u(a, \omega) = \beta\ g(a, \omega) + \gamma\ \pi(a, \omega)$$

Record Type
$\omega = 1$
$\omega = 2$

Back to Example

Illustrate functioning of economy $\mathcal{E}_3$ with our earlier example

Return to case of market unravelling ($\beta < \epsilon$, $\gamma = 0$):

$$u(a, \omega) = \beta\ g(a, \omega) + \gamma\ \pi(a, \omega)$$

Record Type	**Prices**
$\omega = 1$	$p^*(1)$
$\omega = 2$	$p^*(2)$

Back to Example

Illustrate functioning of economy $\mathcal{E}_3$ with our earlier example

Return to case of market unravelling ($\beta < \epsilon$, $\gamma = 0$):

$$u(a, \omega) = \beta\ g(a, \omega) + \gamma\ \pi(a, \omega)$$

Record Type	**Prices**
$\omega = 1$	$p^*(1, a = 1)$
	$p^*(1, a = 2)$
$\omega = 2$	$p^*(2, a = 1)$
	$p^*(2, a = 2)$

Back to Example

Illustrate functioning of economy $\mathcal{E}_3$ with our earlier example

Return to case of market unravelling ($\beta < \epsilon$, $\gamma = 0$):

$$u(a, \omega) = \beta\ g(a, \omega) + \gamma\ \pi(a, \omega)$$

Record Type	**Prices**
$\omega = 1$	$p^*(1, a = 1)$
	$p^*(1, a = 2)$
$\omega = 2$	$p^*(2, a = 1)$
	$p^*(2, a = 2)$

Back to Example

Illustrate functioning of economy $\mathcal{E}_3$ with our earlier example

Return to case of market unravelling ($\beta < \epsilon$, $\gamma = 0$):

$$u(a, \omega) = \beta\ g(a, \omega) + \gamma\ \pi(a, \omega)$$

Record Type	Prices
$\omega = 1$	$p^*(1,1) = \beta + 1 - \varepsilon$
	$p^*(1,2) = 0$
$\omega = 2$	$p^*(2,1) = -(1 - \varepsilon)$
	$p^*(2,2) = 0$

Back to Example

Illustrate functioning of economy $\mathcal{E}_3$ with our earlier example

Return to case of market unravelling ($\beta < \epsilon$, $\gamma = 0$):

$$u(a, \omega) = \beta\ g(a, \omega) + \gamma\ \pi(a, \omega)$$

Record Type	Prices	Records Kept	Records Used
$\omega = 1$	$p^*(1,1) = \beta + 1 - \varepsilon$ $p^*(1,2) = 0$	0	$1 \rightsquigarrow a = 1$
$\omega = 2$	$p^*(2,1) = -(1 - \varepsilon)$ $p^*(2,2) = 0$	1	$1 \rightsquigarrow a = 1$

Back to Example

Illustrate functioning of economy $\mathcal{E}_3$ with our earlier example

Return to case of market unravelling ($\beta < \epsilon$, $\gamma = 0$):

$$u(a, \omega) = \beta\ g(a, \omega) + \gamma\ \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Records Used**	**Consumers Welfare**
$\omega = 1$	$p^*(1,1) = \beta + 1 - \varepsilon$ $p^*(1,2) = 0$	0	$1 \rightsquigarrow a = 1$	$1 + \beta + \varepsilon$
$\omega = 2$	$p^*(2,1) = -(1 - \varepsilon)$ $p^*(2,2) = 0$	1	$1 \rightsquigarrow a = 1$	

Back to Example

Illustrate functioning of economy $\mathcal{E}_3$ with our earlier example

Return to case of market unravelling ($\beta < \epsilon$, $\gamma = 0$):

$$u(a, \omega) = \beta\ g(a, \omega) + \gamma\ \pi(a, \omega)$$

Record Type	**Prices**	**Records Kept**	**Records Used**	**Consumers Welfare**
$\omega = 1$	$p^*(1,1) = \beta + 1 - \varepsilon$ $p^*(1,2) = 0$	0	$1 \rightsquigarrow a = 1$	$1 + \beta + \varepsilon$
$\omega = 2$	$p^*(2,1) = -(1 - \varepsilon)$ $p^*(2,2) = 0$	1	$1 \rightsquigarrow a = 1$	

Back to Example

Illustrate functioning of economy $\mathcal{E}_3$ with our earlier example

Return to case of market unravelling ($\beta < \epsilon$, $\gamma = 0$):

$$u(a, \omega) = \beta\ g(a, \omega) + \gamma\ \pi(a, \omega)$$

Record Type	Prices	Records Kept	Records Used	Consumers Welfare
$\omega = 1$	$p^*(1,1) = \beta + 1 - \varepsilon$ $p^*(1,2) = 0$	0	$1 \rightsquigarrow a = 1$	$1 + \beta + \varepsilon$
$\omega = 2$	$p^*(2,1) = -(1 - \varepsilon)$ $p^*(2,2) = 0$	1	$1 \rightsquigarrow a = 1$	

Comments

- High-type consumers subsidize the platform to acquire low-type consumers data
- Previously this was not an equilibrium. Why?

How Realistic is $\mathcal{E}_3$?

How Realistic is $\mathcal{E}_3$?

It captures a qualitative feature of recent privacy-protection policies

- EU's GDPR: "*The **specific purposes** for which personal data are processed should be explicit and determined at the time of the collection of the personal data*"

How Realistic is $\mathcal{E}_3$?

It captures a qualitative feature of recent privacy-protection policies

- EU's GDPR: "*The **specific purposes** for which personal data are processed should be explicit and determined at the time of the collection of the personal data*"

However, number of markets required unrealistic large

How Realistic is $\mathcal{E}_3$?

It captures a qualitative feature of recent privacy-protection policies

- EU's GDPR: "*The **specific purposes** for which personal data are processed should be explicit and determined at the time of the collection of the personal data*"

However, number of markets required unrealistic large

Open Questions:

1. Intermediate solutions, partial decentralization?
2. "Non-market" solutions: Data Unions?

conclusions

Summary

1. We introduce framework to study competitive markets for personal data and their equilibria

- Rather general setting: many platforms, many merchants, arbitrary objectives, partially informative records, multiple types

2. We identify a novel externality that can make these markets inefficient

- The way platforms withhold information creates externalities that can lead to market failures

3. We discuss possible solutions and their limits

thank you