The effects of personal data management on competition and welfare

Jiajia Cong (Fudan University)
Noriaki Matsushima (Osaka University)

@CPRC

18 November 2022

What this paper does (1/2)

Setting **A duopoly model in which consumers purchase products in two independent markets: data collection (smart watch) and data application (health care).**

Pricing **In the data application market, each firm can offer personalized prices to its targeted customers and a uniform price to untargeted consumers.**

Privacy management **Each firm's targeted customers can erase their data from the database to become untargeted consumers by incurring a fixed cost *before* the firms offer prices.**

What this paper does (2/2)

Setting **A duopoly model in which consumers purchase products in two independent markets: data collection and data application.**

Results **In the data application market, privacy management harms the total surplus, the consumer surplus, and firms, except for opt-out consumers.**

In the data collection market, privacy management also intensifies competition, lowering the two-market profits and benefiting consumers.

The intensity of competition in the data collection market depends on whether consumers foresee the outcome in the data application market.

Extensions **We extend the model in several directions.**

Background (1/4)

Consumer data and analytics **Combining consumer data and advanced data analytics has been recognized as useful for developing data-utilizing markets (e.g., healthcare) (Goldfarb and Tucker, 2019).**

Big tech and data **The healthcare market interests the famous Big Tech firms, which have high capabilities in data analytics and personalized services (Ozalp et al., 2022, *California Manage. Rev.*).**

Google **becomes a central player in the market since it made public plans to develop Google Health for health insurers and doctors (Ozalp et al., 2022).**

Google Health

https://health.google/

Background (2/4)

Data collection **Google completed the $2.1 billion acquisition of Fitbit (a smartwatch maker) in 2021 (Bourreau et al., 2020; Chen et al., 2022).**

https://www.google.com/ https://www.fitbit.com/global/it/products

Background (2/4)

Data collection **Google-Fitbit merger with $2.1 billion in 2021 (Bourreau et al., 2020; Chen et al., 2022).**

Apple has already sold its smartwatch, the Apple Watch, enabling Apple to provide health support to users (Santos-Lozano et al., 2018).

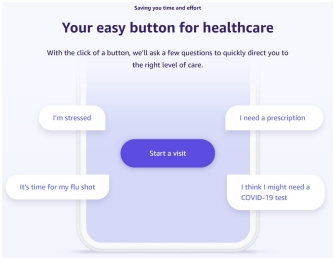
https://www.apple.com/it/apple-watch-series-8/

Background (2/4)

Data collection **Google-Fitbit merger with $2.1 billion in 2021 (Bourreau et al., 2020; Chen et al., 2022).**

The Apple watch enables Apple to provide health support to users (Santos-Lozano et al., 2018).

Amazon allows consumers to communicate with health care companies through a smart speaker, Alexa.



Amazon purchased online pharmacy PillPack and digital health startup Health Navigator, and now offers employees its virtual health care (Farr, 2019).

https://www.amazon.co.jp/gp/product/B07PFFMQ64/
https://www.pillpack.com/ https://amazon.care/about

Background (3/4)

Data privacy **Some firms caused disputes concerning consumers' privacy in the healthcare market (Schneble et al., 2020). Consumers' concerns about their data privacy and raising the need to establish laws on the privacy of consumers' data.**

Data management **The General Data Protection Regulation (GDPR) is a typical example of granting consumers greater rights to control their data.**

Consumers can order the firm to erase their data (Article 17).

Those consumers can order the firm to transmit their data from the firm to another firm if technically feasible (Article 20).

Background (4/4)

On debate **Although privacy laws secure the right of consumers to manage their personal data, the impact of the right on competitive environments is unclear and still under debate (e.g., Jia et al., 2021; Aridor et al., 2022; Peukert et al., 2022).**

What we do **We, therefore, consider the effect of consumers' personal data management on welfare and profits.**

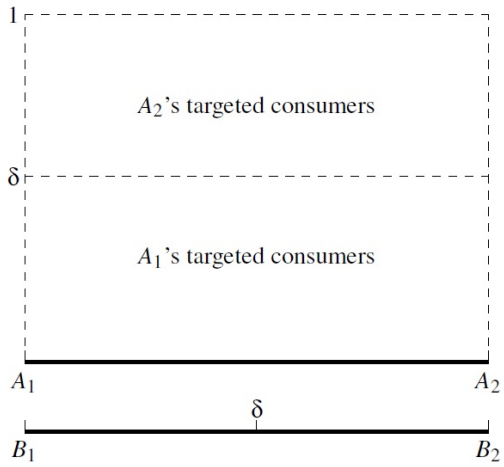
Preview of the model (1/4)

Duopoly model **Consumers purchase products in two independent markets: data collection, market B (e.g., wearable devices) and data application, market A (e.g., healthcare and insurance).**

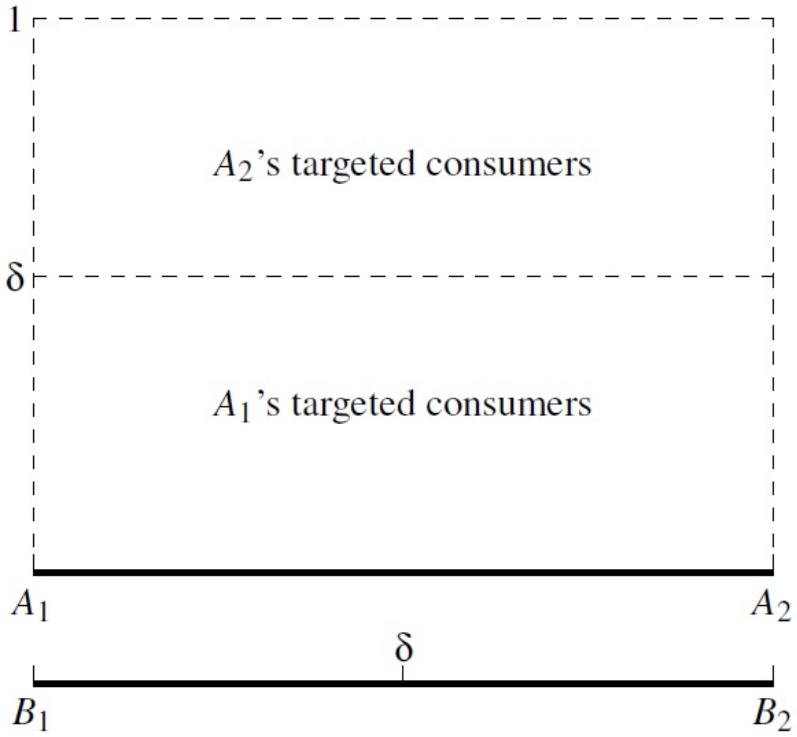
Prview of the model (1/4)

Duopoly model **Consumers purchase products in two independent markets: data collection, market B and data application, market A.**

1. **The firms try to acquire consumers in market B.**
2. **The data collected uniquely by each firm capture its customers' preferences for its product in market A.**
3. **In market A, each firm offers personalized prices based on the data collected in market B to its targeted customers and a uniform price to untargeted consumers.**



Preview of the model (2/4)



No privacy management

The market structure in market A.

δ: The demand for firm 1 in market B

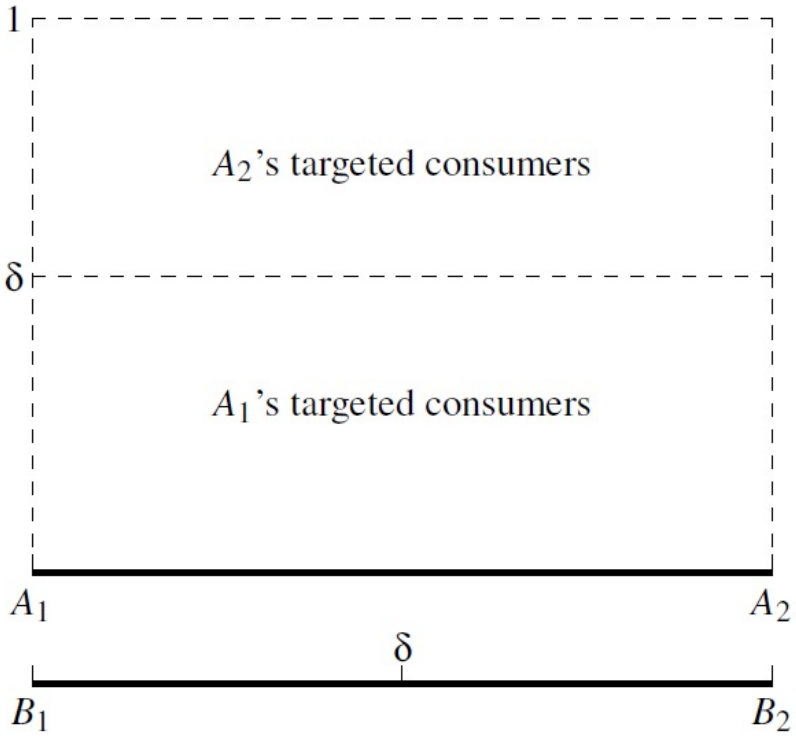
Preview of the model (3/4)

Duopoly model **data collection, market B and data application, market A.**

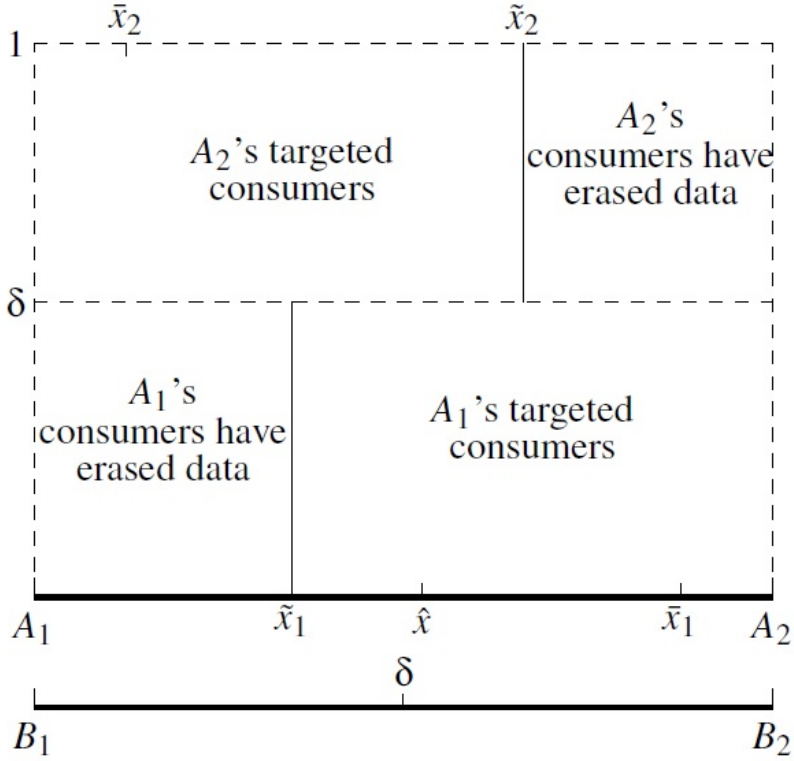
1. **The firms try to acquire consumers in market B.**
2. **The data collected uniquely by each firm capture its customers' preferences for its product in market A.**
3. **In market A, each firm offers personalized prices to its targeted customers and a uniform price to untargeted consumers.**

Data eraser **Each firm's targeted customers can erase their data from the database to become untargeted consumers by incurring a fixed cost.**

Preview of the model (4/4)



No privacy management



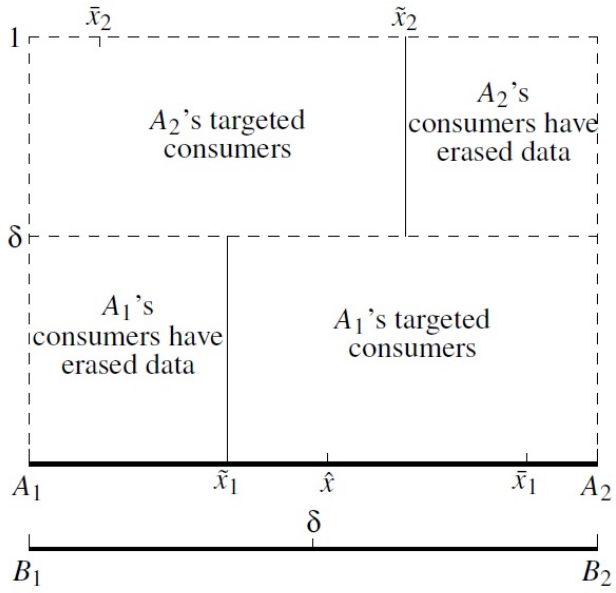
Privacy management

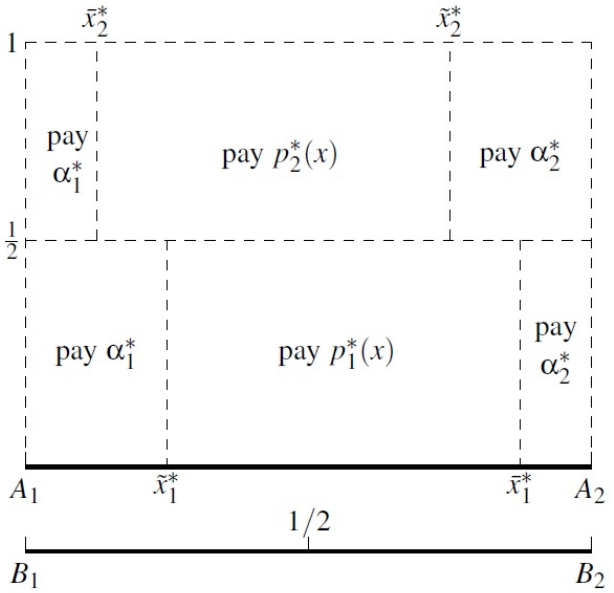
The market structure in market A.

δ: The demand for firm 1 in market B

Preview of the Results (market A)

1. **Consumers who strongly prefer one firm over the other are more likely to erase their data.**
2. **The data erasure by those opt-out consumers increases the uniform prices.**
3. **Those increases induce the firms to set higher personalized prices, harming opt-in consumers.**





Preview of the Results (market B)

- **Privacy management (PM) intensifies competition in market B, although it lowers profits in market A.**

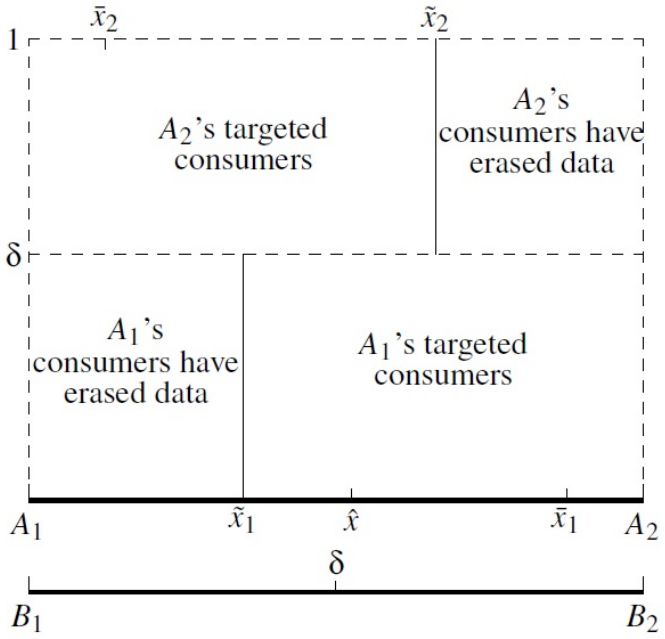
A larger δ,

$\Rightarrow$ **a larger number of opt-out consumers,**

$\Rightarrow$ **a higher uniform price,**

$\Rightarrow$ **consumers are less likely to erase (lower $\tilde{x}_1$),**

$\Rightarrow$ **personalized pricing is more profitable**



Preview of the Results

- **Privacy management (PM) intensifies competition in market B, although it lowers profits in market A.**
- **PM lowers two-market profits.**
- **PM increases consumer welfare in market B. However, it harms consumers in market A except for opt-out consumers.**

  In total, PM decreases consumer welfare in the two markets if consumers are myopic.
  PM increases consumer welfare in the two markets if consumers are forward-looking.

Preview of Extensions

1. **Opt-in product personalization and privacy costs**

   [Result] An increase in the gain from personalized products harms the firms' two-market profits and improves the consumer and total surpluses.

2. **Data portability: Consumers can give their data gathered by a firm to the competing firm.**
3. **Consumer heterogeneity regarding privacy costs.**

Preview of Extensions

1. **Opt-in product personalization and privacy costs**
2. **Data portability: Consumers can give their data gathered by a firm to the competing firm.**

   [Results] Competition in market A intensifies but the firms have lower incentives to acquire a lot of customers' data in market B, improving the firms' two-market profits but diminishing the sum of the consumer surpluses.

3. **Consumer heterogeneity regarding privacy costs.**

Preview of Extensions

1. **Opt-in product personalization and privacy costs**
2. **Data portability: Consumers can give their data gathered by a firm to the competing firm.**
3. **Consumer heterogeneity regarding privacy costs.**

[Result] Privacy management improves the consumer surplus in each market if the number of privacy-sensitive consumers exceeds a threshold value.

Literature (1/5)

Personalized pricing **Earlier works show that personalized pricing is worse for firms than uniform pricing (Thisse and Vives, 1988; Shaffer and Zhang, 1995; Bester and Petrakis, 1996; Zhang, 2011).**

Data acquisition and data application **Two-stage models (Choe et al., 2018; Choe et al., 2022; Chen et al., 2022; Herresthal et al., 2022; Laussel and Resende, 2022).**

Chen et al. (2022) consider two-stage duopoly models in which only one of the firms can apply customer data collected in a market to another market to offer personalized prices. Consumers' data management is out of scope in their paper.

Literature (2/5)

Data management and personalized prices **Monopoly (Conitzer et al., 2012; Belleflamme and Vergote, 2016; Koh et al., 2017, Ke and Sudhir, 2022), duopoly (Ali et al., 2022), oligopoly (differentiated goods: Anderson et al., 2022; ex-ante homogeneous goods: Ke and Sudhir, 2022).**

Ke and Sudhir (2022, *Mng. Sci.*): heterogeneous WTP (BV, 2016); observing prices, consumers can erase the identity (Chen et al., 2020, Section 5.2).

Ex-post indentity management (privacy rights) decreases consumer and social welfare but increases the monopolist's profits when the fixed cost to erase the identity is low enough.

Literature (3/5)

Data management and personalized prices **Monopoly (Conitzer et al., 2012; Belleflamme and Vergote, 2016; Koh et al., 2017, Ke and Sudhir, 2022), duopoly (Ali et al., 2022), oligopoly (differentiated goods: Anderson et al., 2022; ex-ante homogeneous goods: Ke and Sudhir, 2022).**

Ali et al. (2022, *RES*): Consumers can reveal their preferences. All consumers benefit from information revelation; consumers around the center reveal the exact locations, related to our data portability case.

We consider different consumers' information management and the cross-market effect of information acquisitions.

Literature (4/5)

Data management and personalized prices **Monopoly (Conitzer et al., 2012; Belleflamme and Vergote, 2016; Koh et al., 2017, Ke and Sudhir, 2022), duopoly (Ali et al., 2022), oligopoly (differentiated goods: Anderson et al., 2022; ex-ante homogeneous goods: Ke and Sudhir, 2022).**

Anderson et al. (2022, *RES*): Two-stage game (uniform pricing, personalized targeted discounts and uniform pricing). Consumers can deny receiving targeted discounts at the beginning of the game (stage 0).

The denials of having personalized discounts can benefit firms and consumers through mitigating discount competition and lowering uniform prices.

Literature (5/5)

Data and competition **Accumulating data gives the firm a competitive advantage (Farboodi et al., 2019; Prüfer and Schottmüller, 2021; Cordorelli and Padilla, 2022; de Corniére and Taylor, 2022; Hagiu and Wright, 2022). Markets for consumer data (Choi et al., 2019; Ichihashi, 2021; Acemoglu et al., 2022; Bergemann et al., 2022).**

Ichihashi (2020): Information disclosure by a consumer and product recommendation with pricing by a seller in buyer-seller models. Price commitment by the seller benefits the seller but harms the buyer.

The interaction between consumers' data management and personalized pricing is out of scope in the papers.

Model (1/4)

Two markets **Data application (A) and data collection (B).**

Firms 1 and 2 **A_1 and A_2 in A; B_1 and B_2 in B. Zero costs.**

Consumers **are distributed on the two independent Hotelling lines $[0,1] \times [0,1]$. Unit demand.**

Market B **B_1 and B_2 are at the edges on $[0,1]$.**

The utitlity of consumer $y \in [0,1]$ is

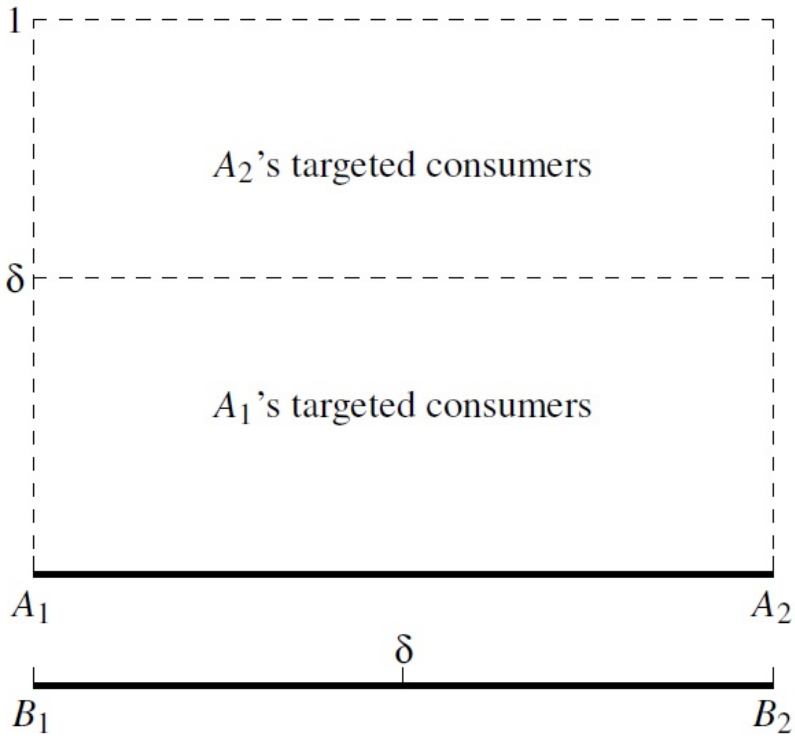
$$\begin{cases} v_B - ty - \beta_1 & \text{buying from } B_1, \\ v_B - t(1-y) - \beta_2 & \text{buying from } B_2, \end{cases}$$

v_B and t: positive constants; β_i: B_i's price.

Market A **A_1 and A_2 are at the edges on $[0,1]$.**

A_i can know the exact realized locations x of consumers in market A if those consumers are B_i's targeted consumers thanks to the help of consumer data.

Model (2/4)



The market structure in market A.

δ: The demand for firm 1

Model (3/4)

Two markets **Data application (A) and data collection (B).**

Firms 1 and 2 **A_1 and A_2 in A; B_1 and B_2 in B. Zero costs.**

Consumers **are on $[0,1] \times [0,1]$. Unit demand.**

Market A **A_1 and A_2 are at the edges on $[0,1]$.**

$p_i(x)$: A_i's personalized prices to targeted consumers,

α_i: A_i's uniform price to non-targeted consumers.

Targeted consumers **The choices of A_i's targeted consumers**

1. $u = v_A - tx - p_i(x)$ **by purchasing from** A_i **($x \in [0,1]$),**

2. $u = v_A - t(1-x) - \alpha_j$ **by puchasing from** A_j**.**

Erasure **Consumers can erase data *before* the firms set prices.**

When one erases data by incurring $\varepsilon(>0)$, the choices:

1. $u = v_A - tx - \alpha_i$ **by purchasing from** A_i **($x \in [0,1]$),**

2. $u = v_A - t(1-x) - \alpha_j$ **by purchasing from** A_j**.**

Model (4/4)

Two markets **Data application (A) and data collection (B).**

Firms 1 and 2 **A_1 and A_2 in A; B_1 and B_2 in B. Zero costs.**

Consumers **are on $[0,1] \times [0,1]$. Unit demand.**

Targeted consumers **The choices of A_i's targeted consumer**

$$A_i.\ u = v_A - tx - p_i(x);\ A_j.\ u = v_A - t(1-x) - \alpha_j.$$

Erasure **Incur $\varepsilon(> 0)$, the choices of untergated consuemrs**

$$A_i.\ u = v_A - tx - \alpha_i;\ A_j.\ u = v_A - t(1-x) - \alpha_j.$$

Timing **1. Compete in market B under uniform prices.**

2. Consumers decide whether to erase their data.

3. Posting observable uniform prices in market A.

4. A_i offers $p_i(x)$ to its targeted consumers.

The sequence follows the literature (Thisse and Vives, 1988) and reflects the flexibility in personalized prices.

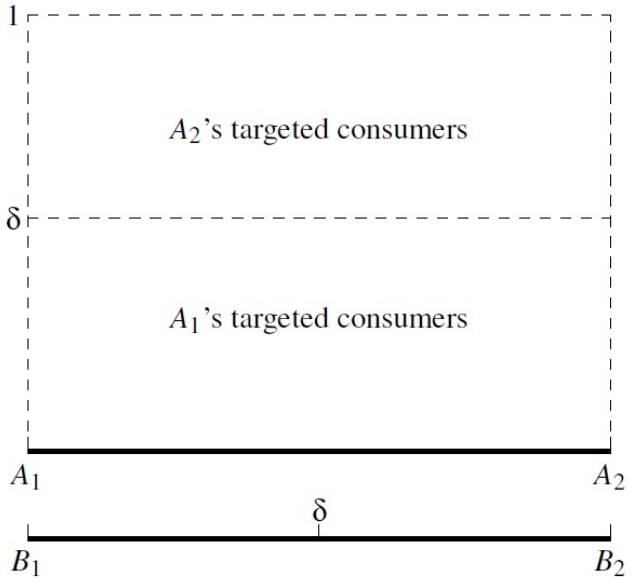
Analysis w/o privacy management (1/2)

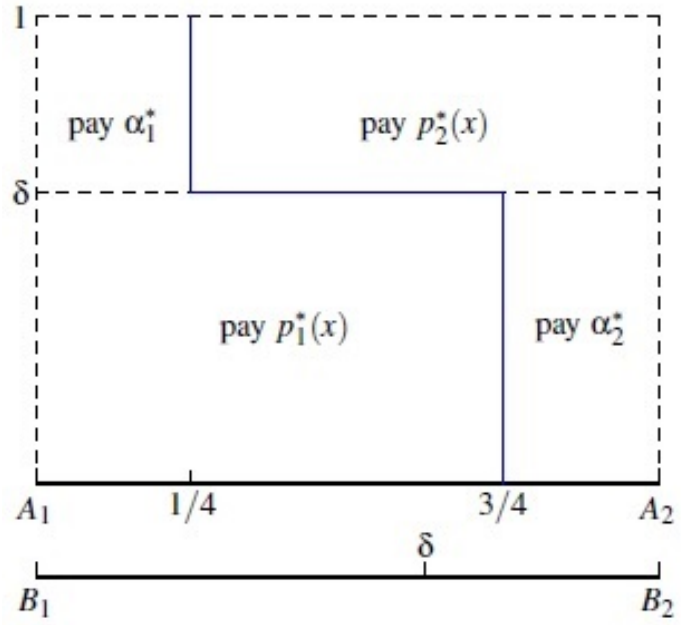
Mrkt A **The same as Thisse and Vives (1988) in market A:**

$$\alpha_1^n = \alpha_2^n = t/2,$$

$$p_1^n(x) = \begin{cases} 2t(3/4 - x) & \textbf{if} \quad x \leq 3/4, \\ 0 & \textbf{if} \quad x \geq 3/4, \end{cases}$$

$$p_2^n(x) = \begin{cases} 0 & \textbf{if} \quad x \leq 1/4, \\ 2t(x - 1/4) & \textbf{if} \quad x \geq 1/4. \end{cases}$$





Analysis w/o privacy management (2/2)

Mrkt B **Two cases about consumers' foresight: Myopic and forward-looking.**

The expected consumer surplus from choosing firm i is the same as that from choosing firm j under w/o privacy management.

Indifferent consumer $\delta = (t + \beta_2 - \beta_1)/(2t)$ **(β_i: B_i's price)**

Objectives **Firm i maximizes the two-market profits:**

$$\Pi_1 = \pi_{A1} + \pi_{B1}, \quad \Pi_2 = \pi_{A2} + \pi_{B2},$$

π_{ki}: profit of $i \in \{1, 2\}$ in market $k \in \{A, B\}$.

The equilibrium outcome is

$\beta_i^n = 9t/16$, $\delta^n = 1/2$, $\pi_{B_i}^n = 9t/32$, $\pi_{A_i}^n = 11t/32$, $\Pi_i^n = 5t/8$.

Analysis with privacy management (1/9)

Market A (1/3) **The choices of A_1's targeted consumers:**

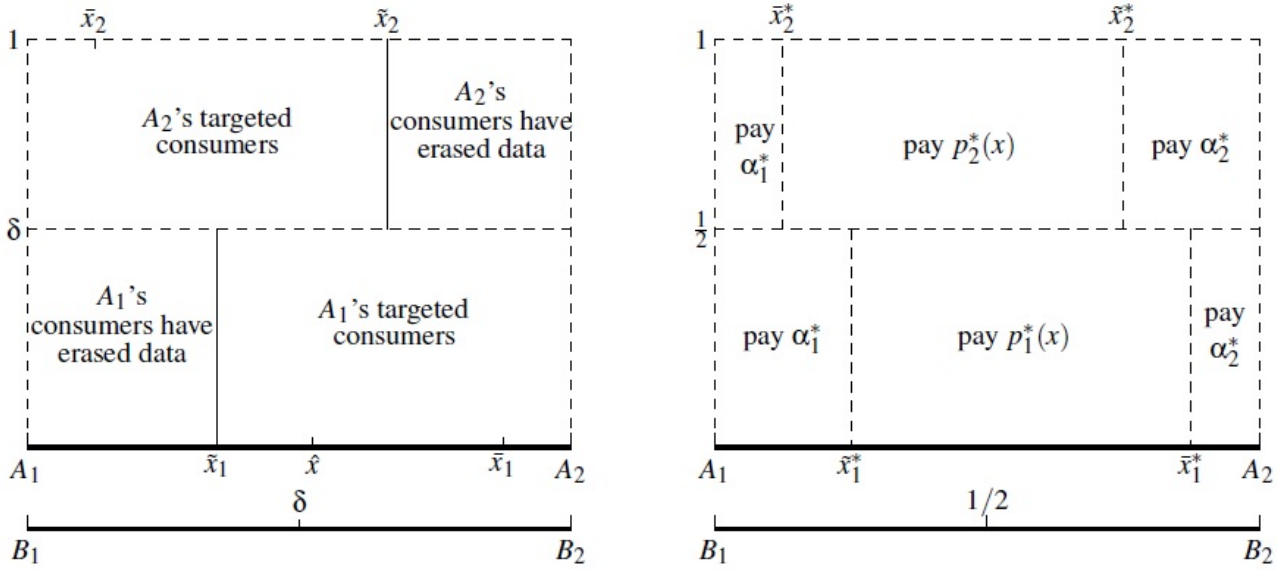
Erasure: $v_A - tx - \alpha_1^a - \varepsilon$

No erasure: $v_A - tx - p_1^a(x) = v_A - tx - (\alpha_2^a + t(1-2x))$

Consumers with $x \leq \tilde{x}_1$ erase their data, where

$$\tilde{x}_1 \equiv \frac{1}{2} + \frac{\alpha_2^a - \alpha_1^a}{2t} - \frac{\varepsilon}{2t}.$$

Similar to A_2's targeted consumers.



(a) Targeted consumers after privacy management

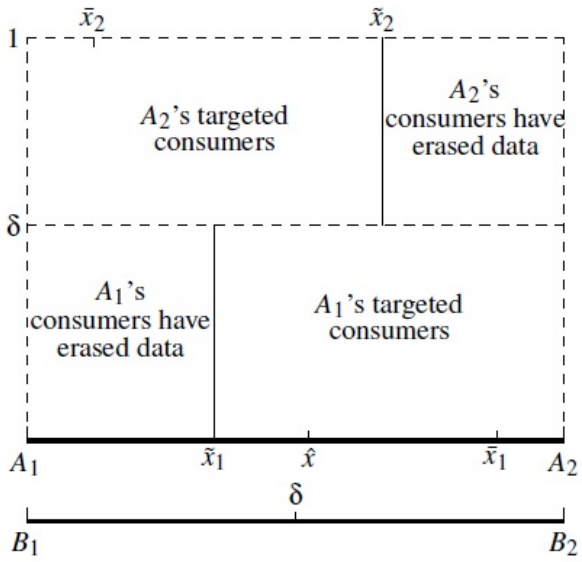
(b) Equilibrium market outcome

Analysis with privacy management (2/9)

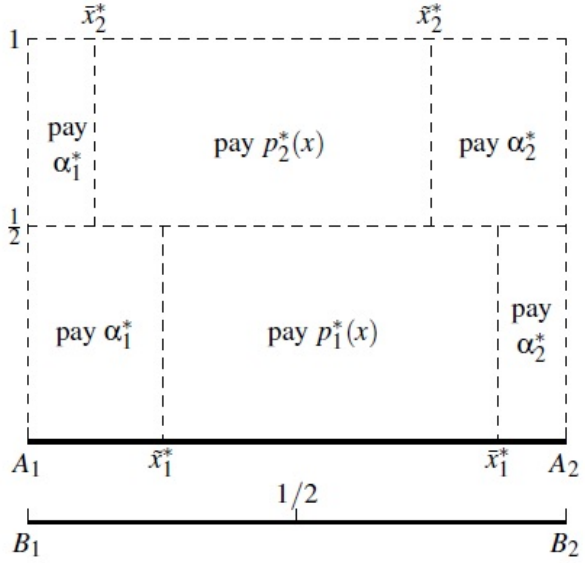
Market A (2/3) A_1 **sets** α_1 **to maximize the following:**

$$\begin{cases} \alpha_1 \left[(1-\delta)\left(\frac{1}{2} - \frac{\alpha_1}{2t}\right) + \delta\tilde{x}_1 \right] & \textbf{when } \alpha_1 \le t \\ \alpha_1 \delta \tilde{x}_1 & \textbf{when } \alpha_1 \ge t \textbf{ and } \hat{x} \ge \tilde{x}_1. \end{cases}$$

$$\Rightarrow \alpha_1 = \frac{t}{2} + \frac{t\tilde{x}_1\delta}{1-\delta}, \quad \alpha_2 = \frac{t}{2} + \frac{t(1-\tilde{x}_2)(1-\delta)}{\delta}.$$



(a) Targeted consumers after privacy management



(b) Equilibrium market outcome

Analysis with privacy management (3/9)

Market A (3/3) A_1 **sets** α_1 **to maximize the following:**

$$\begin{cases} \alpha_1 \left[(1-\delta) \left(\frac{1}{2} - \frac{\alpha_1}{2t} \right) + \delta \tilde{x}_1 \right] & \textbf{when } \alpha_1 \leq t \\ \alpha_1 \delta \tilde{x}_1 & \textbf{when } \alpha_1 \geq t \textbf{ and } \hat{x} \geq \tilde{x}_1. \end{cases}$$

$$\Rightarrow \alpha_1 = \frac{t}{2} + \frac{t\tilde{x}_1\delta}{1-\delta}, \quad \alpha_2 = \frac{t}{2} + \frac{t(1-\tilde{x}_2)(1-\delta)}{\delta}.$$

By $\tilde{x}_1 \equiv \frac{1}{2} + \frac{\alpha_2^a - \alpha_1^a}{2t} - \frac{\varepsilon}{2t}$ **and** $\tilde{x}_2 \equiv \frac{1}{2} + \frac{\alpha_2^a - \alpha_1^a}{2t} + \frac{\varepsilon}{2t}$**,**

$$\alpha_1^* = \frac{t}{2} + \delta(t-\varepsilon), \quad \alpha_2^* = \frac{t}{2} + (1-\delta)(t-\varepsilon),$$

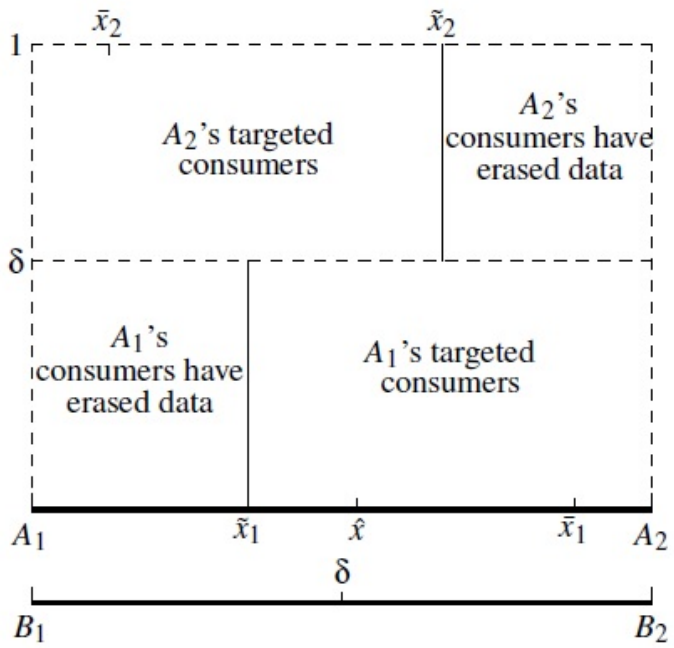
$$\tilde{x}_1^* = \frac{(1-\delta)(t-\varepsilon)}{t}, \quad \tilde{x}_2^* = 1 - \frac{\delta(t-\varepsilon)}{t}.$$

♢ **A higher** δ **leads to a higher** α_1^* **and a lower** $\tilde{x}_1^*$**.**
A_1 **focuses more on its opt-out consumers whose reservation values are high.**

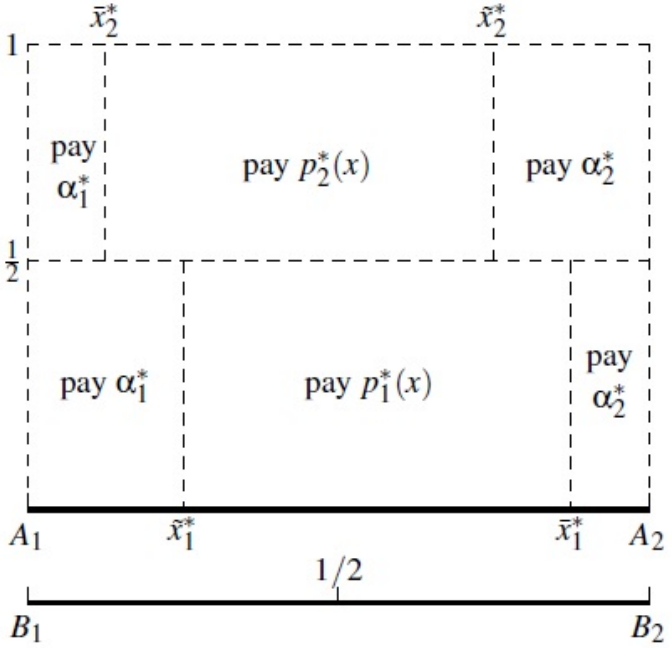
Analysis with privacy management (4/9)

Outcome (1/2) A_1 **wins the rival's targeted consumers on** $[0, \bar{x}_2^*]$**,** A_2 **wins the rival's targeted consumers on** $[\bar{x}_1^*, 1]$**.**

$$\bar{x}_2^* = \frac{1}{4} - \frac{\delta(t-\varepsilon)}{2t}, \quad \bar{x}_1^* = \frac{3}{4} + \frac{(1-\delta)(t-\varepsilon)}{2t}.$$



(a) Targeted consumers after privacy management



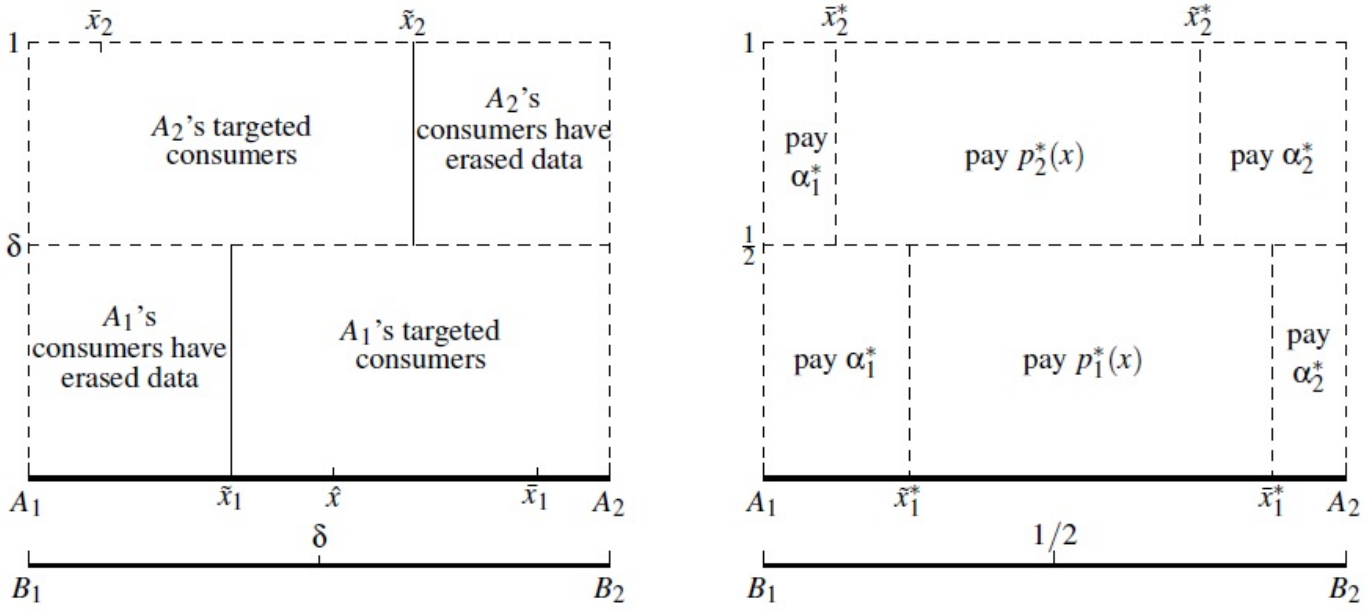
(b) Equilibrium market outcome

Analysis with privacy management (5/9)

Outcome (2/2) $p_1^*(x) = \alpha_2^* + t(1-2x), \quad p_2^*(x) = \alpha_1^* + t(2x-1),$

$$\pi_{A_1} = \alpha_1^*[\delta\tilde{x}_1^* + (1-\delta)\bar{x}_2^*] + \delta\int_{\tilde{x}_1^*}^{\bar{x}_1^*} p_1^*(x)dx,$$

$$\pi_{A_2} = \alpha_2^*[(1-\delta)(1-\tilde{x}_2^*) + \delta(1-\bar{x}_1^*)] + (1-\delta)\int_{\bar{x}_2^*}^{\tilde{x}_2^*} p_2^*(x)dx.$$



(a) Targeted consumers after privacy management

(b) Equilibrium market outcome

Analysis with privacy management (6/9)

Result **When consumers can manage their privacy,**

(i) **opt-out consumers mitigate price competition in market A;**

(ii) **A_i's uniform price α_i^* increases with its amount of opt-out consumers;**

(iii) **as ε becomes lower from a high level, the impact of an increase in δ on A_1's profit becomes stronger if $\delta \geq 1/2$; as ε becomes lower from a high level, the impact of an decrease in δ on A_2's profit becomes stronger if $\delta \leq 1/2$.**

Analysis with privacy management (7/9)

Market B **The competition mode is different from that without privacy management.**

Two cases about consumers' foresight: Myopic ($g = 0$) and forward-looking ($g = 1$).

Indifferent consumer $\delta = \frac{1}{2} + \frac{t(\beta_2 - \beta_1)}{2(t^2 - g(t-\varepsilon)\varepsilon)}$ **(β_i: B_i's price)**

- **The consumers' expected surplus from choosing a larger market share is higher than that from choosing a smaller market share.**
- **Forward-looking consumers are more price elastic.**

Analysis with privacy management (8/9)

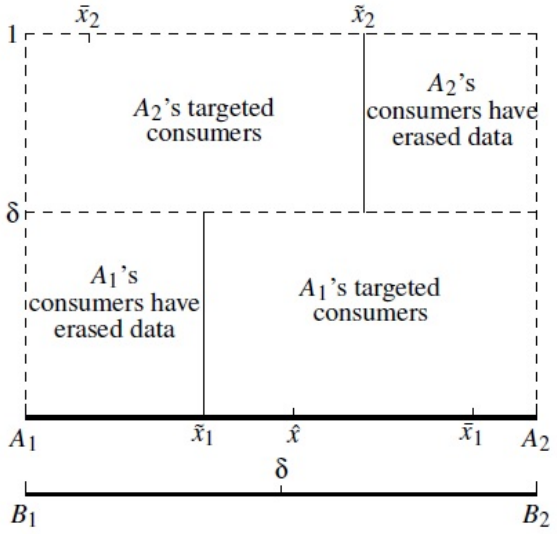
Indifferent consumer $\delta = \frac{1}{2} + \frac{t(\beta_2 - \beta_1)}{2(t^2 - g(t-\varepsilon)\varepsilon)}$ (β_i: B_i's price)

The equilibrium outcome (when ε decreases from t)

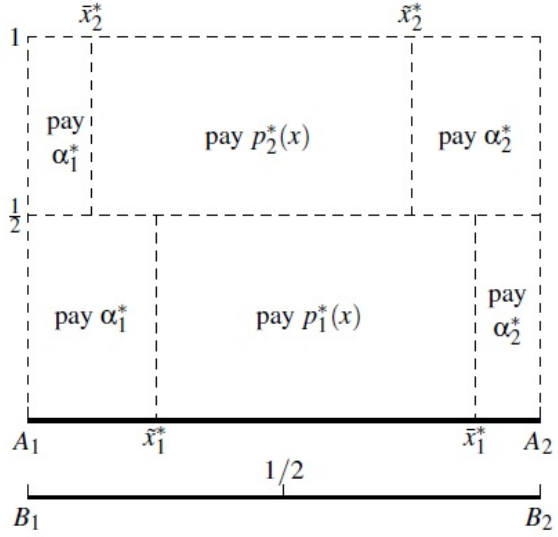
$\beta_i^* = \frac{(2t+\varepsilon)(4t-\varepsilon)}{16t} - \frac{g(t-\varepsilon)\varepsilon}{t} \downarrow$, $\pi_{B_i}^* = \frac{(2t+\varepsilon)(4t-\varepsilon)}{32t} - \frac{g(t-\varepsilon)\varepsilon}{2t} \downarrow$,

$\tilde{x}_1^* = \frac{t-\varepsilon}{2t} \uparrow$, $\alpha_i^* = \frac{2t-\varepsilon}{2} \uparrow$, $p_1^*(x) = \alpha_2^* + t(1-2x) \uparrow$, $\bar{x}_1^* = \frac{4t-\varepsilon}{4t} \uparrow$,

$\pi_{A_i}^* = \frac{12t^2+3\varepsilon^2-4t\varepsilon}{32t} \downarrow$, $\Pi_i^* = \frac{10t^2+\varepsilon^2-t\varepsilon}{16t} - \frac{g(t-\varepsilon)\varepsilon}{2t} \downarrow$



(a) Targeted consumers after privacy management



(b) Equilibrium market outcome

Analysis with privacy management (9/9)

Summary **Under privacy management, as the cost ε decreases,**

- (i) **profits decrease in markets A and B, and two-market profits decrease;**
- (ii) **consumer surplus decreases in market A and increases in market B, and total two-market consumer surplus decreases (resp. increases) if consumers are myopic (resp. forward-looking);**
- (iii) **social welfare in market A decreases and total social welfare decreases.**

Three extensions (1/7)

1. Gain and loss from personalization $\omega = \underbrace{\Delta v}_{gain} - \underbrace{c}_{loss}$.

$$p_1^*(x) = \begin{cases} 2t(1-x) - (\varepsilon - \omega)/2 & \textbf{when } \tilde{x}_1^* < x < \bar{x}_1^* \\ 0 & \textbf{when } x \geq \bar{x}_1^*, \end{cases}$$

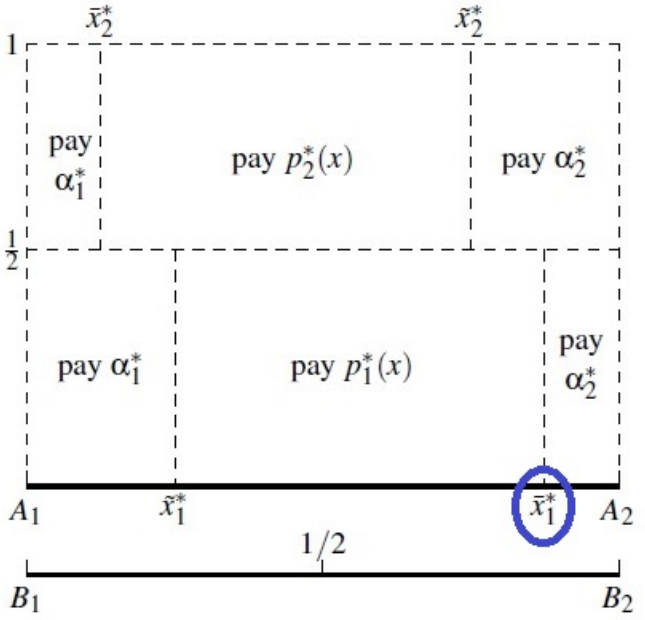
where $\bar{x}_1^* = 1 - (\varepsilon - \omega)/(4t)$, $\alpha_i^* = t - (\varepsilon + \omega)/2$.

$\beta_i^* = ((2t+\varepsilon)(4t-\varepsilon) - \omega(10t-\omega))/(16t)$, $\delta^* = 1/2$.

$$\pi_{A_i}^* = \frac{12t^2+3\varepsilon^2-4t\varepsilon+\omega(6\varepsilon+3\omega-4t)}{32t},$$

$$\pi_{B_i}^* = \frac{(2t+\varepsilon)(4t-\varepsilon)-\omega(10t-\omega)}{32t},$$

$$\Pi_i^* = \frac{10t^2+\varepsilon^2-t\varepsilon-\omega(7t-3\varepsilon-2\omega)}{16t}.$$



(b) Equilibrium market outcome

Three extensions (2/7)

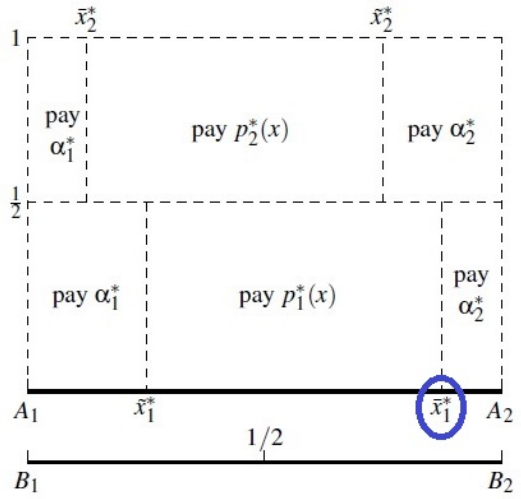
1. Gain and loss from personalization $\omega = \underbrace{\Delta v}_{gain} - \underbrace{c}_{loss}$.

Summary **Under privacy management,**

(i) The number of consumers who erase data is the same as in the main model, and their opt-out mitigates the price competition in market A;

(ii) as ω increases, A_i's profit increases iff $\omega > (2t - 3\varepsilon)/3$, and profits in market B always decrease;

(iii) firms in market A earn a lower profit iff $6\omega + 3\varepsilon > t$ holds, and firms in market B always earn a lower profit;



(b) Equilibrium market outcome

Three extensions (3/7)

1. Gain and loss from personalization $\omega = \underbrace{\Delta v}_{gain} - \underbrace{c}_{loss}$.

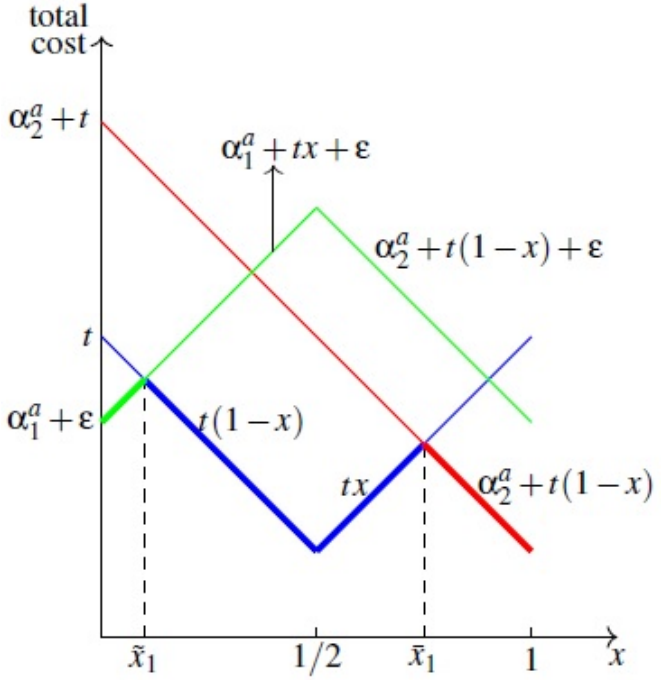
Summary **Under privacy management,**

(iv) the highest privacy management cost (i.e., $\varepsilon = t$) brings the largest total consumer surplus and total social welfare;

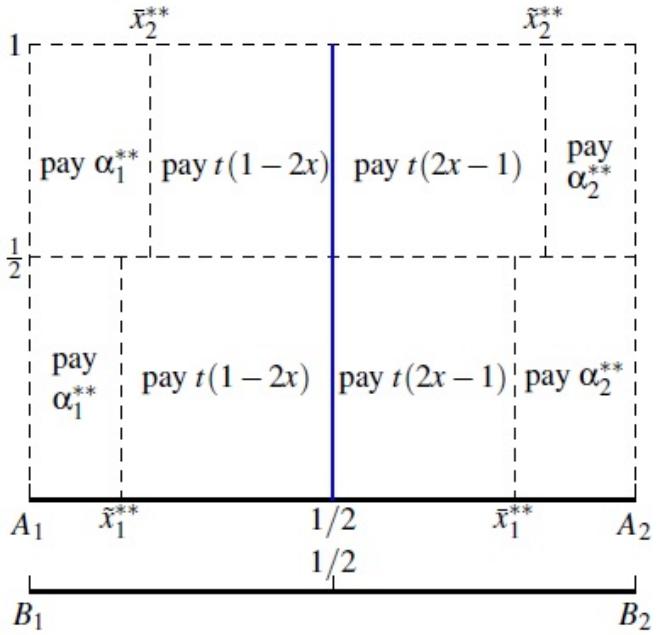
(v) the welfare properties are identical to the main model, except opt-out consumers become better off.

Three extensions (4/7)

2. Data portability **(i) A_i's targeted consumers can also ask the firm to transfer their data to the rival A_j without any costs (ii) in addition to the costly data erasure option.**



A_i's consumers' costs

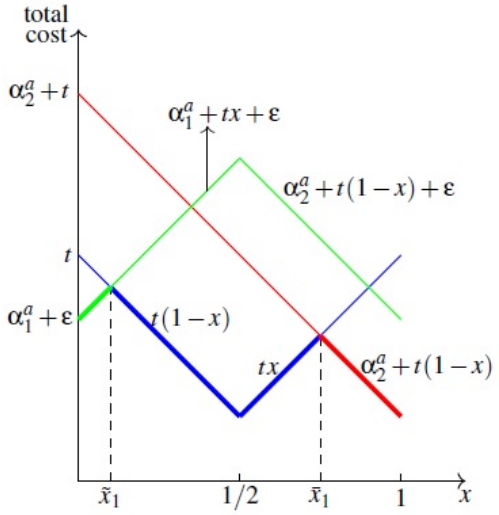


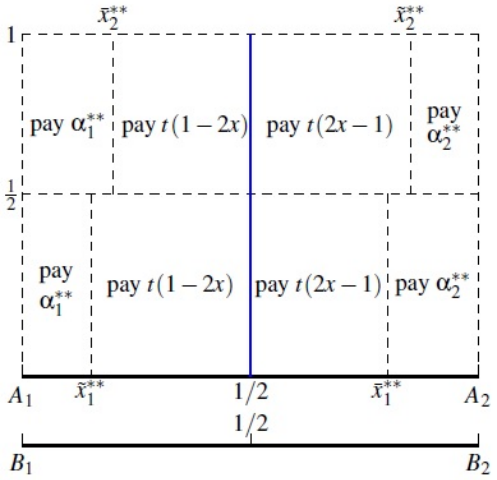
Outcomes in market A

Green: opt-out, **Blue**: data portability, **Red**: opt-in

Three extensions (5/7)

2. Data portability **The outcomes are the following:**





Green: opt-out, **Blue**: data portability, **Red**: opt-in

Summary **Data portability leads to**

(i) $\alpha_i \uparrow$ **and** $p_i(x) \downarrow$

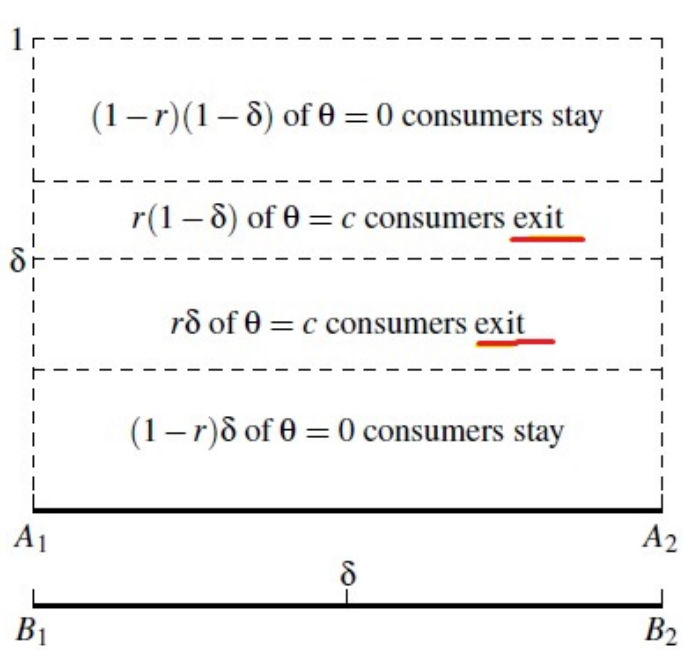
(ii) $\pi_{Ai} \downarrow$, $\pi_{Bi} \uparrow$, **and** $\Pi_i \uparrow$

(iii) $CS_A \uparrow$, $CS_B \downarrow$, **and** $CS_A + CS_B \downarrow$

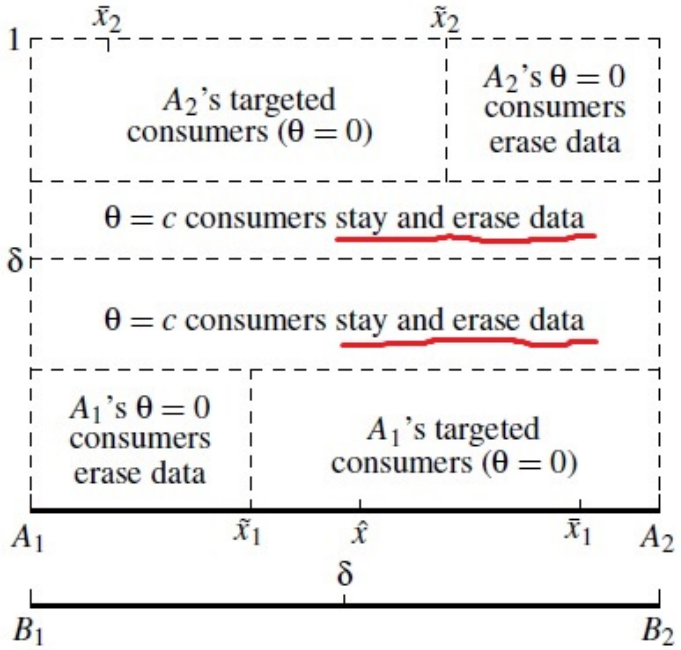
(iv) SW_A **and** SW_B **are the maximim values.**

Three extensions (6/7)

3. Heterogeneous privacy costs **(i) privacy-sensitive with privacy cost $\theta = c$ with prob. r; (ii) privacy-insensitive without any privacy costs $\theta = 0$ with prob $1 - r$.**



(a) Consumers' distribution without privacy management

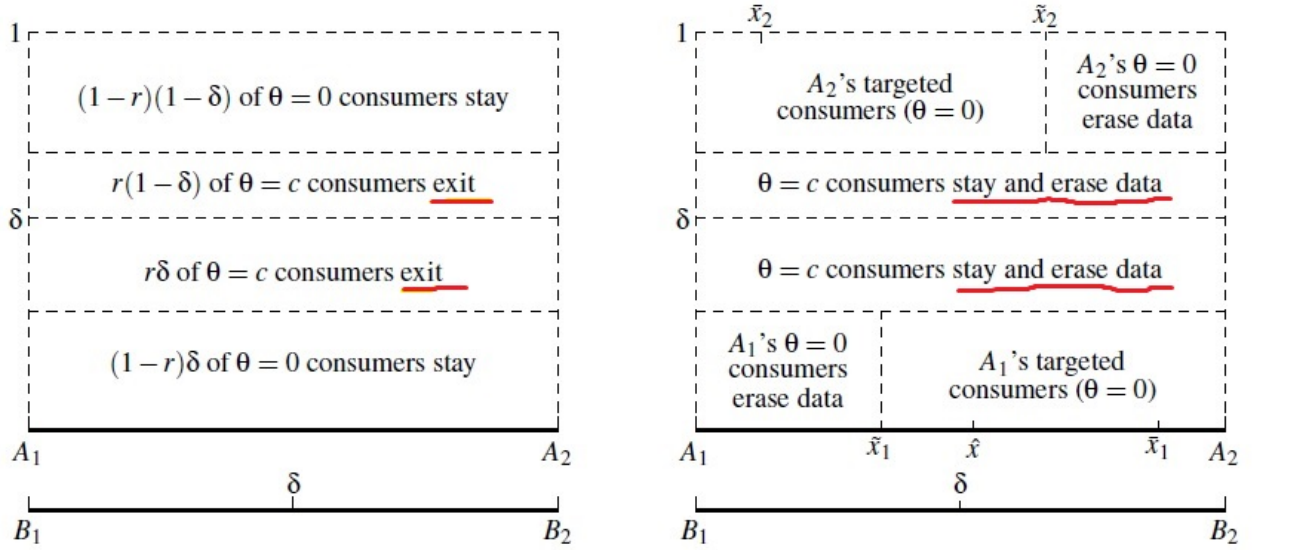


(b) Consumers' distribution under privacy management

Privacy management helps privacy-sensitive consumers be in market A if c is high enough.

Three extensions (7/7)

3. Heterogeneous privacy costs **(i) c (prob. r); (ii) 0 (prob. $1-r$).**



(a) Consumers' distribution without privacy management (b) Consumers' distribution under privacy management

Summary **When some consumers' privacy costs are high, privacy management leads to**

(i) higher consumer demands in market A,

(ii) price competition becomes weak in market A,

(iii) price competition intensifies in market B.

Conclusion (1/2)

The model **We consider a duopoly model in which consumers purchase products in two independent markets: data collection and data application.**

Result (M) **In the data application market, privacy management harms the total surplus, firms, and consumers, except for opt-out consumers.**

In the data collection market, consumers' privacy management also intensifies competition, lowering the two-market profits and benefiting consumers in this market.

Privacy management increases (resp. decreases) two-market consumer welfare if consumers are forward-looking (resp. myopic).

Conclusion (2/2)

Result (E1) **An increase in the gain from personalized products harms the firms' two-market profits and improves the consumer and total surpluses.**

Result (E2) **Competition in market A intensifies but and the firms have lower incentives to acquire a lot of customers' data in market B, improving the firms' two-market profits but diminishing the sum of the consumer surpluses.**

Result (E3) **Privacy management improves the consumer surplus in each market if the number of privacy-sensitive consumers exceeds a threshold value.**

References (mentioned in the slide)

1. Acemoglu, D., A. Makhdoumi, A. Malekian, and A. Ozdaglar (2022). Too much data: Prices and inefficiencies in data markets. *American Economic Journal: Microeconomics*, 14(4), 218-56.
2. Ali, S.N., G. Lewis, and S. Vasserman (2022). Voluntary disclosure and personalized pricing. *Review of Economic Studies*, Forthcoming.
3. Anderson, S., A. Baik, and N. Larson (2022). Price discrimination in the information age: Prices, poaching, and privacy with personalized targeted discounts. *Review of Economic Studies*, Forthcoming.
4. Aridor, G., Y.-K. Che, and T. Salz (2022). The effect of privacy regulation on the data industry: Empirical evidence from GDPR. *RAND Journal of Economics*, Forthcoming.
5. Belleflamme, P. and W. Vergote (2016). Monopoly price discrimination and privacy: The hidden cost of hiding. *Economics Letters*,149: 141-144.
6. Bergemann, D., A. Bonatti, and T. Gan (2022). The economics of social data. *RAND Journal of Economics*, 53(2): 263-296.
7. Bester, H. and E. Petrakis (1996). Coupons and oligopolistic price discrimination. *International Journal of Industrial Organization*, 14(2): 227-242.
8. Bourreau, M., C. Caffarra, Z. Chen, C. Choe, G. Crawford, T. Duso, C. Genakos, P. Heidhues, M. Peitz, T. Rønde, M. Schnitzer, N. Schutz, M. Sovinsky, G. Spagnolo, O. Toivanen, T. Valletti, and T. Vergé (2020). Google/Fitbit will monetise health data and harm consumers.
9. Chen, Z., C. Choe, J. Cong and N. Matsushima (2022). Data-driven mergers and personalization. *RAND Journal of Economics*, 53(1): 3-31.
10. Chen, Z., C. Choe, and N. Matsushima (2020). Competitive personalized pricing. *Management Science*, 66(9): 4003-4023.
11. Choe, C., King. S. and N. Matsushima (2018). Pricing with cookies: behavior-based price discrimination and spatial competition. *Management Science*, 64(12): 5669-5687.
12. Choe, C., N. Matsushima, and M.J. Tremblay (2022). Behavior-based personalized pricing: When firms can share customer information. *International Journal of Industrial*

Organization, 82: 102846.
13. Choi, J.-P., D.-S. Jeon, and B.-C. Kim (2019). Privacy and personal data collection with information externalities. *Journal of Public Economics*, 173: 113-124.
14. Conitzer, V., C.R. Taylor, and L. Wagman (2012). Hide and seek: Costly consumer privacy in a market with repeat purchases. *Marketing Science*, 31(2): 277-292.
15. Cordorelli, D. and J. Padilla (2022). Data-driven envelopment with privacy-policy tying.
16. de Cornière, A. and G. Taylor (2022). Data and competition: A general framework with applications to mergers, market structure, and privacy policy.
17. Farboodi, M., R. Mihet, T. Philippon, and L. Veldkamp (2019). Big data and firm dynamics. *AEA Papers and Proceedings*, 109: 38-42.
18. Farr, C. (2019). Amazon acquires start-up Health Navigator, its first health-related purchase since PillPack. CNBC, 23 October, 2019.
19. Goldfarb, A. and C. Tucker (2019). Digital economics. *Journal of Economic Literature*, 57(1): 3-43.
20. Hagiu, A. and J. Wright (2022). Data-enabled learning, network effects and competitive advantage. *RAND Journal of Economics*, Forthcoming.
21. Herresthal, C., T. Mayskaya, and A. Nikandrova (2022). Data linkage between markets: Does the emergence of an informed insurer cause consumer harm? Working paper.
22. Ichihashi, S. (2020). Online privacy and information disclosure by consumers. *American Economic Review*, 110(2): 569-95
23. Ichihashi, S. (2021). Competing data intermediaries. *RAND Journal of Economics*, 52(3): 515-537.
24. Jia, J., G.Z. Jin, and L. Wagman (2021). The short-run effects of the General Data Protection Regulation on technology venture investment. *Marketing Science*, 40(4): 661-684.
25. Ke, T. and K. Sudhir (2022). Privacy rights and data security: GDPR and personal data driven markets. *Management Science*, Forthcoming.
26. Koh, B., Raghunathan, S., and Nault, B.R (2017). Is voluntary profiling welfare enhancing? *MIS Quarterly*, 41(1): 23-41.
27. Laussel, D. and J. Resende (2022). When is product personalization profit-

enhancing? A behavior-based discrimination model. *Management Science*, Forthcoming.
28. Ozalp, H., P. Ozcan, D. Dinckol, M. Zachariadis, and A. Gawer (2022). "Digital colonization" of highly regulated industries: An analysis of Big Tech platforms' entry into health care and education. *California Management Review*, 64(4), 78-107.
29. Peukert, C., S. Bechtold, M. Batikas, and T. Kretschmer (2022). Regulatory spillovers and data governance: Evidence from the GDPR. *Marketing Science*, 41(4): 318-340.
30. Prüfer, J. and C. Schottmüller (2021). Competing with big data. *Journal of Industrial Economics*, 69(4): 967-1008.
31. Santos-Lozano, A., C. Baladrón, J. Martín-Hernández, J.S Morales, L. Ruilope, and A. Lucia (2018). mHealth and the legacy of John Snow. *Lancet*, 391(10129): 1479-1480.
32. Schneble, C. O., B.S. Elger, and D. M. Shaw (2020). Google's Project Nightingale highlights the necessity of data science ethics review. *EMBO Molecular Medicine*, 12(3): e12053.
33. Shaffer, G. and Z. J. Zhang (1995). Competitive coupon targeting. *Marketing Science*, 14(4): 395-416.
34. Thisse J.-F. and X. Vives (1988). On the strategic choice of spatial price policy. *American Economic Review*, 78(1): 127-137.
costs, essential facility. *Review of Industrial Organization*, 54(4): 683-694.
35. Zhang, J. (2011). The perils of behavior-based personalization. *Marketing Science*, 30 (1): 170-186.