Dynamic Privacy Choices

Shota Ichihashi

Bank of Canada

Bendheim Center and Luohan Academy
Privacy Workshop
Feb 21, 2020


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This Paper

This Paper

Consumer uses

Platform

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Platform monetizes info

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Impact on consumer (potentially negative)

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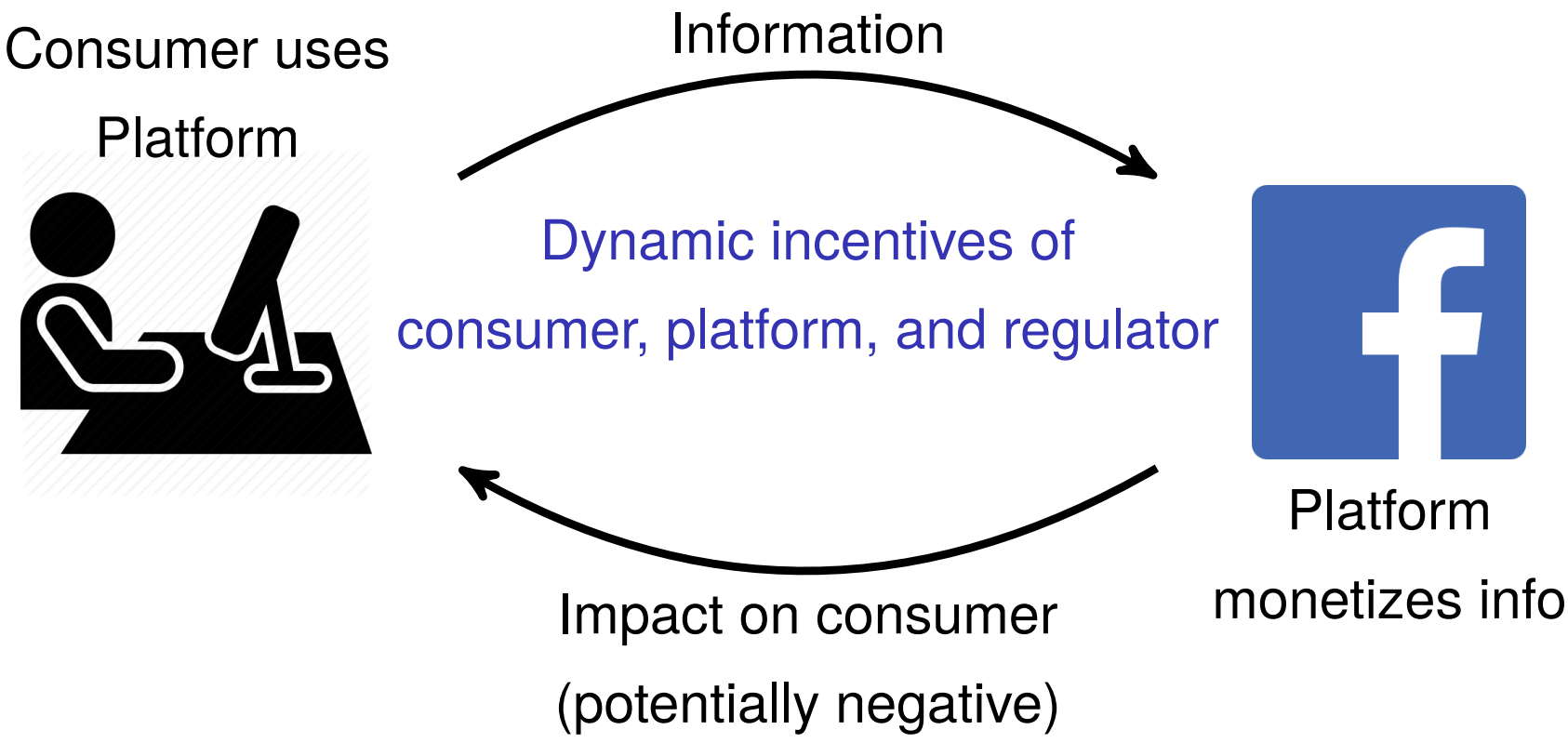
Consumer uses Platform
Information
Dynamic incentives of consumer, platform, and regulator
Platform monetizes info
Impact on consumer (potentially negative)

Roadmap

1. Monopoly
   - Model
   - Equilibrium
2. Competition
   - Model
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Time $t = 1, 2, \ldots$

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All random variables are mutually independent

Platform Payoffs

Platform's payoff in period t

$$\sigma_0^2 - \sigma_t^2$$

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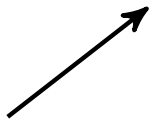

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- More info better
- Increasing in $(a_1, \ldots, a_t)$ and decreasing in $(\gamma_1, \ldots, \gamma_t)$
- Discount future payoffs

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value of privacy

Consumer is myopic (relaxed in the paper)

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Pure-strategy SPE with Consumer tie-breaking

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Marginal Privacy Cost

Lemma

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- Platform knows $X \rightarrow$ MC $= 0$
- Lower payoff $\leftrightarrow$ Higher incentive to use platform

Stationary Privacy Policy

1. Platform chooses a privacy policy $(\gamma_1, \gamma_2, \dots)$
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- $\sigma_t^2 \to 0$ and $a_t \to a^*$
- High γ hurts Consumer in the long-run (in paper)

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- Early: high marginal cost $\to$ high γ_t to encourage activity

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- Early: high marginal cost $\to$ high γ_t to encourage activity
- Later: low marginal cost $\to$ low γ_t to speed up data collection
- Extend to a forward-looking consumer (paper)

Implication on Consumer

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- Privacy paradox (discussion in paper)

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- Rational addiction (e.g. Becker and Murphy 1988)
  - Complementarity between present and future consumption
  - Harmful addiction

Implication on Platform

Implication on Platform

Facebook privacy policy

2004

Use of Cookies

A cookie is a piece of data stored on the user's computer tied to information about the user. We use session ID cookies to confirm that users are logged in. These cookies terminate once the users close the browser. We do not and will not use cookies to collect private information from any user.

https://web.archive.org/web/20050107221705/http://www.thefacebook.com/policy.php

2020

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Equilibrium Privacy Policy

- Statically maximize the informativeness of signals
- Same outcome under short-run commitment

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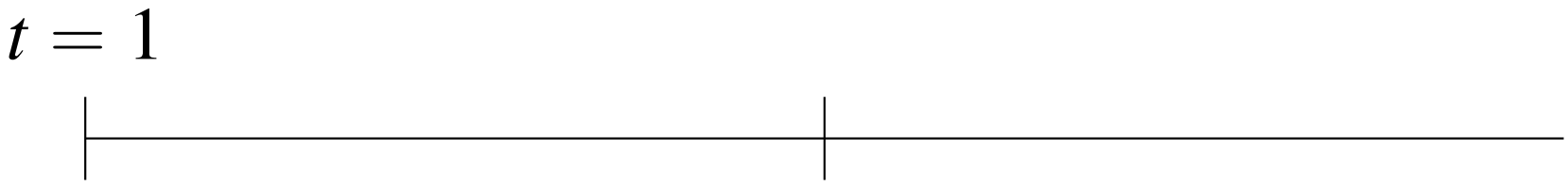

Platform I

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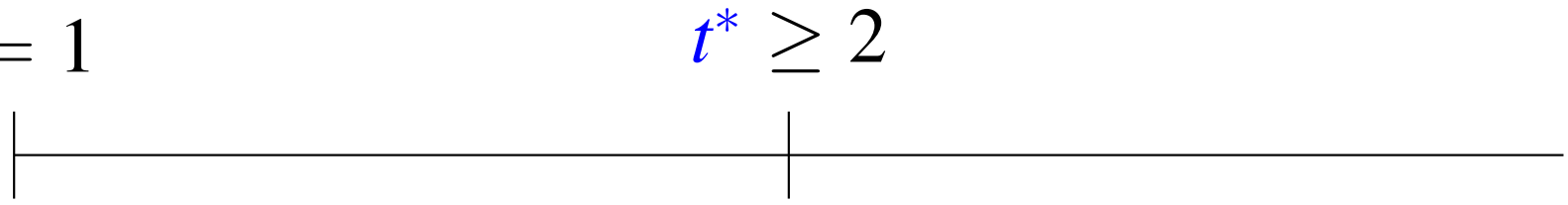

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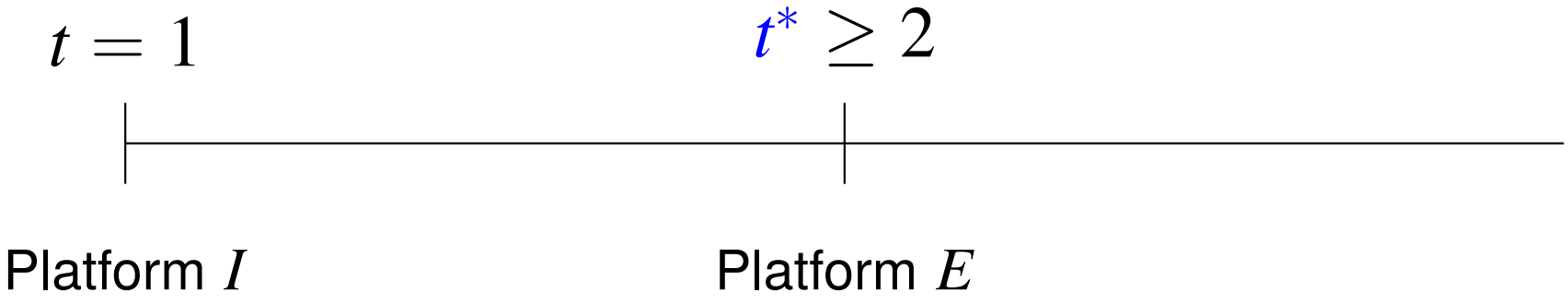

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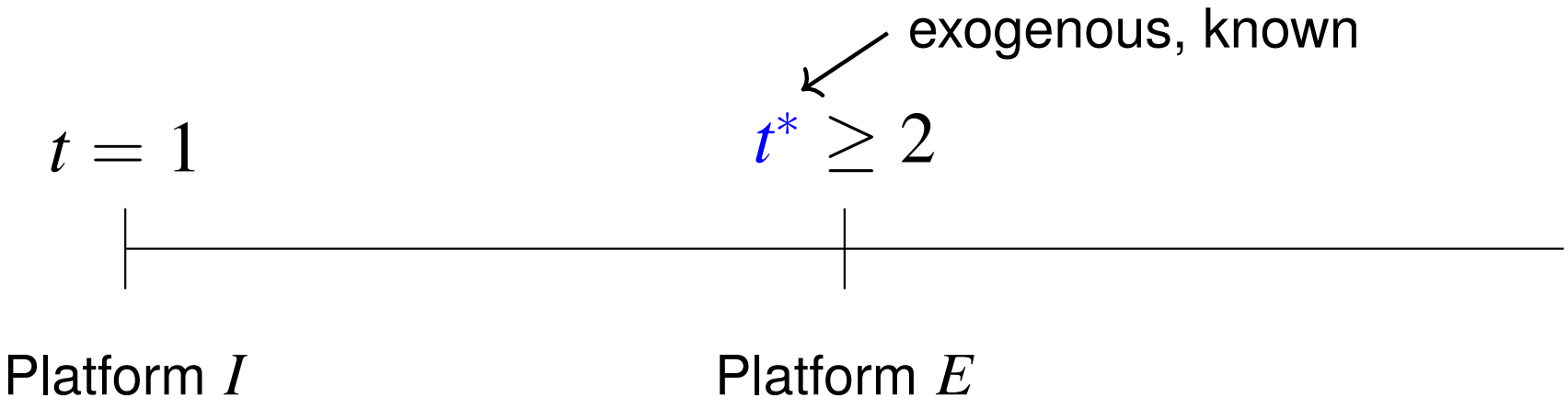

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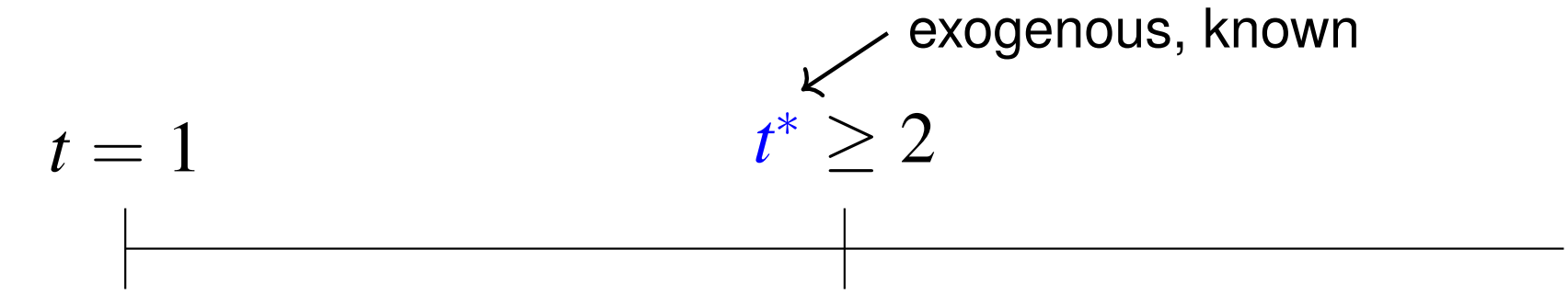

Before entry:

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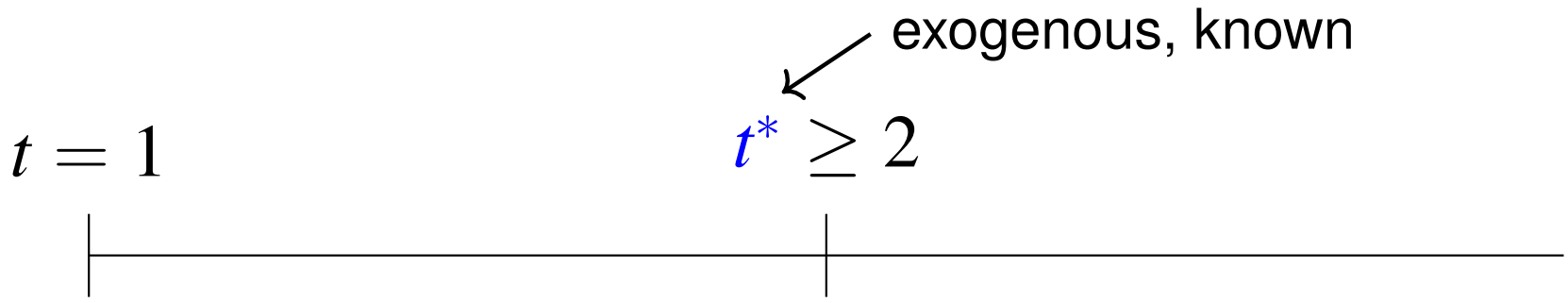

Platform I

Platform E

Before entry:

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After entry:

C chooses (a_t^I, a_t^E)

s.t. $\min(a_t^I, a_t^E) = 0$

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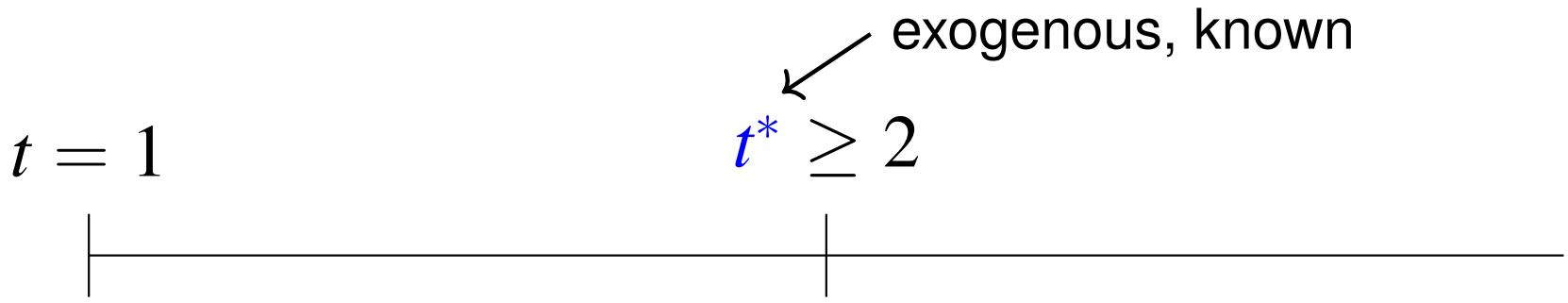

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An upper bound of feasible privacy levels

Payoffs

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$$u(a_t^I) - v \cdot (\sigma_0^2 - \sigma_{I,t}^2) + u(a_t^E) - v \cdot (\sigma_0^2 - \sigma_{E,t}^2)$$

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- Privacy cost from past info is sunk

  $\rightarrow$ Consumer decision based on marginal cost

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Equilibrium

Proposition

Regardless of commitment power,

Equilibrium

Proposition

Regardless of commitment power, there is an equilibrium such that :

- *Consumer only uses I:* $a_t^I > 0$ *and* $a_t^E = 0$ *for all* t
- $\gamma_t^I \to 0$, $\sigma_{I,t}^2 \to 0$, *and* $a_t^I \to a^*$

For a large t^**, any equilibrium equals monopoly.*

Intuition

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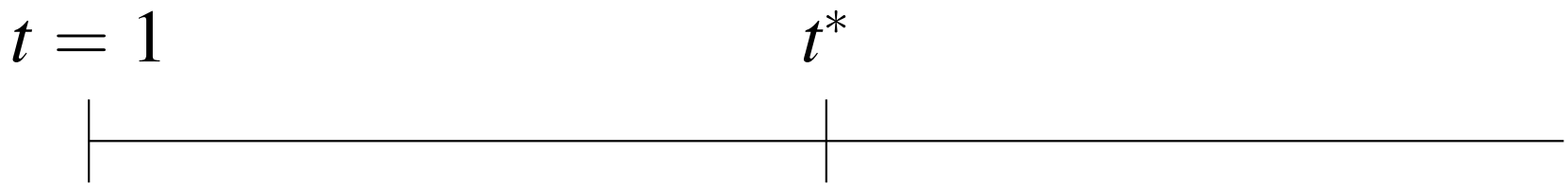

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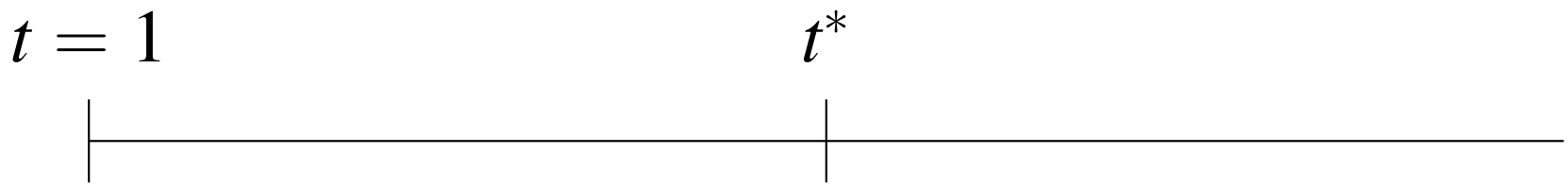

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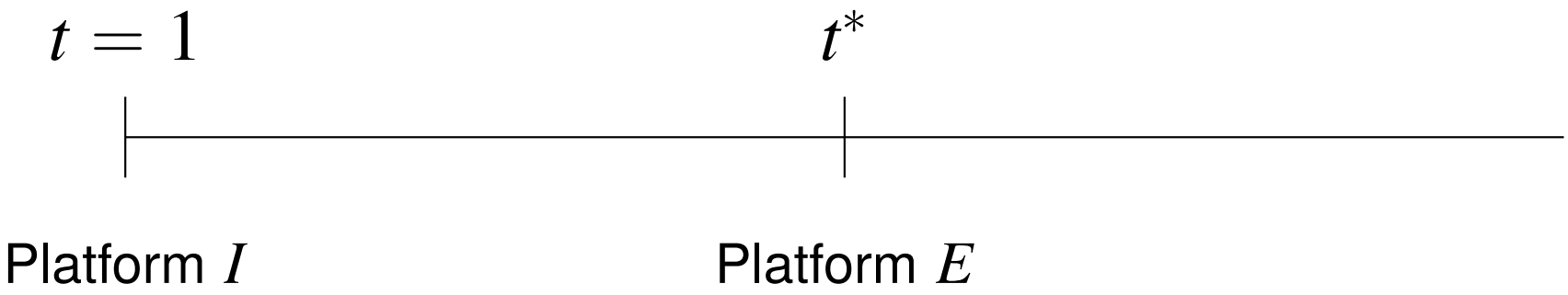

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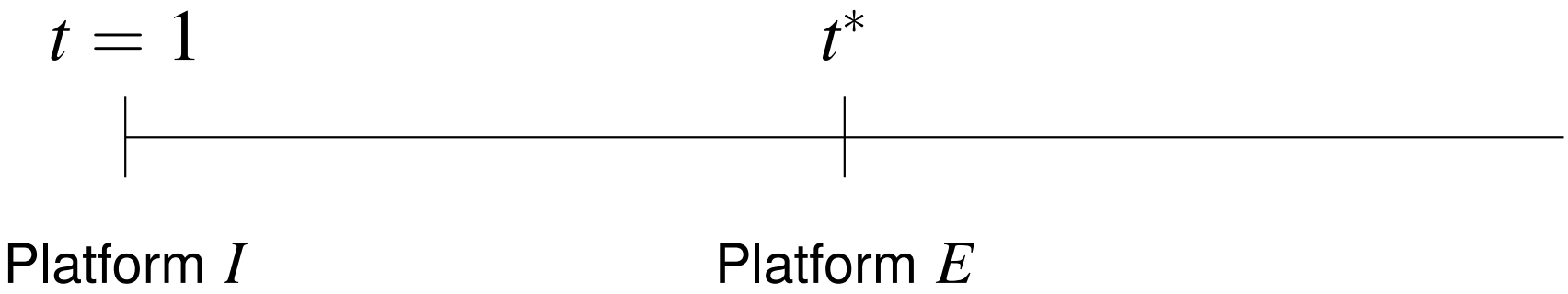

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but I can keep C

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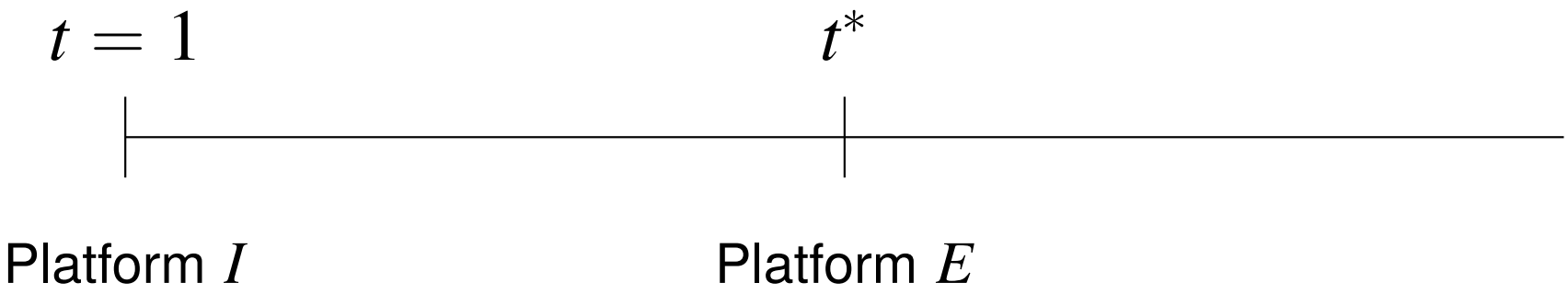

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In the long-run, $\gamma_t^I \to 0$

and retain C

Data as an Entry Barrier

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- “Right to be forgotten”

Other results

- Forward-looking consumer: still $\sigma_t^2 \to 0$ and $a_t^* \to a^*$
- Harmful entry: E can poach consumers by "eroding privacy"
- Erasing past information
- Endogenous quality: Patient platform does not invest in quality

Recap

Decreasing marginal incentive to protect privacy

- Long-run privacy loss but high activity level
- Platform commits to collect less info in early periods
- Competition unlikely when consumer welfare is low

Equilibrium Privacy Policy

$a(\sigma^2, \gamma)$: optimal a_t given $\sigma^2_{t-1} = \sigma^2$ and $\gamma_t = \gamma$

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Proposition

Platform's eqm policy $(\gamma_1^*, \gamma_2^*, \dots)$ *is recursively defined as:*

$$\gamma_t^* \in \arg\min_{\gamma \geq 0} \frac{1}{a(\sigma^2_{t-1}, \gamma)} + \gamma,$$

$$\sigma^2_t = \textit{Bayes' rule given } \sigma^2_{t-1},\ \gamma_t^*, \textit{ and } a(\sigma^2_{t-1}, \gamma_t^*)$$

Interpretation

$$\min_{\gamma_t \geq 0} \frac{1}{a(\sigma_{t-1}^2, \gamma_t)} + \gamma_t$$

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Platform observes $s_t = X + \varepsilon_t + z_t$

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Trade-off $\rightarrow$ high activity level & adding less noise

No Dynamic Trade-off

Platform statically maximizes the informativeness of the signal

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Platform statically maximizes the informativeness of the signal

- Decreasing marginal cost
- Continuation value is increasing in the amount of info today
- Short-run commitment power is enough for Platform

Roadmap

1. Monopoly
   - High a_t, privacy loss, potentially negative payoff in the long-run
   - Strong commitment power unnecessary
   - Less privacy $\rightarrow$ lower incentive to protect it
2. Competition
   - Entry barrier $\leftrightarrow$ lower consumer welfare
   - The “right to be forgotten” may work

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Consumer discounts future payoffs

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- Key: supermodularity in activity levels and information
- Value of commitment?

Endogenous Quality

Platform chooses a quality $q \geq 0$ before $t = 1$

- Consumer $u(a) = qa - \frac{1}{2}a^2$
- Platform $\sigma_0^2 - \sigma_t^2 - c(q), \quad c(\cdot)$ strictly increasing

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Proposition

As $\delta_P \to 1$, along any sequence of equilibria:

- $q^* \to 0$
- *Consumer's sum of discounted payoffs* $\to 0$

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- Info collection reduces consumer payoff & marginal cost
- For a high ρ, switching occur
- For a not too high c, there is a “switching equilibrium”
- Consumer worse off than monopoly

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Literature

Platform data collection: Acemoglu et al. (2019); Bergemann et al. (2019); Choi et al. (2018)

- Information externality lowers the price of data
- This paper: intertemporal externality
  - A single consumer, full privacy loss in the long-run
  - Market entry, value of commitment, right to be forgotten, etc

Competition with data: Cornière and Taylor (2020); Prufer and Schottmüller (2017); Hagiu and Wright (2020), etc

- Data collection benefit consumers

Switching cost, barrier to entry: Farrell and Shapiro (1988); Klemperer (1995); Fudenberg and Tirole (2000), etc

Total Welfare

Difficult to compare the sum of payoffs

- Different discount factors $\rightarrow$ "backload" data collection?

For any discount factors, we can calculate long-run welfare

- Without transfer $\rightarrow$ eqm efficient (platform best)
- With transfer $\rightarrow$ efficient (low v) or too much data collection

Same δ & transfer & compare discounted total surplus

- Inefficiently low activity levels?
- Inefficiently low privacy level?