Competition Through Recommendations

Robin Ng

Mannheim

KU

Roadmap

Introduction

Monopoly

Competition

Extensions

Conclusion

Introduction

Motivation

- Historical problem: How to *foster* trust on the internet?
  - No recommender system

Pierre Omidyar

to

Hello folks,

Here is the current listing of non-computer items for auction at AuctionWeb:

http://www.ebay.com/aw/

All items are offered by the individual sellers, and anyone is free to bid on any item, or to add items, free of charge.

For more information about any of these items, please visit the AuctionWeb site at the above URL.

Cheers,

Pierre

AuctionWeb Listings

Click on the title to get an expanded description or to bid on that item. These items are not verified by AuctionWeb; caveat emptor. You may jump to a particular category using this list:
* Antiques, Collectibles
* Automotive
* Books & Comics
* Computer Hardware
* Computer Software
* Consumer Electronics
* Miscellaneous

Antiques, Collectibles

Superman metal lunchbox,l967,used good condition
Current bid: $22.00
Auction ends on: 09/26/95, 21:30:48 PDT
Auction started on: 09/12/95, 21:30:48 PDT

Autographed Marky Mark Underwear
Current bid: $400
Auction ends on: 09/25/95, 10:09:29 PDT
Auction started on: 09/11/95, 10:09:29 PDT

Autographed Elizabeth Taylor Photo
Current bid: $200
Auction ends on: 09/25/95, 10:02:31 PDT
Auction started on: 09/11/95, 10:02:31 PDT

Autographed Michael Jackson Poster
Current bid: $400
Auction ends on: 09/25/95, 09:59:02 PDT
Auction started on: 09/11/95, 09:59:02 PDT

Toy Power Boat, late 50's - early 60's
Current bid: $60.00
Auction ends on: 09/23/95, 20:26:49 PDT
Auction started on: 09/09/95, 20:26:49 PDT

Hubley #520 Cast Iron Hook and Ladder Truck
Current bid: $300.00
Auction ends on: 09/23/95, 13:42:45 PDT
Auction started on: 09/09/95, 13:42:45 PDT

Computer Hardware

[NEW!] XIRCOM Pocket Network Adaptor (LPT-1)
Current bid: $75.00
Auction ends on: 09/26/95, 20:26:35 PDT

Trident 8900C Video Card
Current bid: $40
Auction ends on: 09/25/95, 18:58:31 PDT

Intel DX2/66 Processor
Current bid: $90
Auction ends on: 09/25/95, 18:50:38 PDT

NovaCom 486/50mhz Laptop
Current bid: $900
Auction ends on: 09/25/95, 17:24:04 PDT

Apple PowerBook 140
Current bid: $500
Auction ends on: 09/25/95, 17:20:42 PDT

Fujitsu 325 Point PEN BASED PC!
Current bid: $1000
Auction ends on: 09/25/95, 17:17:49 PDT

Amiga 2000HD 3/100, 1084S, Gemini 10X Printer, Modem
Current bid: $450
Auction ends on: 09/24/95, 22:15:33 PDT

HP Draftpro DXL Pen Plotter. A-D size. Includes pens & paper
Current bid: $1100

Introduction

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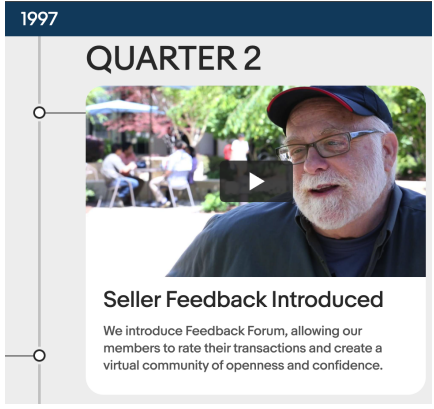

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Motivation

- Historical problem: How to *foster* trust on the internet?
  - No recommender system $\Rightarrow$ reputation and recommender systems.
    - Improved profits and higher consumer trust.
    - Reputation $\Longleftrightarrow$ feedback $\Longleftrightarrow$ value-for-money

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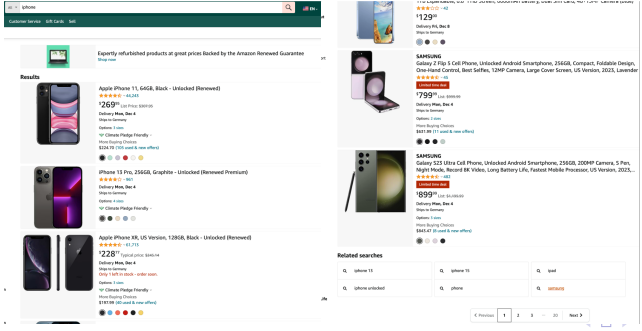

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- Today: A dreading sense of *ensh*ttification*.

Pluralistic: How monopoly enshittified Amazon/28 Nov 2022

Among Linguists, the Word of the Year Is More of a Vibe

The American Dialect Society selected a term that refers to the deterioration of online platforms.

Not about fakes and bots

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- *Fostering*: Recommender systems becoming more informative of consumption utility/value-for-money.
- Today: A dreading sense of *ensh*ttification*.
  - Recommender systems showing poorer results.
  - Fear recommender systems form part of the systemic risk posed by platforms.
  - DSA: Enhanced transparency (Art. 27) and user agency (Art. 38).
  - DMA: Data sharing to stimulate cross platform competition.

Introduction

Approach

- Study the evolution of rec.sys. in a two-sided market by:
  - Platforms designing rec.sys. to be informative of consumption utility.
  - Competition between platforms (or lack thereof) affects this design.
  - 'Simple Model'

Questions

- Do monopolist inherently create (un)informative rec.sys.?
- If/how competition promotes informative rec.sys.?
- How rec.sys. redistribute surplus?
- Discuss the role of regulation (DSA / DMA).

Preview of results

Mechanism

- More informative rec.sys. means
  - Consumers are more likely to interact with firms providing higher utility.
  - On a platform, fiercer price competition, creating a screening effect.
- Platform's tradeoff: volume–per-transaction-revenue

Preview of results

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Implications

- Result 1: Monopolist platform prefers rec.sys. more informative than value-for-money.
- Result 2: Informative rec.sys. inordinately benefit highest quality firms.
- Result 3: Transparency encourages more informative rec.sys.
- Result 4: Competition promotes more informative rec.sys.

Contribution

1: Platform non-price strategies

- Monopolist adopting recommender systems (Casner and Teh, Forthcoming)

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- Price strategies (Damiano and Hao, 2008)
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- Competition in recommender system design
  Empirical support:
  - Recommender systems build trust (Chen and He, 2011)
  - Value-for-money drives reputation (Luca, 2016)
  - Informative systems, lower prices (Jin and Kato, 2006)
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3: Potential mechanism for platform degradation

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Model (I)

Consumers

- Unit mass each demanding a single unit of product.
- Heterogeneous inertia of joining platform, c_i IID $U[0,1]$.
- Utility $u_i(\alpha_j, p_j) = \alpha_j - p_j$, α_j quality of firm j and p it's price.
- Mass of consumers joining platform:
  $n = E[u] = \int_{j \in N} \lambda(\alpha_j, p_j, \alpha_{-j}, \mathbf{p}_{-j}, \sigma)(\alpha_j - p_j)\, d\alpha_j$.

Drop the j subscript.

Model (II)

Firms

- Unit mass of single product firms.
- Products are homogeneous with heterogeneous quality, α IID $U[0,1]$.
- Only sell on platform, no direct sales.
- Marginal cost $= 0$.
- Fees: Ad valorem commission fee, r, to platform.
- $\pi(D(\alpha, p, \boldsymbol{\alpha}_{-j}, \mathbf{p}_{-j}), p, \sigma) = (1 - r)D(\alpha, p, \boldsymbol{\alpha}_{-j}, \mathbf{p}_{-j}, \sigma)p$.
  - Firms select p.
- Set of firms joining platform: N.

Model (III)

Platform

- Intermediates between consumers and firms.
- Provides recommendations through product listings.
- $\Pi = r \int_{j \in N} D_j(\alpha_j, p_j, \boldsymbol{\alpha}_{-j}, \mathbf{p}_{-j}, \sigma) p_j \ d\alpha_j$.
- $D_j(\alpha_j, p_j, \boldsymbol{\alpha}_{-j}, \mathbf{p}_{-j}, \sigma) = n\lambda(\alpha_j, p_j, \boldsymbol{\alpha}_{-j}, \mathbf{p}_{-j}, \sigma)$.

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- $$\lambda(\alpha_j, p_j, \boldsymbol{\alpha}_{-j}, \mathbf{p}_{-j}, \sigma) = \begin{cases} \frac{\alpha_j - p_j - \sigma}{\int_{h \in N} \alpha_h - p_h - \sigma \ d\alpha_h} & \text{if } \alpha - p - \sigma \geq 0 \\ 0 & \text{otherwise,} \end{cases}$$

  Platforms select $\sigma \in \mathbf{R}_+$.

Note: positive utility (free returns).

Model (IV)

Timing

- Platform announces its recommender system, σ.
- Firms decide to join the platform, setting prices.
  (platform 'learns' firm quality)
- Consumers decide to join the platform, obtains recommendations and consume.

Find SPNE.

Illustrative Baseline: No recommender system

$$\lambda(p, \mathbf{p}_{-j}) = \frac{1}{\int_{h \in N} 1 \; d\alpha_h}.$$

- Highly uninformative

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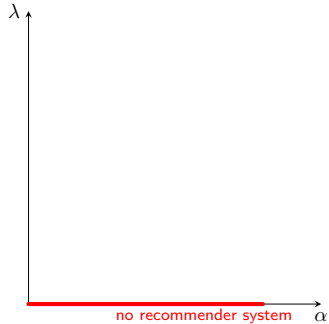

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Welfare maximizing equilibrium

$$r \int_{h \in N} n\lambda(p, \mathbf{p}_{-j}) p_h \; d\alpha_h + n$$

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Welfare maximizing equilibrium

$$\int_{j \in N} \lambda(p, \mathbf{p}_{-j})(\alpha - p) \; d\alpha \left[r \int_{h \in N} \lambda(p, \mathbf{p}_{-j}) p_h \; d\alpha_h + 1 \right]$$

- Firms set $p^s = 0$.
- Consumers join the platform if $E[u] \geq c_i$.
- Total welfare is $\frac{1}{2}$, $CS = \frac{1}{2}$, and firm and platform make zero surplus.

Value-for-money recommendations

Constrain $\sigma = 0$:

$$\lambda^{v}(\alpha, p, \boldsymbol{\alpha}_{-j}, \mathbf{p}_{-j}) = \begin{cases} \frac{\alpha - p}{\int_{h \in N} \alpha_h - p_h \ d\alpha_h} & \text{if } \alpha - p \geq 0 \\ 0 & \text{otherwise.} \end{cases}$$

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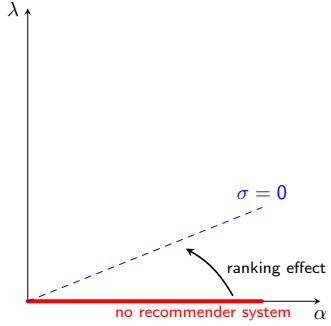
- λ^{v} highlights a ranking effect.



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- λ^{v} highlights a ranking effect.
  - Higher relative value-for-money $\Rightarrow$ higher on the list.
  - Platform can generate utility using value-for-money recommendation rule.

Equilibrium

Consumers

- Always purchase if join the platform.
- $n^v = E[u^v] = \int_{g \in N} \frac{\alpha_g - p_g}{\int_{h \in N} \alpha_h - p_h \ d\alpha_h} (\alpha_g - p_g) \ d\alpha_g.$

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Firms

- $\pi^v = n^v \times \frac{a-p}{\int_{h \in N} \alpha_h - p_h \ d\alpha_h} \times (1-r)p.$
- $p^v = \frac{\alpha}{2}.$

Surplus

- Platform and firm total profits: $\frac{1}{9}$, > 0.
- Consumer surplus: $\frac{1}{3}$, $< \frac{1}{2}$.
- Total surplus: $\frac{4}{9}$, $< \frac{1}{2}$.

Remark

Recommender systems based solely on consumer feedback can lower total welfare.

Informative recommendations

$$\lambda(\alpha, p, \boldsymbol{\alpha}_{-j}, \mathbf{p}_{-j}, \sigma) = \begin{cases} \frac{\alpha - p - \sigma}{\int_{h \in N} \alpha_h - p_h - \sigma \ d\alpha_h} & \text{if } \alpha - p - \sigma \geq 0 \\ 0 & \text{otherwise.} \end{cases}$$

Higher σ emphasises value-for-money.

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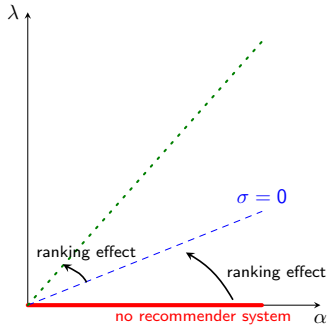

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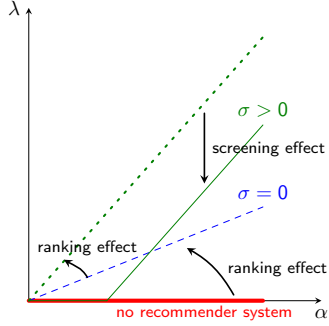
Higher σ emphasises value-for-money.

- Amplifies ranking effect.
- Creates screening effect: Some lower quality firms prefer not to sell.



Equilibrium (I)

Consumers

- Always purchase if join the platform.
- $n^m = E[u] = \int_{g \in N} \frac{\alpha_g - p_g - \sigma}{\int_{h \in N} \alpha_h - p_h - \sigma \ d\alpha_h} (\alpha_g - p_g) \ d\alpha_g$.

Firms

- $\pi = n^m \times \frac{a - p - \sigma}{\int_{h \in N} \alpha_h - p_h - \sigma \ d\alpha_h} \times (1 - r)p$.
- $p^* = \frac{\alpha - \sigma}{2}$.
  - Set low prices to attract demand, low quality firms become unprofitable.
  - Only sufficiently high quality firms are active on the platform, $\bar{\alpha} = \sigma$.

Equilibrium (II)

Platform

$$\Pi = \int_{\sigma}^{1} \lambda(\alpha_h, p_h^*, \mathbf{p}_{-h}, \sigma)(\alpha_h - p_h^* - \sigma)\ d\alpha_h r \int_{\sigma}^{1} \lambda(\alpha_h, p_h^*, \mathbf{p}_{-h}, \sigma) p_h^*\ d\alpha_h$$

- Balance: Transaction volume and per transaction revenue.

Equilibrium (II)

Platform

$$\Pi = \frac{1+2\sigma}{3} r \frac{1-\sigma}{3}.$$

- Balance: Transaction volume and per transaction revenue.
- Raising σ:
  - Ranking effect—More transactions between consumers and better firms.
  - Screening effect—Only higher quality firms remain.
  - Price competition—each firm sets lower prices.

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Proposition

There exists a unique SPNE where a monopolist platform sets $\sigma^m = \frac{1}{4} > 0$.

Surplus

Suppose $\sigma \uparrow$:

- Redistribution of profits towards to highest quality firms.
- All other firms worse-off: lower prices, fewer (zero) transactions.
- Consumers face higher quality firms at lower prices (better-off).

Note: variety, protectionism/industrial policy

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- Total profits $\frac{1}{8}$, $> \frac{1}{9}$.
- Consumer surplus: $\frac{1}{2}$, 'identical' to no recommender system.
  (Postulation) Better if: positive prices, risk aversion.
- Total surplus: $\frac{5}{8}$, $> \frac{1}{2}$.

Surplus

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1. *Platform has an incentive to introduce rec.sys. more informative than value-for-money.*
2. *Platform preferred rec.sys. allows consumers to be at least as well-off as no recommender system, generating surplus.*

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DSA Article 27: ability to modify main parameters.
Has no bite? Consumers already better off than when "left to their own devices".

Naivete

Recommender systems are complex:

- Consumers may not be able to fully rationalise the effects of recommender systems.

Alternate environment:
Consumers do not rationalise equilibrium effect of σ on prices.

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Alternate environment:
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- To consumers, $p^c = \frac{\alpha}{2}$.

$$\lambda^c = \begin{cases} \frac{\frac{\alpha}{2} - \sigma}{\int_0^1 \frac{\alpha_h}{2} - \sigma \ d\alpha_h} & \text{if } \alpha - p^c - \sigma \geq 0 \\ 0 & \text{otherwise} \end{cases}.$$

Consumers wrongly imagine all firms are active.

- They under-anticipate the value of recommender systems
- And so under-participate for any $\sigma > 0$,

Naivete

Proposition

When consumers are naive, $\sigma^N = 0$.

- $\pi = n^N \times \frac{a-p-\sigma}{\int_{h \in N} \alpha_h - p_h - \sigma \ d\alpha_h} \times (1-r)p$.
- Firms still set prices $p^* = \frac{\alpha - \sigma}{2}$.
- But consumers less responsive to σ, platform prefers $\sigma = 0$.
- Welfare: Platforms / total firm surplus is lower, consumer surplus is lower.

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- But consumers less responsive to σ, platform prefers $\sigma = 0$.
- Welfare: Platforms / total firm surplus is lower, consumer surplus is lower.
- DSA Article 27 on transparency:
  Aligned with consumers' concerns.
  Already in line with platform's preference.

Roadmap

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Competition: setting

- Suppose there exist two platforms $k \in \{I, C\}$ incumbent and competitor, acting simultaneously.
- Consumers:
  - Inertia IID drawn $c_{i,k} \sim U[0,1]$.
  - Single home—only join platform which gives highest $E[u_k] - c_{ik}$.

$$n_k = \begin{cases} E[u_k] - \frac{E[u_{-k}]^2}{2} & \text{if } E[u_k] \geq E[u_{-k}] \\ E[u_k](1 - E[u_{-k}] + \frac{E[u_k]}{2}) & \text{if } E[u_k] < E[u_{-k}]. \end{cases}$$

- Firms: costless to join platforms, and may choose to multi-home.

Competition: No recommender system (I)

Consumers

- Join platform with highest expected utility.
- Buy recommended product.

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Firms

- Set $p^* = \frac{\alpha - \sigma}{2}$ on incumbent, $p = 0$ on competitor.
  Positive profit on incumbent, zero profit on competitor.

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Firms

- Set $p^* = \frac{\alpha - \sigma}{2}$ on incumbent, $p = 0$ on competitor.
  Positive profit on incumbent, zero profit on competitor.
- Firms single-home:
  - Join competitor $\iff$ cannot make profit on incumbent.
  - Multi-homing decreases incumbent demand.

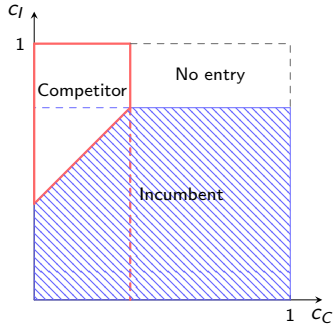
Competition: No recommender system (II)

Proposition

When the competitor does not adopt a recommender system, $\sigma_I = \frac{2}{9} < \sigma^m$.

Remark

1. *Competition does not necessarily lead to more informative recommendations.*
2. *Any increase in consumer surplus driven by 'new' consumers accessing the competitor* **not** *recommendations.*



Competition: equilibrium (I)

Lemma

An incumbent designs more informative recommender systems if the competitor has more informative recommender systems, $\frac{\partial \sigma_I}{\partial \sigma_C} > 0$.

- Competition can improve the informativeness of recommender systems.

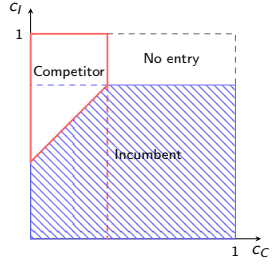
Competition: equilibrium (II)

Proposition

There exists a unique symmetric equilibrium where:

1. $\sigma_I = \sigma_C \equiv \sigma^s = 0.379 > \sigma^m$.
2. *Firms multi-home if $\alpha \geq \sigma^s$ and are inactive otherwise.*

- Consumer surplus increases—driven by 'new' consumers + recommendations (better firms and lower prices given quality).



Competition: equilibrium (II)

Proposition

There exists a unique symmetric equilibrium where:

1. $\sigma_I = \sigma_C \equiv \sigma^s = 0.379 > \sigma^m$.
2. *Firms multi-home if* $\alpha \geq \sigma^s$ *and are inactive otherwise.*

- Issues with symmetric equilibrium?
  DMA: data sharing and portability // level playing field between platforms
  $\rightarrow$ competition between firms on each platform.

Fostering–Degradation

- Monopoly (eBay): from no recommender system to value-for-money rec sys.
- Consumer awareness leads to more informative rec.sys.
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Degradation Phase

- Rise of monopolies and gatekeepers $\Rightarrow$ less informative of value-for-money.
- More complex recommendation mechanisms $\Rightarrow$ less informative of value-for-money. (less transparent)

Platform degradation bad, but better than relying solely on consumer feedback.

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More results (I): marginal cost

In the monopoly setting, suppose instead:

- Firms face a positive marginal cost e.

Firms:

- Optimal pricing strategy $\frac{\alpha-\sigma+e}{2}$.
- Only firms with $\alpha > \sigma + e$ are active—marginal costs drives screening.

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Platform:

- Firms set higher prices $\rightarrow$ platforms fee increases.
- Tradeoff between per transaction revenue and volume becomes less stark.
- Obtain volume: prefer more informative recommendations, $\sigma > \sigma^m$.

All effects serve to improve CS.

More results (II): Sequential platform competition

In the competition setting, suppose instead:

- Platforms announce their recommender system sequentially.
- Allow the incumbent to be more 'flexible' and move second.

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Proposition

There exists a unique equilibrium where $\sigma_I = 0.360 > \sigma_C = 0.311$, $\Pi_I > \Pi_C$.

More results (III): Costly firm entry

In the competition setting where:

- Platforms compete sequentially, entrant before incumbent.
- Costly for firms to join second platform, M.

From the previous result, we know $\sigma_I > \sigma_C$ and firms optimally set $p = \frac{\alpha - \sigma_k}{2}$.

- A highest quality group, $\alpha > \tilde{\alpha} > \sigma_I$ multi-home.
  Profitable to sell on both platform at high price.

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  For $\alpha \in (\sigma_I, \underline{\alpha}]$: Better to be best of the worst
- $\alpha < \sigma_C$ inactive.

More results (IV): Asymmetric consumer inertia

In the competition setting, suppose instead:

- There is asymmetric consumer inertia across platforms:
  - The distribution of inertia to join competitor first order stochastic dominate the inertia to join incumbent. (more costly to join competitor.)
  - Crudely suppose: $c_{i,I} \sim U[0,1]$ and $c_{i,C} \sim$ triangular distribution peak 1.

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Proposition

There exists a unique equilibrium where $\sigma_C = 0.475 > \sigma_I = 0.319$.

Closely relates to how new competitors are incentivised to design much better algorithms than incumbents.

More results (V): Multi-homing consumers

In the competition setting, suppose instead consumers search across platforms:

- Consumers join platform giving highest $E[u_k] - c_{i,k}$.
- They are recommended a firm, and observe its value-for-money.
- If the value-for-money is too low, they repeat the process on the other platform.
- Compare both firms before buying.

Note: search is 'costly' in that inertia is positive.

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Proposition

There exists a unique symmetric equilibrium where $\sigma < \sigma^m$.

Remark

When consumers multi-homing degrade recommender systems and lowers consumer surplus.

More results: Robustness

Monopoly

- General distributions: Relative informativeness of rec.sys. hold if
  - Distribution of consumer inertia not too bottom heavy.
- Negative consumption utility
- General recommender function

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Summary

- Capture how recommender systems evolved over time (1997 – 2024).
- Rise of Gatekeepers can explain ensh*ttification.
- Consumers are not necessarily worse-off despite Gatekeepers.
- Aligned goals of regulator and platform:
  Platforms prefer transparency.
  Difficult for consumers to do better than platform.
- Regulating gatekeepers does not only facilitate competition between platforms but between firms on platforms.