Merger Analysis in the App Economy:
An Empirical Model of Ad-Sponsored media

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Motivation

- Antitrust/regulation issues in the app economy:
  - Google's acquisition of YouTube;
  - Facebook's acquisition of WhatsApp;
  - FTC v. Facebook;
  - Epic Games v. Apple/Google.
- Challenge: **co-existence of multiple business models**
  - Paid apps;
  - Free ad-sponsored apps;
  - Combination of paid/ad monetization.
- Difficulty in traditional (=price-based) antitrust analysis
  $\rightarrow$ rooms for misguided policies.

Research question

- How can we estimate demand/supply parameters of an imperfect competition of ad-sponsored media with multiple monetization policies?
- Do product categories in the app marketplace, such as “Social" apps constitute relevant markets?
- Does market definition work in the app economy?
- How does the change in the transaction fee imposed by the marketplace affect consumer and aggregate surplus?

Method and materials

- Develop an empirical model of ad-sponsored media:
  - Consider consumers with budget and time constraints.
  - App developers compete in utility by setting prices and advertising intensities.
  - Introduce well-defined notion of “cost" for using an app.
- Establish an estimator based on available data about Google Play.
- Using a notion of “cost" conduct an SSNIP test for defining antitrust markets.

Results

- Estimates:
  - Disutility from ads is 5-6% of the app's advertising revenue.
  - Game apps are more segmented by categories than non-game apps.

- Market definition:
  - Some game categories constitute relevant market.

  ex Action, Puzzle, and Role Playing games.

- Merger simulation:
  - Only the mergers within relevant markets have large impact on welfare.

- Transaction fees:
  - Reduction in fees can *increase* prices and reduce ads, especially for non-game apps.

Roadmap

Today's talk proceeds in the following order:

1. Model of competition of ad-sponsored media.
2. Estimation of the model.
3. Market definition and merger simulation.
4. Reduction in transaction fees.

1. Model of ad-sponsored media
2. Mobile app industry
3. Estimation
4. Market definition and merger simulation
5. Transaction fees

Setting

- For each market t:
  - A set of apps j.
  - A set of app developers d.
  - A mass of consumers.
- An app developer j:
  - sets the download price F_j, and
  - advertising intensity a_j.
- Consumer i:
  - downloads at most one app j, and
  - choose the usage time q_j of downloaded app.
- Consider a static pure-strategy Nash equilibrium.

Consumer's problem

- The indirect utility from downloading app j:

$$u_{ij} := S_j + \beta'_{di} X_{dj} - \alpha_y F_j + \xi_{dj} + \underbrace{\varepsilon_{ij}}_{\text{TIEV}}$$

- The usage surplus is:

$$S_j = \max_{q_j} v_j,$$

where

$$v_j := \kappa \left[\left(\beta'_{uj} X_{uj} - \alpha_a a_j - \alpha_y w + \xi_{uj} \right) q_j - \frac{\eta}{2} q_j^2 \right].$$

- With this specification,
  - usage time q_j and
  - download share s_j

  are analytically solved.

App developer's problem

- The per-app profit:

$$\pi_j := s_j \times \left\{ (1-\rho)F_j + q_j(a_j r - \lambda) - \epsilon_j \right\}$$

- The total profit of app developer d:

$$\Pi_d := \sum_{j \in \{d\text{'s apps}\}} \pi_j .$$

- Each developer chooses (a_j, F_j) of the owned apps to maximizes the total profit, *with non-negativity constraints* $a_j \geq 0$, $F_j \geq 0$.

- The *free apps* and *ad-free* apps are captured by a corner solution.

Competition in utility

- The mean utility is sufficient statistics of price and advertisement for consumers.
- The assumption of no random coefficient in the usage-related utility is crucial for this.
- The per-app profit can be expressed as

$$\pi_j(\delta) := s_j(\delta) \times \bar{\pi}_j(\delta_j),$$

  - δ_j is mean utility from app j;
  - $\bar{\pi}_j(\delta_j)$ is maximal per-consumer profit to achieve δ_j.

- Developer's problem is then to choose $\{\delta_j\}$ to maximize

$$\Pi_d := \sum_{j \in \{d\text{'s apps}\}} \pi_j(\delta)$$

Notion of cost

- Define the *cost* for using an app j

$$c_j := \delta_j^0 - \delta_j,$$

  - δ_j^0: mean utility achieved by zero price/ads.
  - δ_j: actual mean utility.

- Under price competition, $c_j = \alpha_y F_j$.

- Thus, the notion of cost generalizes the notion of price.

- This notion is used for market definition.

Discussion

- Direct marginal cost of advertising intensity is zero.
- Competitive advertising markets.
- No consumer heterogeneity in the usage surplus.
- Static framework: no entry, innovation, or customer-base accumulation.

1. Model of ad-sponsored media
2. Mobile app industry
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Covered apps

- Platform: Google Play.
- Selection of apps:
  - For game/non-game apps and each business model (free/ad, paid/ad, paid/no-ad).
  - Select apps based on the # of times that ranked above a certain threshold on the download and usage ranking.
- Missing values:
  - The data is not recorded if an app's download and usage is below top 1000 of the category in a week.
  - We filled the missing values with the minimum value of the recorded apps in the same category (mostly zero or near zero).
- Period: March 2015 to January 2017.

Mobile app industry

Summary statistics at the week/app-level

	N	Mean	SD	Median	Min	Max
Application						
Usage time (Hour)	28164	1.3	1.1	0.9	0.5	13.7
Download	28164	12984.2	21775.1	6032.5	1.0	369601.0
Download price (JPY)	28164	123.1	267.7	0.0	0.0	886.4
Game						
Usage time (Hour/User)	21203	3.8	3.0	3.3	0.5	26.7
Download	21203	9427.0	17459.1	4256.0	2.0	537098.0
Download price (JPY)	21203	2492.8	3745.6	704.1	0.0	12404.0

Mobile app industry

Shares of business models for each product category (Application)

Category	N	Paid/Ad sponsored	Paid/Ad free	Free/Ad sponsored
Comics	1171	0.693	0.081	0.225
Communication	1296	0.255	0.275	0.470
Education	1988	0.082	0.508	0.409
Entertainment	1375	0.255	0.131	0.615
Lifestyle	1113	0.092	0.081	0.827
Music and Audio	3238	0.148	0.311	0.540
News and Magazines	4191	0.026	0.072	0.902
Personalization	646	0.173	0.115	0.712
Photography	1853	0.131	0.107	0.761
Productivity	1204	0.098	0.425	0.477
Social	1649	0.534	0.136	0.329
Tools	2241	0.124	0.007	0.869
Video Players	1612	0.093	0.223	0.684
Total	23577	0.175	0.188	0.637

App characteristics data

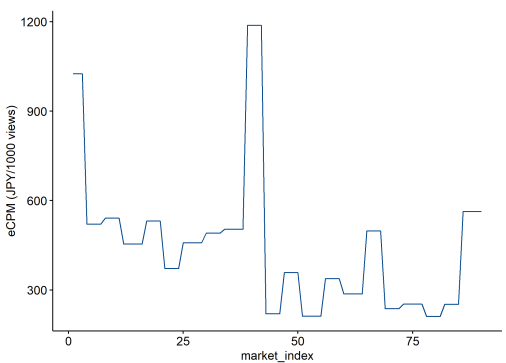
- Scraped app descriptions in Google Play.

Numerical representation of app descriptions

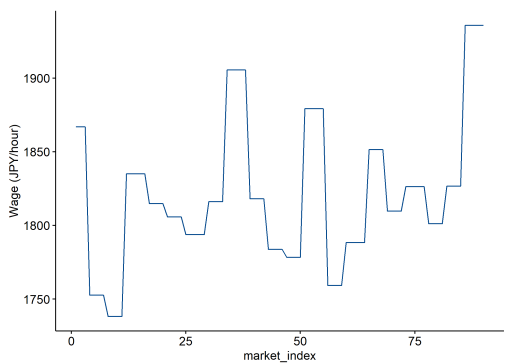
- Converted each word in an app description into a 300-dimensional *word vector* using the National Language Web Corpus of Japanese.
- For each app, take the average of the word vectors weighted by the reciprocal of the frequency of the word in the descriptions of the covered apps, and use it as a word vector representing the description of the app.

Market data

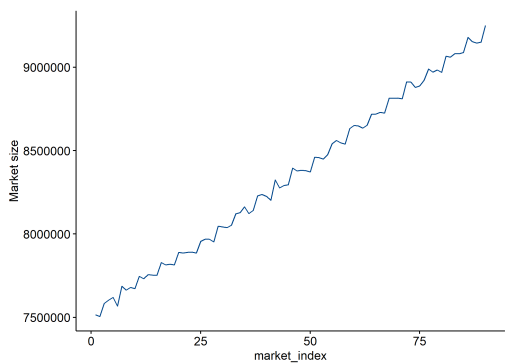
- Average advertising price data of Android app is from Adtapsy (JPY/eCPM).
- Average hourly wage data is from Basic Survey on Wage Structure (JPY/USD).
- The market size is constructed as the number of active devices times a constant to ensure that no total market share exceeds 1.



(c) Advertising price



(d) Hourly wage



(e) Market size

1. Model of ad-sponsored media
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Key identification assumption

- We do not observe ad intensity a_j.
- Usually, we identify marginal costs from the (i) observed price and (ii) price optimality condition.
- In this paper, we elicit equilibrium advertising from the advertising optimality condition:
  - under the assumption that the marginal cost for showing advertising is zero.
- Justification: ad-network service.
  - cf. newspapers, TVs.

Key identification assumption

- Price optimality condition cannot point-identify marginal costs of *free apps*
- Some extrapolation is necessary.
- We try to identify the distribution of the costs of free apps by assuming that free/paid versions of the same app has the same marginal costs.
- Some bias may exist because the apps that have free/paid version may not represent free apps.
- Estimation procedure

Estimation result:

Table: Estimation results of demand non-linear parameters

Parameter	Application	Game
α_y	0.0194	0.000856
α_a	0.479	0.0233
η	0.01	0.0105
κ	7.94	52.5

Table: Implied advertisement disutility

Application	Game
24.7	27.2

Estimation result

Download-related parameters:

- More product differentiation for game apps.

Parameter	β_d	σ
Constant	-10.7	0.00252
Positive sentiment	-1.49	0.000198
Negative sentiment	-3.25	0.0017
Log of number of characters	1.31	0.0042
Entertainment	1.92	0.000973
Education	-2.84	0.000219
Communication	0.861	9.03e-05
Personalization	-1.69	0.000671
Music and audio	-0.682	0.000758
News and magazines	-3.22	0.00494
Lifestyle	-1.62	0.000145
Social	2.87	0.000469
Video players	0.619	0.00308
Comics	1.82	0.000204
Tools	-1.49	9.44e-05
Photography	-0.328	4.5e-05
Productivity	-1.01	0.00074

(a) Application

Parameter	β_d	σ
Constant	2.33	0.137
Positive sentiment	-2.43	0.468
Negative sentiment	-1.41	0.0972
Log of number of characters	-0.44	1.21
Puzzle	-1.66	3.33
Card	-2.82	0.591
Casual	-1.75	0.0991
Sports	-6.75	0.507
Strategy	-7.14	0.074
Simulation	-3.05	7.95e-05
Action	-21.1	15
Role playing	-26.5	17.2
Casino	-3.64	0.422
Adventure	-3.9	0.237

(b) Game

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SSNIC test

- Market definition uses SSNIP test:
  - **S**mall but
  - **S**ignificant and
  - **N**on-transitory
  - **I**ncrease in
  - **price**

- SSNIP test considers how the profit of hypothetical firm that own the set of app changes after 5% increase in prices.

- The set of apps forms the market if the profit increases.

- Because we cannot use SSNIP tests for free apps, we use SSNI**C** test.

SSNIC test

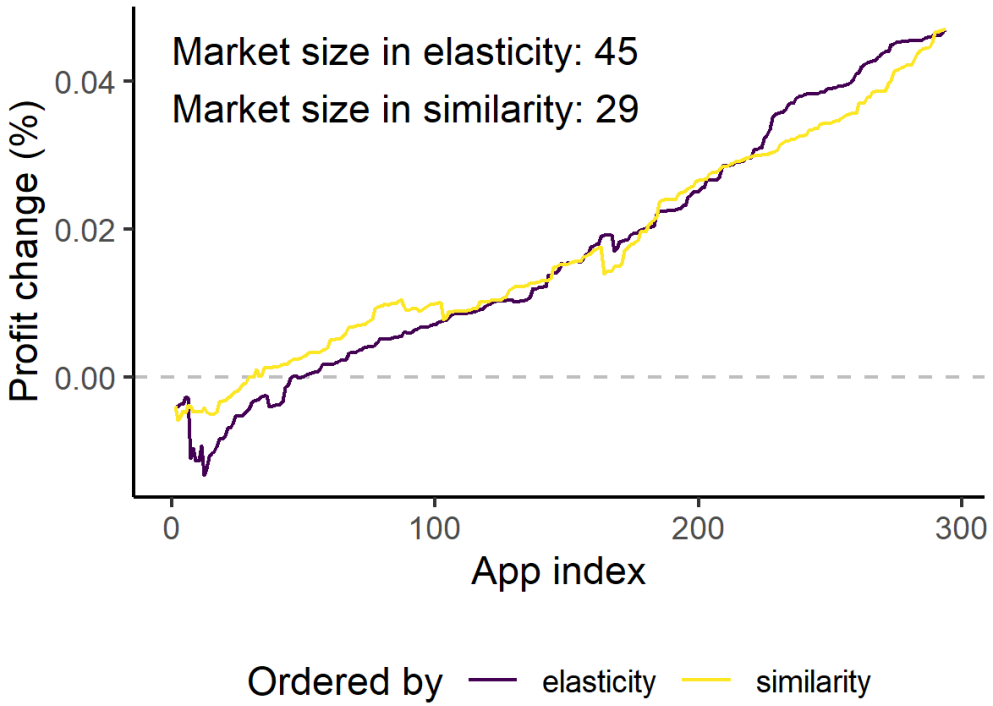

Figure: The SSNIC path of the top social app

SSNIC test

Table: SSNIC test for categories

Category	Profit change (%)
Comics	-6.192
Communication	-12.957
Education	-0.618
Entertainment	-4.131
Lifestyle	-0.105
Music and Audio	-0.168
News and Magazines	-0.438
Personalization	-0.743
Photography	-0.177
Productivity	-0.2
Social	-2.18
Tools	0.01
Video Players	-0.188

(a) Application

Category	Profit change (%)
Action	8.496
Adventure	-0.031
Card	-0.046
Casino	0.103
Casual	0.346
Puzzle	2.944
Role Playing	10.869
Simulation	0.276
Sports	-1.806
Strategy	-0.012

(b) Game

Merger analysis

- Welfare effects of mergers are large only for categories that forms relevant markets.

Category	Consumer surplus	Profit app	Profit platform	Total surplus
Action	0.971	1.16	1.06	0.99
Adventure	1	1	1	1
Card	1	1	1	1
Casino	1	1	1	1
Casual	0.999	1.01	1.01	1
Others	1	1	1	1
Puzzle	0.95	1.23	1.12	0.98
Role Playing	0.916	1.42	1.24	0.971
Simulation	0.999	1.01	1.01	1
Sports	1	1	0.999	1
Strategy	1	1	1	1

(c) Game

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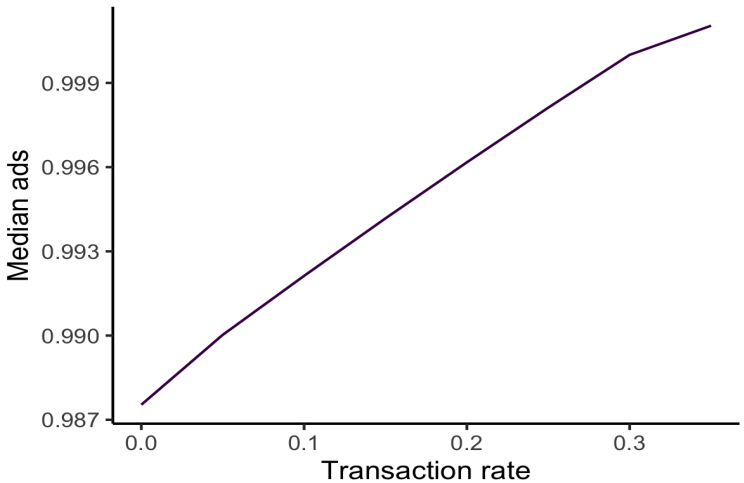
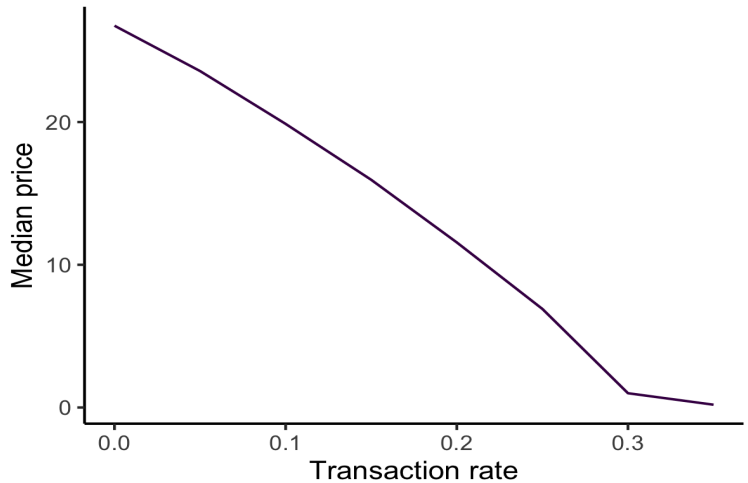
Impact of transaction fees

- What happens if transaction fee is reduced?
- Price may *increase* through 2 channels.
  1. shift from ad-revenue from price revenue.
  2. special feature of proportional fee
- Therefore, the impact of transaction fees on prices is theoretically ambiguous.

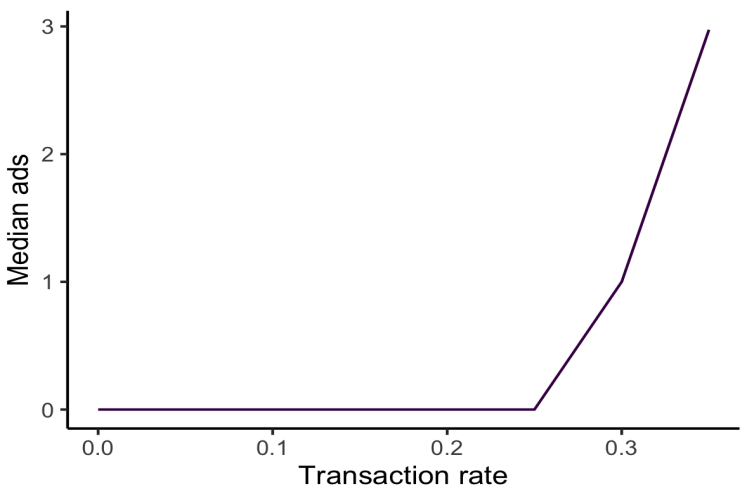
Transaction fees: endogenous variables



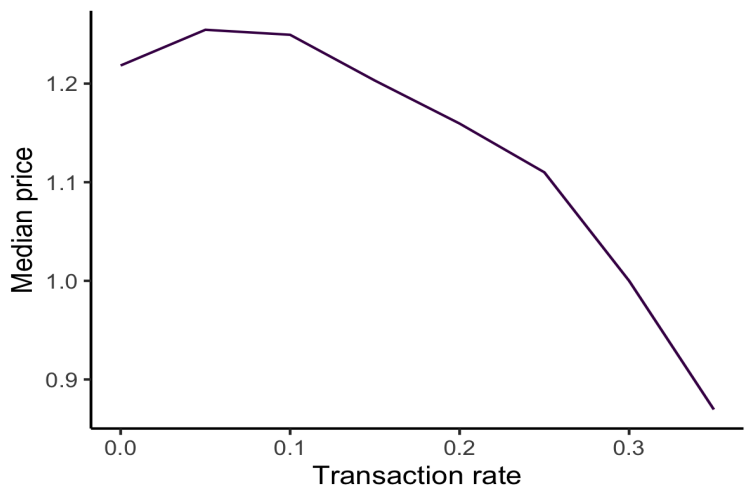
(a) Ad: Application



(b) Price: Application

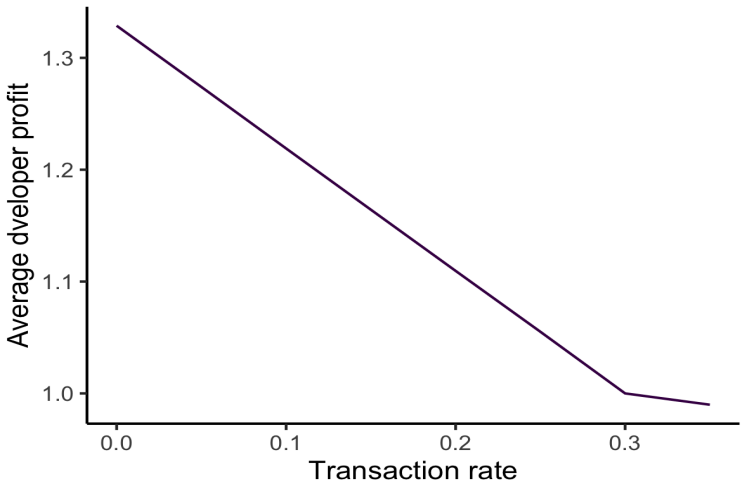


(c) Ad: Game

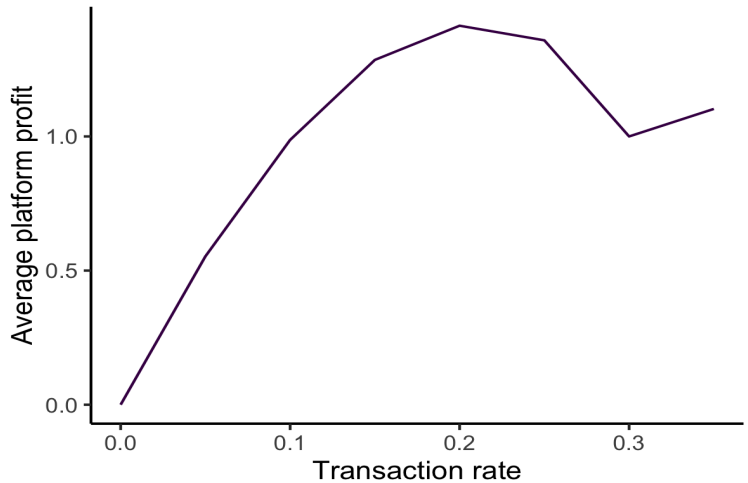


(d) Price: Game

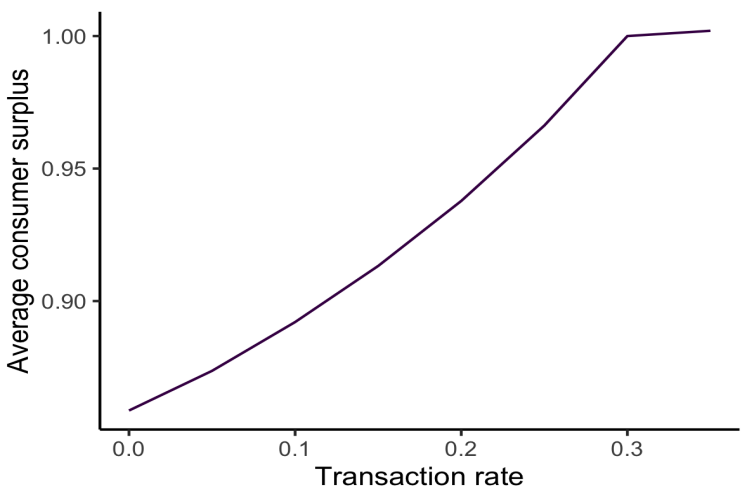
Transaction fees: surplus/application



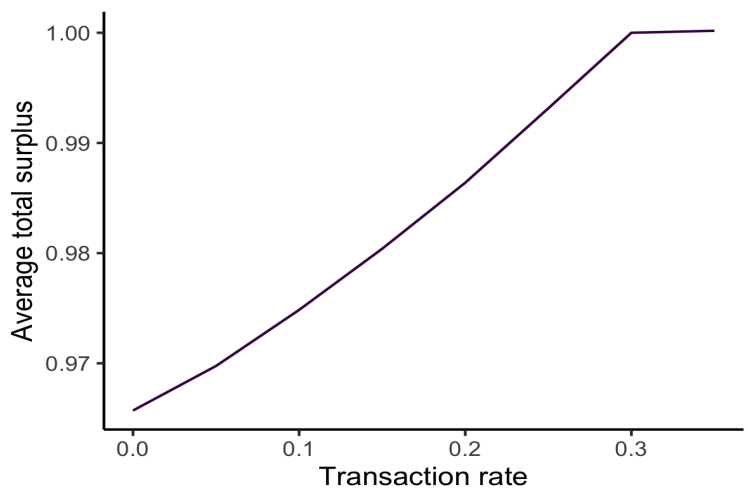
(e) App profit



(f) Platform profit

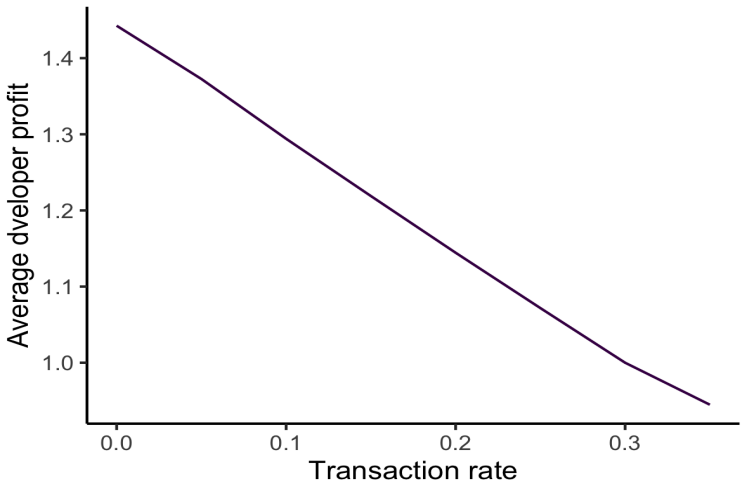


(g) Consumer surplus

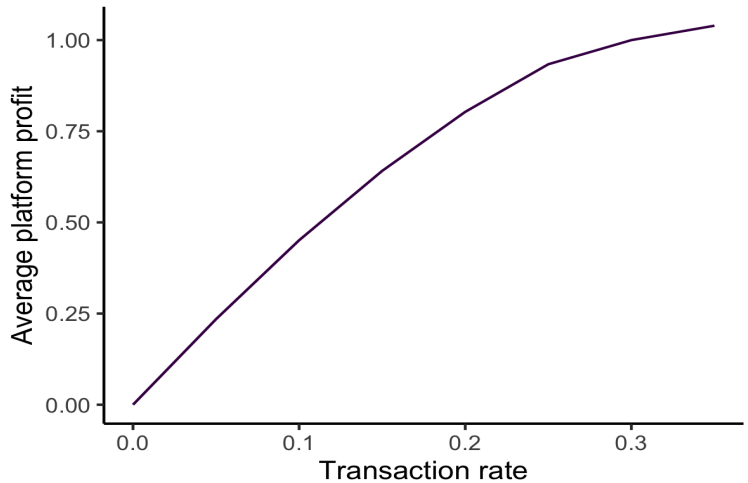


(h) Total surplus

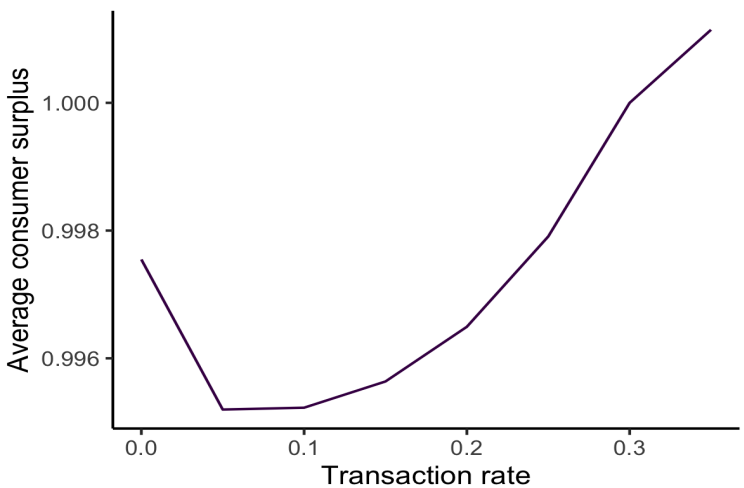
Transaction fees: surplus/game



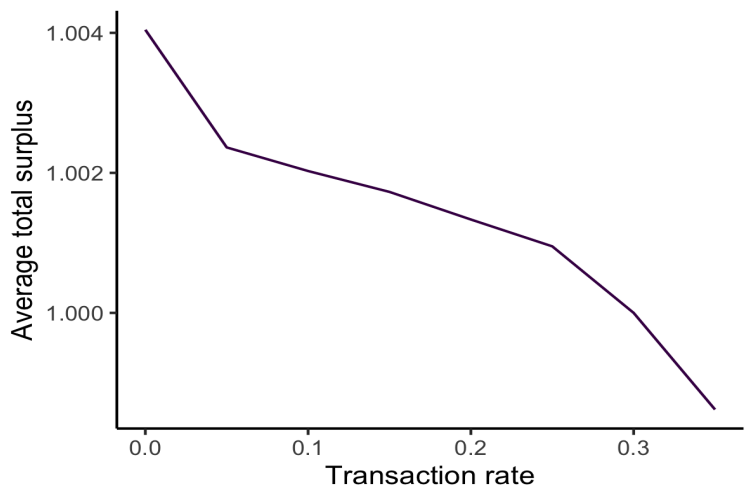
(i) App profit



(j) Platform profit



(k) Consumer surplus



(l) Total surplus

Conclusion

- Our specification captures co-existence of various business models and enables to conduct market definition in free markets.
- Some categories of game apps form relevant market, whereas none of non-game categories form relevant markets.
- Merger simulation shows that a merger in a app category has large welfare impact only when it forms a relevant market.
- A reduction in transaction fees have non-trivial impact on prices/ads through the shifts in business models.

Steps for constructing moment conditions

1. Set data and fix structural parameters.
2. Elicit the implied mean utility from BLP-inversion of the optimal download choice of consumers.
3. Elicit the implied download-related unobserved fixed effects ξ_{dj} from the implied mean utility.
   - This can be done because the usage time is a sufficient statistic of the underlying unobserved advertising intensity.

Steps for constructing moment conditions

4. Elicit the implied equilibrium advertising intensity a_j and marginal cost shocks from the pricing and advertising optimality conditions of developers.

5. Elicit the implied usage-related unobserved fixed effects ξ_{dj} from the usage optimality condition of consumers.

- These steps generate the following objects implied from the data and parameters:
  - The download-related unobserved fixed effects ξ_{dj}.
  - The usage-related unobserved fixed effects ξ_{uj}.
  - The equilibrium advertising intensity a_j.
  - The download marginal costs ϵ_j

GMM estimator

- Demand parameters:
  - Conditional moment conditions of ξ_{dj} and ξ_{uj}.
  - Differential IV as the instrumental variables.
- Supply parameters:
  - Pricing optimality condition augmented with the implied advertising intensity.
  - Classification error between the implied advertising intensity and the observed advertising dummies.
  - The divergence between the elicited marginal costs of paid/free versions of freemium apps.
- Define a GMM estimator based on above moments.