Across-Market Platform Competition in Mobile App Economy

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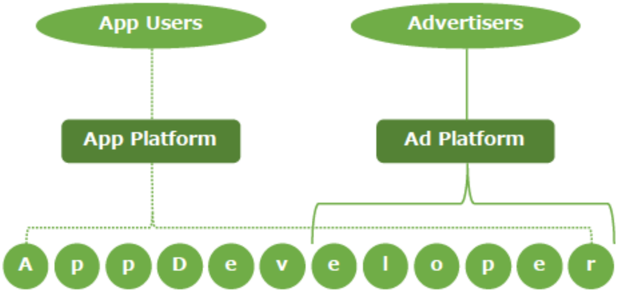
Section 1

Introduction

Industry Background



- App developers have two revenue channels
  1. app sales via app platform market
     - intermediation between users and developers of apps
  2. in-app advertising via ad platform market
     - intermediation between advertisers and ad-funded apps
- Co-existence of two distinct platform markets:

Policy Debate on App Platform Market

Dominant Market Power

- Big market for mobile apps
  - Trades of apps are intermediated by app platforms

    e.g., Apple App Store / Google Play Store
  - Total revenue of paid apps (Statista Inc.)
    - USD 2.7 billion in 2019 / USD 3.6 billion in 2020
- Policy concerns
  - Dominant market power of app platforms
    - Consumers are locked into an app store once they buy an Android or Apple device
    - The gatekeeper position enables Google and Apple to charge a monopolistic 30% commission on app sales
    - Claimed by Epic Game, Spotify, and others

  cf. Digital Markets Act (2020), Cabral et al (2021)

Policy Debate on Ad Platform Market

Dominant Market Power + Market Opacity

- Mobile ad market is bigger
  - App developers shift revenue source toward in-app advertising
    - As of September 2020, 92.3% of iOS apps and 96.5% of Android apps are free of charge (Statista Inc.)
  - Larger than app market (Statista Inc.)

    2019 USD 189 billion (ads) >>> USD 2.7 billion (app)
- Advertising matching (display ads)
  - Real-time matching between ad-funded apps and advertisers is facilitated by ad platforms
    - also called ad network or ad exchange
    - Google AdMob / InMobi / Apple iAd (–2016)
  - Google holds a strong, nearly monopoly position
    - 35% of the value of advertising is, on average, captured by ad platforms (Competition & Markets Authority, 2020)
    - Very opaque... Some money is “lost” (Cabral et al., 2021)

Research Purpose

- Ongoing policy debates
  - Two platform markets are discussed separately
    - Monopolies in app markets are bad
    - Advertising markets are opaque
- An overlooked point of view
  - Across-market platform competition
    - App and ad platforms are competing for app developers' revenue sources
    - Competition affects developers' business model choices
- The purpose of this study is to develop a unified model capturing the complex interplay between distinct platforms

Main Findings

3 models

1. 1 app platform vs. 1 ad platform
   - Current iOS app economy
     - Apple App Store vs. Google AdMob
   - App and ad platforms compete in commission
     - app commission (r) $\searrow \Longrightarrow$ # of paid apps $\nearrow$
     - ad commission (τ) $\searrow \Longrightarrow$ # of ad-funded apps $\nearrow$
   - RESULT
     - App and ad commissions should be set at the same level in terms of social welfare: $r = \tau$
   - IMPLICATION
     - Current: app commission (15-30%) < ad commission (35%-) → Oversupply of paid apps
     - Recent social pressure on app platforms might not be good → Excessive shift from in-app advertising to fee-based business model (Sokol & Zhu, 2021)

Main Findings (cont'd)

2. 1 app platform vs. 2 independent ad platforms
   - Current iOS app economy
     - Apple App Store vs. Google AdMob & InMobi
   - RESULT
     - Fierce ad platform competition
       $\Longrightarrow$ ad commission (τ) ↘ $\Longrightarrow$ app commission (r) ↘
     - Undersupply of paid apps
3. 1 app platform integrating one of 2 ad platforms
   - Current Android app economy
     - Google Play Store vs. Google AdMob & InMobi
   - Past iOS app economy
     - Apple App Store vs. Apple iAd & Google AdMob
   - RESULT
     - Integrated platform can benefit from the shut down of its ad platform division
   - IMPLICATION
     - Why Apple terminated iAd in 2016?

Literature

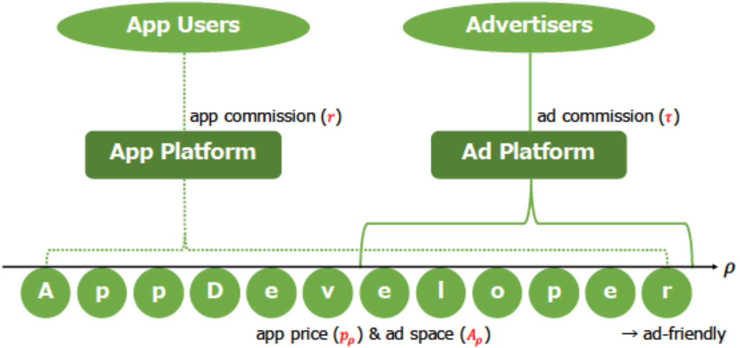
1. Platforms intermediating trades between buyers and sellers
   - Hagiu (2009), Karle et al. (2020), and others
   - dual role/hybrid platforms
     - Hagiu et al. (2020), Kittaka (2020), Zennyo (2021)
2. Advertising-financed (media) platforms
   - Anderson & Coate (2005) and others
   - multi-homing
     - Ambrus et al. (2016), Athey et al. (2018)
   - ad-blockers
     - Anderson & Gans (2011), Despotakis et al. (2021)
3. Ad networks
   - D'Annunzio & Russo (2020)

Section 2

Benchmark Model

Model with 1 App Platform and 1 Ad Platform

- Model overview



- Timing
  - App and ad platforms set r and τ, respectively
  - Each app developer chooses a pair of (p_ρ, A_ρ)

App Developers

- Mass 1 of app developers:
  - $\rho \in [0, \bar{\rho}]$ denotes the type of app developers
    - $\rho \sim G(\rho)$ w/ p.d.f. $g(\rho)$
- Profit function of app ρ

$$\pi_\rho = \underbrace{(1-r)p_\rho D_\rho(p_\rho, A_\rho)}_{\text{app sales}} + \underbrace{(1-\tau)\beta(\rho)A_\rho D_\rho(p_\rho, A_\rho)}_{\text{in-app advertising}} \quad (1)$$

  - $p_\rho \geq 0$: price of app ρ
  - $A_\rho \geq 0$: amount of ads displayed in app ρ
  - $D_\rho(\cdot,\cdot)$: demand of app ρ (detailed later)
  - $\beta(\rho)$: per-user ad revenue generated from a unit of ads
    - $\beta(\rho) > 0$ and $\beta'(\rho) > 0$ for all ρ
    - prices paid by winning bidders (Choi and Jeon, 2020)

App Users

- Mass 1 of users:
  - Every user, $i \in [0, 1]$, is ex-ante identical and negligibly small
- User i's utility from the consumption of app ρ

$$\varepsilon_{i\rho} - p_\rho - \delta(\rho) A_\rho \tag{2}$$

  - $\varepsilon_{i\rho}$: match value of app ρ to user i
    - $\varepsilon_{i\rho} \sim F(\varepsilon)$ w/ p.d.f. $f(\varepsilon)$
  - $\delta(\rho)$: disutility created by a unit of ads in app ρ
    - $\delta(\rho) > 0$ and $\delta'(\rho) < 0$ for all ρ

Assumptions

$\beta'(\rho) > 0$ and $\delta'(\rho) < 0$

  - Low ρ: GoodNote $\longrightarrow$ High ρ: Twitter

App Developers' Business Model Choice

- App demand (monopolistic competition)
  - User i buys app ρ if and only if she gains a positive surplus

$$D_\rho = \Pr(\varepsilon_{i\rho} > p_\rho + \delta(\rho)A_\rho) \quad (3)$$
$$= 1 - F(p_\rho + \delta(\rho)A_\rho) \quad (4)$$

- Profit of app developer ρ

$$\pi_\rho = (1-r)p_\rho D_\rho + (1-\tau)\beta(\rho)A_\rho D_\rho \quad (5)$$
$$= \left\{(1-r)p_\rho + (1-\tau)\beta(\rho)A_\rho\right\} \cdot \left\{1 - F(p_\rho + \delta(\rho)A_\rho)\right\} \quad (6)$$

  - App developer ρ chooses a combination of (p_ρ, A_ρ)

    paid apps if $p_\rho > 0$ and $A_\rho = 0$

    ad-funded apps if $p_\rho = 0$ and $A_\rho > 0$

Across-Market Platform Competition

- Profits of two platforms

$$\Pi_{App}(r) = \int_0^{\bar{\rho}} r p_\rho D_\rho dG(\rho) \tag{7}$$

$$\Pi_{Ad}(\tau) = \int_0^{\bar{\rho}} \tau \beta(\rho) A_\rho D_\rho dG(\rho) \tag{8}$$

  - App platform sets an ad valorem commission of r for intermediation of app sales
  - Ad platform sets an ad valorem commission of τ for intermediation of advertising matching
    - so-called “ad tech tax”

Surplus

- Consumer surplus

$$CS = \int_0^{\bar{\rho}} \int_{p_\rho + \delta(\rho)A_\rho}^{\infty} \left\{ \varepsilon - p_\rho - \delta(\rho)A_\rho \right\} dF(\varepsilon)dG(\rho) \quad (9)$$

- App developer surplus

$$ADS = \int_0^{\bar{\rho}} \pi_\rho dG(\rho) \quad (10)$$

- Social welfare: $W = CS + ADS + \Pi_{App} + \Pi_{Ad}$

Timing and Solution Concept

- Timing of the game
  1. app and ad platforms choose r and τ, respectively
  2. app developers choose a combination of (p_ρ, A_ρ)
- Subgame perfect equilibrium

Analysis of Stage 2

- Profit of app ρ

$$\pi_\rho(p_\rho, A_\rho) = (1-r)\left\{p_\rho + \underbrace{\frac{(1-\tau)\beta(\rho)}{1-r}}_{\text{effective marginal advertising revenue per user}} A_\rho\right\} D_\rho \qquad (11)$$

Proposition 1

A threshold $\hat{\rho}(r,\tau)$ exists such that

- apps with $\rho < \hat{\rho}(r,\tau)$ choose $(p_\rho, A_\rho) = (p^+, 0)$
  - where p^+ solves $1 - F(p^+) = p^+ f(p^+)$
- apps with $\rho > \hat{\rho}(r,\tau)$ choose $(p_\rho, A_\rho) = (0, A^+(\rho))$
  - where $A^+(\rho) = p^+/\delta(\rho)$

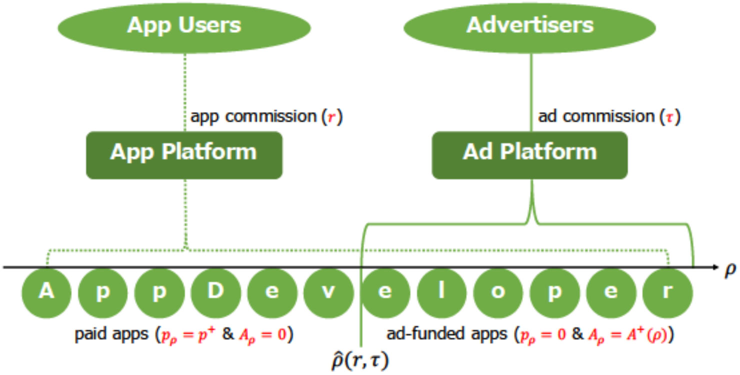
- $\rho = \hat{\rho}(r,\tau) \iff \frac{(1-\tau)\beta(\hat{\rho})}{1-r} = \delta(\hat{\rho})$

  LHS effective marginal advertising revenue per user

  RHS marginal advertising disutility

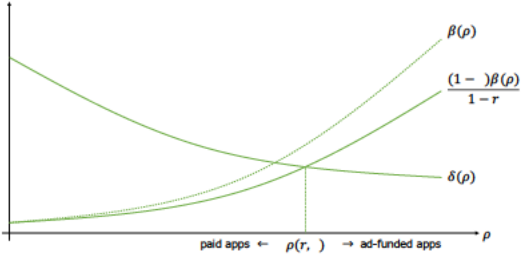
Analysis of Stage 2 (cont'd)

- Illustration of Proposition 1



Analysis of Stage 2 (cont'd)

- Determinant of threshold $\hat{\rho}$: $\frac{(1-\tau)\beta(\hat{\rho})}{1-r} = \delta(\hat{\rho})$



Corollary 1

$\frac{\partial\hat{\rho}(r,\tau)}{\partial r} < 0$ and $\frac{\partial\hat{\rho}(r,\tau)}{\partial\tau} > 0$ hold

- Across-market platform competition
  - Kawaguchi et al (2021)'s counterfactual analysis
    - an exogenous reduction in app commission increases app download prices and decreases the amount of advertisements

Analysis of Stage 1: Welfare Maximization

- With the results of Proposition 1, W can be rewritten as

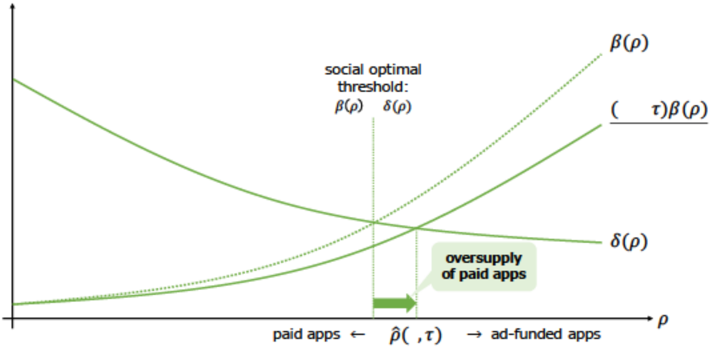
$$\int_{0}^{\bar{\rho}} \int_{p^+}^{\infty} \varepsilon \, dF(\varepsilon) dG(\rho) + p^+ D^+ \int_{\hat{\rho}(r,\tau)}^{\bar{\rho}} \frac{\beta(\rho) - \delta(\rho)}{\delta(\rho)} dG(\rho) \quad (12)$$

Proposition 2

If a policymaker chooses r and τ to maximize social welfare, then these commission rates are set to be the same, i.e., $r = \tau$.

Analysis of Stage 1: Welfare Maximization (cont'd)

- Illustration of Proposition 2



- Current app economy: over-supply of paid apps (?)
  app commission (r) 30% → 15%
  ad commission (τ) at least 35% (CMA Report, 2020)

Analysis of Stage 1: Platform Competition

- Profits of platforms:

$$\Pi_{App}(r,\tau) = \int_0^{\hat{\rho}(r,\tau)} r p^+ D^+ dG(\rho) \tag{13}$$

$$\Pi_{Ad}(r,\tau) = \int_{\hat{\rho}(r,\tau)}^{\bar{\rho}} \tau\beta(\rho) \frac{p^+}{\delta(\rho)} D^+ dG(\rho) \tag{14}$$

- Assumption for the existence and uniqueness of equilibrium:

$$\frac{g'(\hat{\rho})}{g(\hat{\rho})} + \frac{\beta'(\hat{\rho})}{\beta(\hat{\rho})} + \frac{\delta'(\hat{\rho})}{\delta(\hat{\rho})} < \frac{(1-\tau)\beta''(\hat{\rho}) - (1-r)\delta''(\hat{\rho})}{(1-\tau)\beta'(\hat{\rho}) - (1-r)\delta'(\hat{\rho})} < \frac{g'(\hat{\rho})}{g(\hat{\rho})} + 2\frac{\beta'(\hat{\rho})}{\beta(\hat{\rho})} \tag{15}$$

  - Both functions $\beta(\cdot)$ and $\delta(\cdot)$ are not too convex and not too concave

Analysis of Stage 1: Platform Competition (cont'd)

- FOCs:

$$\frac{\partial \Pi_{App}}{\partial r} = p^+ D^+ \left(G(\hat{\rho}(r,\tau)) + r g(\hat{\rho}(r,\tau)) \frac{\partial \hat{\rho}(r,\tau)}{\partial r} \right) = 0 \quad (16)$$

$$\frac{\partial \Pi_{Ad}}{\partial \tau} = p^+ D^+ \left(\int_{\hat{\rho}(r,\tau)}^{\bar{\rho}} \frac{\beta(\rho)}{\delta(\rho)} dG(\rho) - \tau \frac{\beta(\hat{\rho}(r,\tau))}{\delta(\hat{\rho}(r,\tau))} g(\hat{\rho}(r,\tau)) \frac{\partial \hat{\rho}(r,\tau)}{\partial \tau} \right) = 0 \quad (17)$$

  - With Condition (15), r and τ are strategic complements
    - Bertrand-like price competition

Analysis of Stage 1: Platform Competition (cont'd)

Proposition 3

- With Condition (15), a unique equilibrium (r^*, τ^*) exists
- Paid apps are over-supplied in terms of social welfare if and only if $r^* < \tau^*$, or equivalently

$$\frac{\delta(\rho^*)}{\beta(\rho^*)} \int_{\rho^*}^{\bar{\rho}} \frac{\beta(\rho)}{\delta(\rho)} dG(\rho) > G(\rho^*) \tag{18}$$

- A (simple) sufficient condition: $G(\rho^*) < 1/2$ (Corollary 2)
  - Ratio of paid apps is less than 50%
    - Over 90% of apps are free of charge
  - This sufficient condition does NOT depend on r and τ

Section 3

Ad-Platform Competition

Independent Ad Platforms

- Two competing ad-platforms $(j = 1, 2)$
  - homogeneous (perfect competition)
    - App developers choose an ad platform with lower τ_j

$$\Pi_{Ad}^{j} = \begin{cases} \int_0^{\bar{\rho}} \tau_j \beta(\rho) A_\rho D_\rho dG(\rho) & \text{if } \tau_j < \tau_k \\ \frac{1}{2} \cdot \int_0^{\bar{\rho}} \tau_j \beta(\rho) A_\rho D_\rho dG(\rho) & \text{if } \tau_j = \tau_k \\ 0 & \text{if } \tau_j > \tau_k \end{cases} \quad (19)$$

    - Standard Bertrand competition leads to $\tau_1^{**} = \tau_2^{**} = 0$
  - App commission r^{**} also declines due to strategic complementarity
    - $0 < r^{**} = r(0) < r(\tau^*) = r^*$

Proposition 4

Paid apps are under-supplied in terms of social welfare

Across-Market Platform Integration

- App platforms (used to) operate an ad platform
  - Google is operating AdMob in addition to Play Store
  - Apple used to operate iAd in addition to App Store until 2016

Proposition 5

Even if the app platform integrates either one of two ad platforms, the equilibrium outcome remains the same as that of Proposition 4

- Standard Bertrand competition leads to $\tau_1^{**} = \tau_2^{**} = 0$
- It engenders a low app commission as well
  - $r^{**} < r^{*}$

Benefit from the Shut-Down of Ad-Platform Division

Proposition 6

The integrated platform benefits from the shut down of its ad platform division. Formally, it follows that

$$\Pi_{App}(r^*, \tau^*) > \Pi_{App}(r^{**}, \tau^{**}) + \Pi^1_{Ad}(r^{**}, \tau^{**}) \tag{20}$$

- Intuition:
  - Termination of iAd mitigates ad platform competition
    → ad commission (τ) ↗
    → it increases # of paid apps and enables Apple to keep charging a high app commission
    → app commission revenue ↗
- This might be one of the reasons why Apple terminated iAd

Section 4

Discussion & Conclusion

Discussion

- In 2021, Apple introduced “AppTrackingTransparency” (ATT)
  - App developers have to receive the user’s permission when tracking information essential to providing personalized advertising
  - This policy change is expected to diminish the value of mobile advertising (Sokol & Zhu, 2021)
- Insights from the model
  - ATT is beneficial to Apple
    - ATT → downward shift of function $\beta(\cdot)$
      → threshold type $\hat{\rho}(r, \tau) \nearrow$
      → # of paid apps $\nearrow$ (→ oversupply of paid apps)
      → app commission revenue $\nearrow$
  - Optimal commission rule can be assessed independently of changes in the policy and design of platforms
    - Result of $r = \tau$ remains unchanged even if $\beta(\cdot)$ and $\delta(\cdot)$ change

Conclusion

- Contributions

  Present: Oversupply of paid apps

  Past: Apple's termination of iAd service

  Future: Apple's AppTrackingTransparency (ATT)

  - Results could not be reached without consideration for across-market platform competition
- Limitations
  - Complex chains of advertising intermediaries are abstracted away from the present model
  - The model assumes monopolistic competition among apps
  - No 1st-party apps are considered (e.g., Apple Music)
  - Sales of devices are not addressed
    - Google Android OS vs. Apple iOS
    - See Etro (2021)

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