Platform Competition with Network-based Advertising

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Motivation

- In late 2015, Twitter changed its advertising strategy (Kafka 2016)
- Users with many followers no longer saw ads, or saw very few
- Likely an attempt to retain influential users
  - Risk that influential users move to another platform, like Instagram
  - Influential users engaged $\longrightarrow$ Followers engaged

Motivation

- Users on Twitter/Instagram care about
  1. Viewing posts (especially from friends)
  2. Not seeing ads
- Both platforms are free, so cannot compete on price
- Can compete through advertising
  - Choose **ad load** for each user: ratio of ads to real posts

My goal

Explore this competition by bridging gap between two literatures:

- Platform competition and network effects
- Price discrimination on networks

Where I need help:

- Suggestions on motivation
- Suggestions on model
- Modeling content creation vs. modeling advertising

Literature

- N consumers linked in a network
- Two platforms, labeled 0 and 1
- Network modeled as a graph, adjacency matrix $G = (g_{ij})$
  - **Exogenous** network (for now)

- Per-period utility for consumer i spending t minutes on platform m:

$$\zeta_i^m + \underbrace{(1 - p_i^m)t - \frac{1}{2}t^2}_{\text{Content/ads}} + \underbrace{t\nu \sum_{j=1}^{N} g_{ij}\chi_j^m}_{\text{Network effects}}$$

- ζ_i^m: platform-specific benefit
- p_i^m: ad load for consumer i on platform m
- g_{ij}: weight on link from consumer i to consumer j
- χ_j^m: indicates whether consumer j is on platform m
- ν: strength of network effects
- See e.g. Chen, Zenou, and Zhou 2018

Consumers (the myopic case)

- Timing each period:
  1. Platforms set ad loads given current platform choices $x = (x_1, \ldots, x_N)$
  2. One consumer randomly chosen to update platform choice
     - Draw $\zeta_i^0 - \zeta_i^1$ from distribution Φ
     - Choose platform
     - No multihoming (for now)
  3. Each consumer chooses how much time to spend on their platform this period
  4. Platforms and firms receive payoffs
- Optimal number of minutes for consumer i to spend on platform m:

$$t_i^* = 1 - p_i^m + \nu \sum_{j=1}^{N} g_{ij} \chi_j^m$$

Consumer i, if selected to update, chooses platform 0 when

$$\underbrace{\zeta_i^0 + \frac{1}{2}\left(1 - p_i^0 + \nu \sum_{j=1}^{N} g_{ij}(1 - x_j)\right)^2}_{\text{Utility from platform 0}} > \underbrace{\zeta_i^1 + \frac{1}{2}\left(1 - p_i^1 + \nu \sum_{j=1}^{N} g_{ij} x_j\right)^2}_{\text{Utility from platform 1}}$$

$$\implies \zeta_i^0 - \zeta_i^1 > \frac{1}{2}\left(1 - p_i^1 + \nu \sum_{j=1}^{N} g_{ij} x_j\right)^2 - \frac{1}{2}\left(1 - p_i^0 + \nu \sum_{j=1}^{N} g_{ij}(1 - x_j)\right)^2$$

Consumer i chooses platform 0 with probability

$$q(i,x) := 1 - \Phi\left[\frac{1}{2}\left(1 - p_i^1 + \nu\sum_{j=1}^{N} g_{ij}x_j\right)^2 - \frac{1}{2}\left(1 - p_i^0 + \nu\sum_{j=1}^{N} g_{ij}(1-x_j)\right)^2\right]$$

Platforms

- Each period, platform m receives $t_i^* p_i^m$ from each consumer i on platform m
  - Implicit assumption: market rate for advertising space
- Platforms set ad loads to maximize expected payoffs

- x: the state (platform choices of all consumers)
- δ: discount rate (for now, $\delta = 0$)
- Value function for platform 0:

$$v^0(x) = \sum_{i=1}^{N} \frac{1}{N} q(i,x) \underbrace{p_i^0(1 - p_i^0 + \nu \sum_{j=1}^{N} g_{ij}(1 - x_j))}_{\text{Payoff if consumer i selected}}$$

$$+ \frac{N-1}{N} \underbrace{(1 - x_i) p_i^0(1 - p_i^0 + \nu \sum_{j=1}^{N} g_{ij}(1 - x_j))}_{\text{Payoff if consumer i not selected}}$$

$$+\delta \sum_{i=1}^{N} \frac{1}{N} \left(q(i,x) v^0 \underbrace{[(I - E_{ii})x]}_{\text{New state if i chooses 0}} + (1 - q(i,x)) v^0 \underbrace{[(I - E_{ii})x + e_i]}_{\text{New state if i chooses 1}} \right)$$

Value function for platform 1:

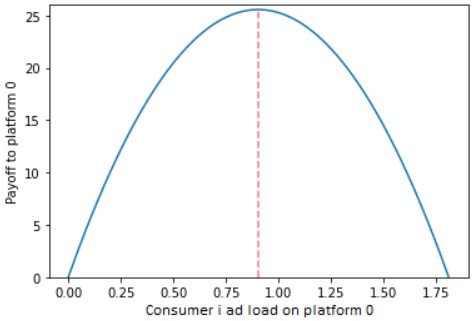
$$v^1(x) = \sum_{i=1}^{N} \frac{1}{N}(1 - q(i,x)) \underbrace{p_i^1(1 - p_i^1 + \nu \sum_{j=1}^{N} g_{ij} x_j)}_{\text{Payoff if consumer i selected}}$$

$$+ \frac{N-1}{N} \underbrace{x_i p_i^1(1 - p_i^1 + \nu \sum_{j=1}^{N} g_{ij} x_j)}_{\text{Payoff if consumer i not selected}}$$

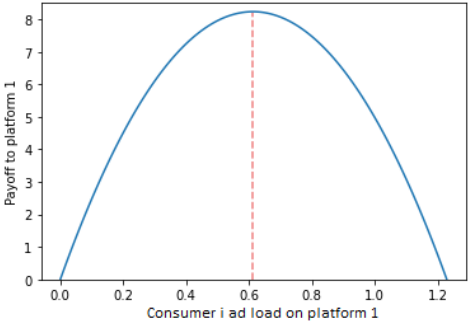
$$+\delta \sum_{i=1}^{N} \frac{1}{N} \left(q(i,x) v^1 \underbrace{[(I - E_{ii})x]}_{\text{New state if i chooses 0}} + (1 - q(i,x)) v^1 \underbrace{[(I - E_{ii})x + e_i]}_{\text{New state if i chooses 1}} \right)$$

Platforms ($\delta = 0,\ \Phi \sim \mathcal{N}(0,1)$)

Expected payoffs when $x_i = 0$, other ad loads fixed



Platform 0



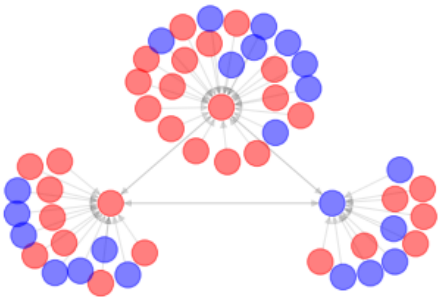
Platform 1

Questions

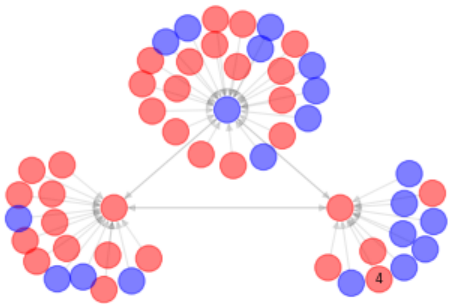
- Under what conditions will one platform take over the market?
  - Initial platform choices
  - Network structure
  - Model parameters
- Can one platform become dominant by showing fewer ads to particular consumers?
  - Which consumers?
  - Can a platform with a small initial user base overcome its disadvantage?
    - What if the small platform is higher quality? (Φ is skewed)

Simulations: starting point

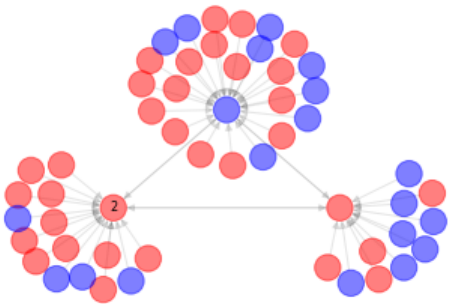
- Instagram (red) vs. Twitter (blue)
- 3 core consumers (all connected)
- 50 periphery consumers (connected to 1 core consumer)
- Consumer at head of arrow influences consumer at tail



Period 49: consumer 2 selected, stays on Instagram

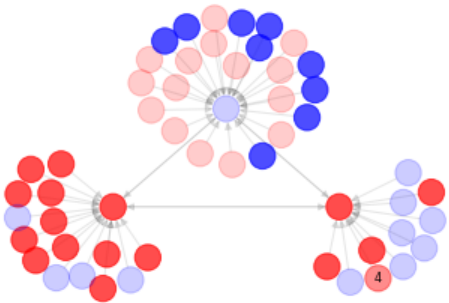


Period 48

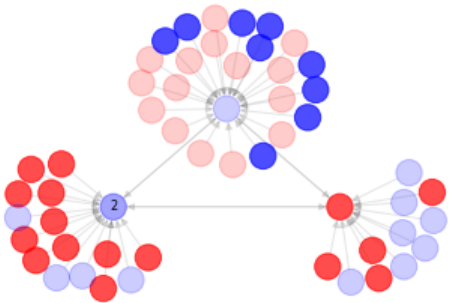


Period 49

Period 49: consumer 2 selected, switches to Twitter due to lower ad load



Period 48

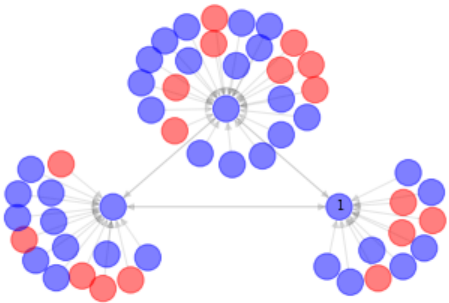


Period 49

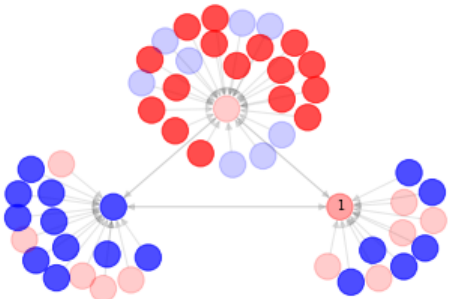
Darker shading $\longrightarrow$ higher ad load

Simulations: $\nu = 1,\ \Phi \sim \mathcal{N}(0,1)$

Weak network effects $\longrightarrow$ neither platform dominates

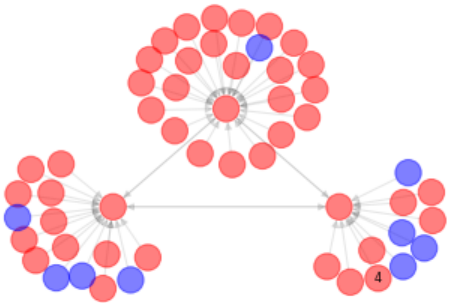


No pricing, period 300

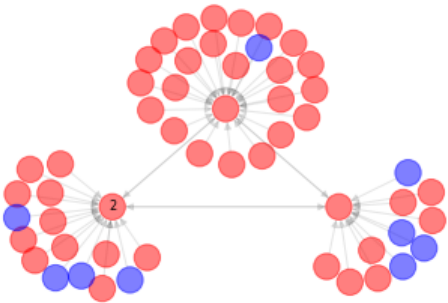


Optimal pricing, period 300

Period 49: consumer 2 selected, stays on Instagram



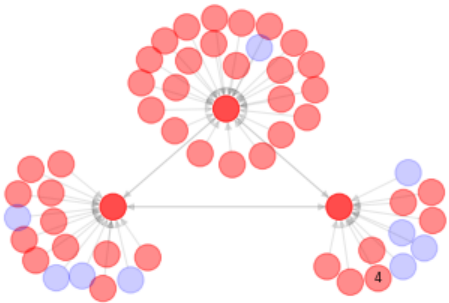
Period 48



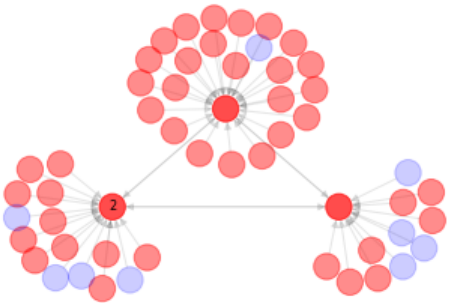
Period 49

Simulations: $\nu = 5,\ \Phi \sim \mathcal{N}(0,1)$, individualized ad loads

Consumer 2 offered lower ad load on Twitter, does not switch due to network effects



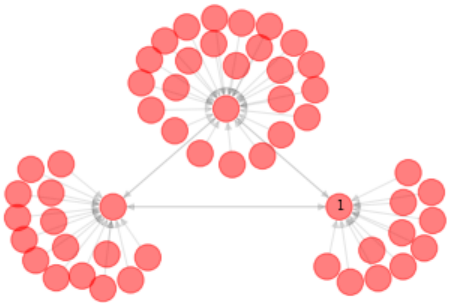
Period 48



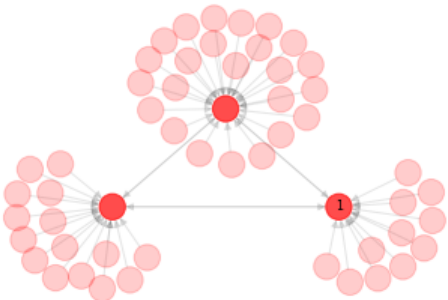
Period 49

Simulations: $\nu = 5,\ \Phi \sim \mathcal{N}(0, 1)$

Strong network effects $\longrightarrow$ one platform dominates



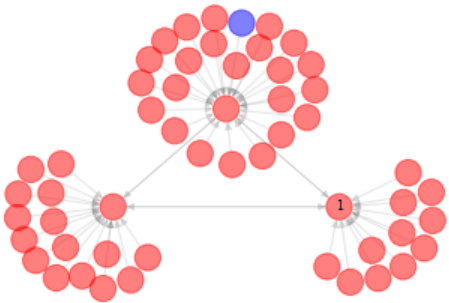
Uniform ad load, period 300



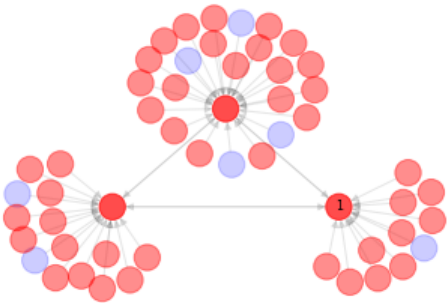
Individualized ad loads, period 300

Simulations: $\nu = 2,\ \Phi \sim \mathcal{N}(0,1)$

Weaker network effects $\longrightarrow$ dominance takes longer



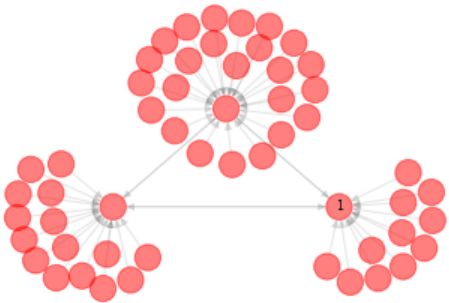
Uniform ad load, period 300



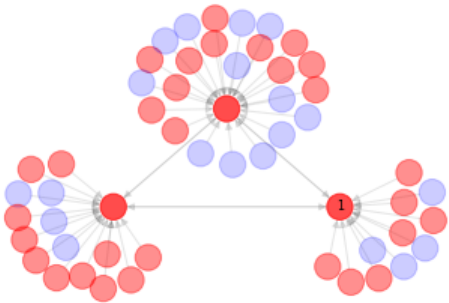
Individualized ad loads, period 300

Simulations: $\nu = 5,\ \Phi \sim \mathcal{N}(-5, 1)$

Twitter higher quality $\longrightarrow$ Instagram doesn't always dominate



Uniform ad load, period 300



Individualized ad loads, period 300

Next steps

- Analytical results
  - May only be possible for certain parameter values
- Numerical simulations when $\delta > 0$
- Possibly model content creation
  - A coefficient measures the degree to which an individual is a creator
- Address multihoming
- Model the market for ads?
- Twitter data?

Related literature

- Platform competition and network effects, e.g.
  - Fudenberg and Tirole (2000)
  - Cabral (2011)
  - Halaburda, Jullien, and Yehezkel (2020)
- Price discrimination on networks, e.g.
  - Candogan, Bimpikis, and Ozdaglar (2012)
  - Fainmesser and Galeotti (2016, 2020)
  - Chen, Zenou, and Zhou (2018)

Related literature

- Bimpikis, Ozdaglar, and Yildiz 2016
  - Firms allocate marketing budgets to maximize brand awareness
  - Higher centrality agents get a higher share of the marketing budget
  - Word of mouth communication among agents
  - Firms allocate based on the limit of brand awareness (so they aren't really changing the budget allocation over time)
  - This is different from how social media platforms operate: Instagram maximizes ad revenue
  - In this paper there is no negative effect from advertising, which is why central agents are targeted. On social media platforms, ads may cause users to spend less time on the platform. Central agents see fewer ads.