Revisiting the Uber Effect, Artificial Intelligence and Entrepreneurship, Do Apps Play Follow the Leader

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Introduction

Personal tech/entrepreneurship background (Navy, Amazon, Startup)

- New tech effects labor market
- Tech breakthrough effects business formation and labor market
- Market dynamics effect tech and business formation

First Two Chapters

Revisiting the Uber Effect

- Do Uber drivers displace conventional taxi drivers?
- 8.5-9.8% decrease in hourly earnings of wage employed drivers, 7.7-12.3% decrease in labor supply of wage employed drivers, random entry?, not robust to non-Uber effected occupational controls
- Original paper's results not robust

Artificial Intelligence and Entrepreneurship

- Literature review of impact of AI on entrepreneurship
- How AI technologies affect entrepreneurial opportunities and uncertainty, the adoption of AI technologies by startups, entry barriers, and the performance of entrepreneurial businesses
- How AI may affect entrepreneurship indirectly through impacting local and sectoral labor markets; how the regulation of AI may affect the entrepreneurship landscape

Motivation

- Theory suggests that when buyouts are possible, startups are more likely to develop similar products under an entry to buyout mechanism
- Startups are a key driver of innovation
- Federal Trade Commission v. Meta Platforms, Inc.
  -more (or better) options sooner

Introduction

- We empirically test market concentration's relationship with product differentiation
- Machine learning provides an opportunity to look at similarity (substitutes/complements) without relying on price variation
- We look to the Google Play Store, as a market with many startups, specifically to intra-category app descriptions, to see if descriptions from concentrated categories increase in similarity.

Literature (Theory)

- Rasmussen 1988: motive to enter a market in order to be bought out
- Hoberg and Phillips 2010: mergers and acquisitions are more likely between firms producing products that are similar to each other and differentiated from products produced by other rivals
- Phillips and Zhdanov 2013: acquisitions raise level of investment in innovation by potential acquisition targets
- Bryan and Hovenkamp 2020: incentive to be acquired by an incumbent (leader) skews direction of innovation, modeled by a startup selling a component technology to a leader or laggard
- Cunningham et al. 2021: competitors acquired to scrap products
- Dijk et al. 2024: startups allocate more towards rival projects when buyouts permitted

Literature (Language Modeling)

- Harris, 1954: Bag of words
- Sutskever et al., 2014: Sequence-to-sequence
- Vaswani et al. 2017: establish transformer architecture, show significant improvement in machine translation tasks compare to past methods with RNNs, CNNs, encoders and decoders
- Devlin et al. 2018: introduce BERT (Bidirectional Encoder Representations from Transformers) model showing very strong results on many NLP tasks
- Bajari et al. 2023: uses BERT to create Amazon description embeddings to estimate hedonic prices to measure inflation

Data

Sources

1. Google Playstore (Dec 2019)

1. Cross-sectional Data
2. Consists of all apps on Play Store during Dec 2019
3. App creation heavily skewed towards recent years
4. Downloads are in ranges
5. Downloads are upper bounded at 10 Billion

Data

Dropped in Data Cleaning

- non-english language apps
- $<$5k downloads
- 2008-2010
- missing values for category, year created, number of downloads, size, developer, rating, or price

Data

Summary Statistics

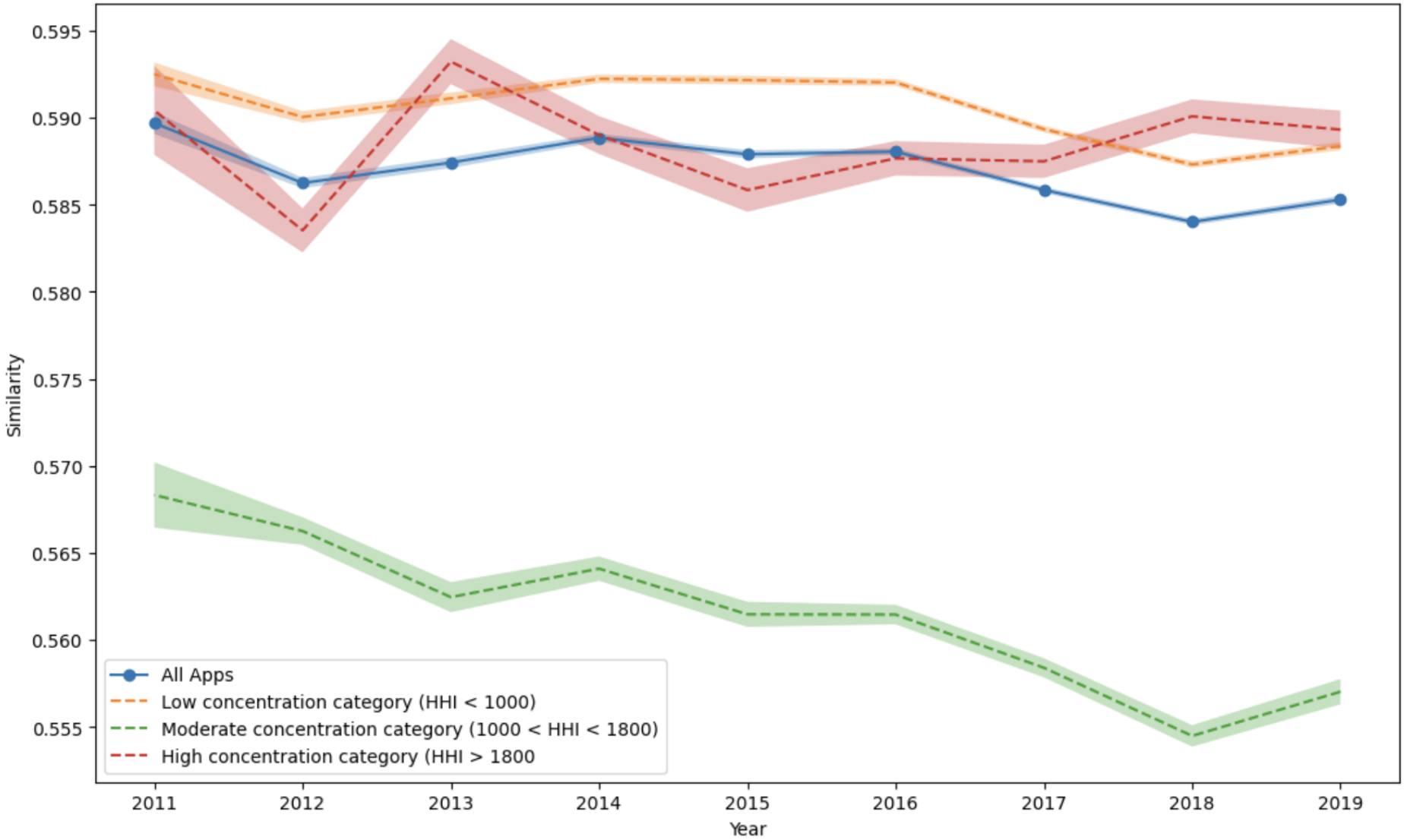
	Mean	σ	Min	Max
HHI	447.4	667.9	18.5	3592.4
similarity	0.586	0.050	0.153	0.714
weighted similarity	0.593	0.054	0.154	0.780
year created	2016.3	2.1	2011	2019
year of last update	2018.0	1.5	2011	2019
developer total apps	24.9	88.5	1	1141
screenshots	8.7	5.7	0	32
downloads	619.6k	25.4M	5k	5B
size (bytes)	19.4M	28.8M	3.2k	3.3B
number of ratings	11.1k	369.8k	0	101M
5 star rating	0.178	0.383	0	1
4 star rating	0.639	0.480	0	1
3 star rating	0.149	0.356	0	1
2 star rating	0.028	0.165	0	1
1 star rating	0.002	0.045	0	1
not rated	0.004	0.062	0	1
ads	0.688	0.464	0	1
digital purchases	0.217	0.412	0	1
not free	0.018	0.132	0	1
game	0.230	0.421	0	1
users interact	0.110	0.313	0	1
shares location	0.022	0.148	0	1
mature	0.030	0.170	0	1
violence	0.051	0.221	0	1

425,817 observations; Google Playstore 2019

Data


Number of Apps
Number of Downloads
Apps (Thousands)
Downloads (Billions)
Year
10
20
30
40
50
60
70
80
2011
2012
2013
2014
2015
2016
2017
2018
2019

Data


0.595
0.590
0.585
0.580
0.575
0.570
0.565
0.560
0.555
Similarity
2011
2012
2013
2014
2015
2016
2017
2018
2019
Year
All Apps
Low concentration category (HHI < 1000)
Moderate concentration category (1000 < HHI < 1800)
High concentration category (HHI > 1800

Methods (Similarity Score Construction)

- clean app descriptions (extra space, repeated punctuation, emoticons, symbols, foreign characters)
- transform descriptions into numerical vector (rows x tokens x 768)
- concatenate last 4 hidden layers (rows x 1 x 3072)
- take cosine similarity to all other apps in category (row_c x row_c)
- take mean across row and correct for self comparisons (row_c x 1)

Similarity Score Correction:

$$\text{similarity} = \frac{\text{biased similarity} \times \text{number of apps in category - 1}}{\text{number of apps in category - 1}} \quad (1)$$

Methods (BERT)

Bidirectional Encoder Representations from Transformers

- Trained on BooksCorpus (800M words) and Wikipedia (2.5B words)
- Trained on masked word prediction and next sentence prediction tasks
- 15% of words are replaced (80% mask, 10% random, 10% unchanged)
- Typically fine-tuning approach, but outperforms state of the art feature based methods (ELMo) in most NLP tasks

Text Example

Reference App

Flight Simulator: Fly Plane 3D. i6 Games 2014. 50M downloads.

Flight Simulator: Fly Plane 3D is an awesome new 3D Airplane Simulator game, become the pilot and fly your commercial jet to the destination. Guide and steer your plane through all of the waypoints to ensure you head to the correct destination, go through all of the waypoints and land at your destination airport within the time limit to earn yourself more pilot stripes. When arriving at your destination zone, slow the plane down and prepare for landing, be careful not to crash! Guide your plane towards the runway and park within the marked zone to complete the level. While parking your plane, be very careful to avoid the buses, helicopters etc parked along the run way.

Nearest Neighbor

Fly Flight Landing Simulator. RG Games 2017. 10k downloads.

Fly Flight Landing Simulator: Fly Plane 3D is an awesome new 3D Airplane Simulator game, become the pilot and fly your commercial jet to the destination. Guide and steer your plane through all of the waypoints to ensure you head to the correct destination, go through all of the waypoints and land at your destination airport within the time limit to earn yourself more pilot stripes. When arriving at your destination zone, slow the plane down and prepare for landing, be careful not to crash! Guide your plane towards the runway and park within the marked zone to complete the level. While parking your plane, be very careful to avoid the buses, helicopters etc parked along the run way.

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2nd Nearest Neighbor

Flight Simulator Fly plane. GR Mobile Games 2016. 100k downloads.

Flight Simulator Fly plane is an awesome new 3D Airplane Simulator game, become the pilot and fly your commercial jet to the destination. Guide and steer your plane through all of the waypoints to ensure you head to the correct destination, go through all of the waypoints and land at your destination airport within the time limit to earn yourself more pilot stripes. When arriving at your destination zone, slow the plane down and prepare for landing, be careful not to crash! Guide your plane towards the runway and park within the marked zone to complete the level. While parking your plane, be very careful to avoid the buses, helicopters etc parked along the run way.

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3rd Nearest Neighbor

Airplane Flight Simulator 3D. i6 Games 2014. 1M downloads.

Airplane Flight Simulator 3D is an awesome 3D Air Plane Sim flying game. Start off with learning how to fly a plane, you simply take off from airport island and flying the plane to another Airport Runway. You must then park the airplane on the runway. In this aircraft flying simulation game, complete the levels within 50% of the given time and collect all the rings to earn all 3 badges; so racing through the levels can get you all of the badges. As you develop your skills and progress through the game, you have the opportunity to unlock bigger and faster planes. Be very careful, there's a lot of passengers relying on your pilot skills.

Text Example

Reference App

Flight Simulator: Fly Plane 3D. i6 Games 2014. 50M downloads.

Flight Simulator: Fly Plane 3D is an awesome new 3D Airplane Simulator game, become the pilot and fly your commercial jet to the destination. Guide and steer your plane through all of the waypoints to ensure you head to the correct destination, go through all of the waypoints and land at your destination airport within the time limit to earn yourself more pilot stripes. When arriving at your destination zone, slow the plane down and prepare for landing, be careful not to crash! Guide your plane towards the runway and park within the marked zone to complete the level. While parking your plane, be very careful to avoid the buses, helicopters etc parked along the run way.

4th Nearest Neighbor

Taxi Bus Driver 3D. Han's Games 2015. 10k downloads.

With its smooth full hd graphics and small size, Taxi & Bus Driver 3D has never been this much fun to pick up passengers and drift at the same time. Show your excellent driving skills and pick up your passengers and reach the destination on time while drifting. You must also improve your driving skills in challenging conditions with the active traffic system and take care to obey traffic rules.

Methods (Industry Concentration Score Construction)

Herfindahl-Hirschman Index (HHI):

$$HHI_c = 10,000 * \sum_{i=1}^{N_c} s_i^2 \tag{2}$$

N_c: number of apps in category c
s_i: share of category downloads for app i

low concentration: HHI < 1000
moderate concentration: $1000 <$ HHI < 1800
high concentration: HHI > 1800

Methods

$$y_i = \alpha_1 HHI_i + \alpha_2 HHI_i^2 + \delta X_i + \xi_i \tag{3}$$

$$y_i = \alpha_1 HHI_i + \alpha_2 HHI_i^2 + \beta_1 HHI_i * t_i + \beta_2 HHI_i^2 * t_i + \beta_3 t_i + \delta X_i + \xi_i \tag{4}$$

$$y_i = \alpha_1 HHI_i^l + \alpha_2 HHI_i^h + \delta X_i + \xi_i \tag{5}$$

ti: cohort (starting year of app $_i$, first year coded as 0)
y_i: similarity of app $_i$

Control variables are introduced by tiers and include creation year, whether users interact, location sharing, info sharing, size, rating, editor's choice selection, ads, digital purchases, free, mature content, gambling, violence, adult language, suggestive themes, and drug references

Results

Quadratic Regressions, Outcome: Similarity

	(1) Base	(2) Creation Year	(3) Update Year	(4) Users Interact
HHI/10k	-0.274(0.122)**	-0.267(0.094)***	-0.402(0.136)***	-0.302(0.127)**
HHI/10k squared	0.717(0.315)**	0.672(0.231)***	0.929(0.365)**	0.790(0.329)**
creation year		-0.000715(0.000518)		
creation year x HHI/10k		-0.00191(0.00966)		
creation year x HHI/10k squared		0.00996(0.02746)		
update year			-0.000957(0.000423)**	
update year x HHI/10k			0.0182(0.0062)***	
update year x HHI/10k squared			-0.0304(0.0166)*	
users interact				-0.00318(0.00285)
users interact x HHI/10k				0.167(0.065)**
users interact x HHI/10k squared				-0.451(0.169)***
Constant	0.594(0.006)***	0.598(0.005)***	0.601(0.007)***	0.595(0.007)***
R-squared	0.0220	0.0229	0.0225	0.0232

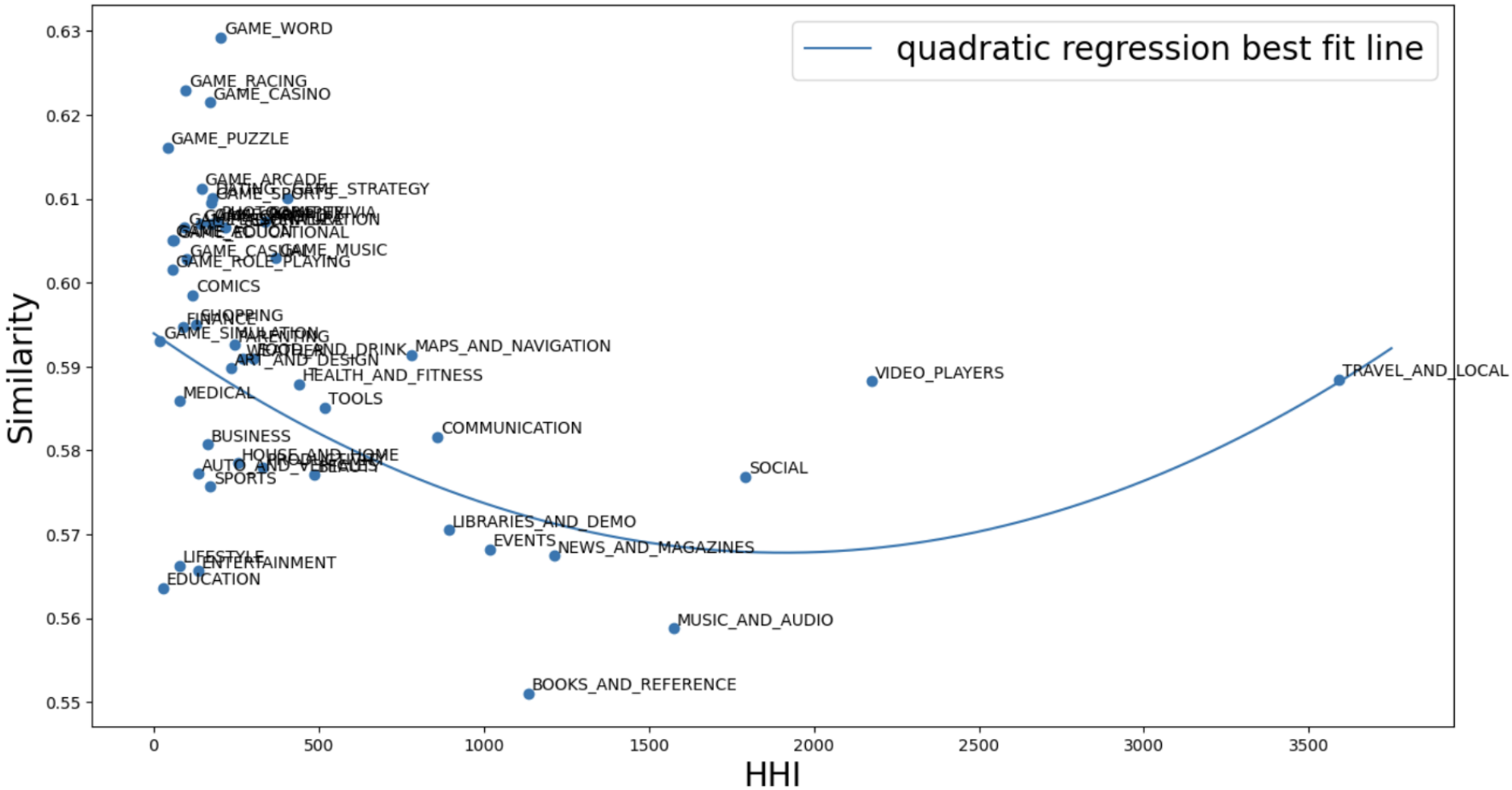
425,817 observations; Google Playstore 2019

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

HHI is divided by 10k to scale the results

Results


quadratic regression best fit line
Similarity
HHI
0.63
0.62
0.61
0.60
0.59
0.58
0.57
0.56
0.55
0
500
1000
1500
2000
2500
3000
3500
GAME_WORD
GAME_RACING
GAME_CASINO
GAME_PUZZLE
GAME_ARCADE
GAME_STRATEGY
GAME_SPORTS
GAME_EDUCATIONAL
GAME_CASUAL
GAME_MUSIC
GAME_ROLE_PLAYING
COMICS
SHOPPING
FINANCE
PARENTING
FOOD_AND_DRINK
MAPS_AND_NAVIGATION
ART_AND_DESIGN
HEALTH_AND_FITNESS
MEDICAL
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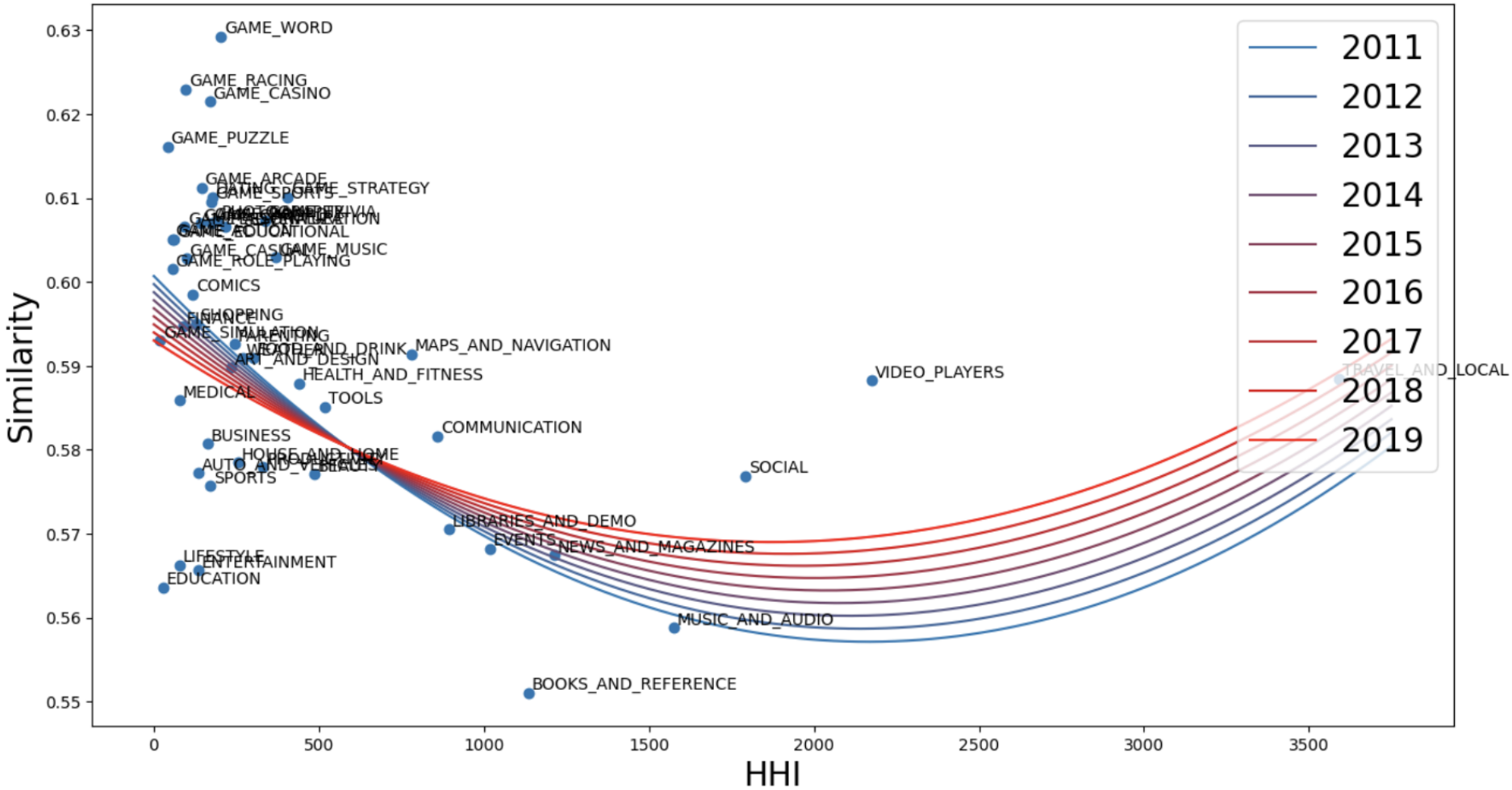
VIDEO_PLAYERS
TRAVEL_AND_LOCAL
COMMUNICATION
BUSINESS
HOUSE_AND_HOME
SOCIAL
SPORTS
LIBRARIES_AND_DEMO
EVENTS
NEWS_AND_MAGAZINES
LIFESTYLE
ENTERTAINMENT
EDUCATION
MUSIC_AND_AUDIO
BOOKS_AND_REFERENCE

Results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2013
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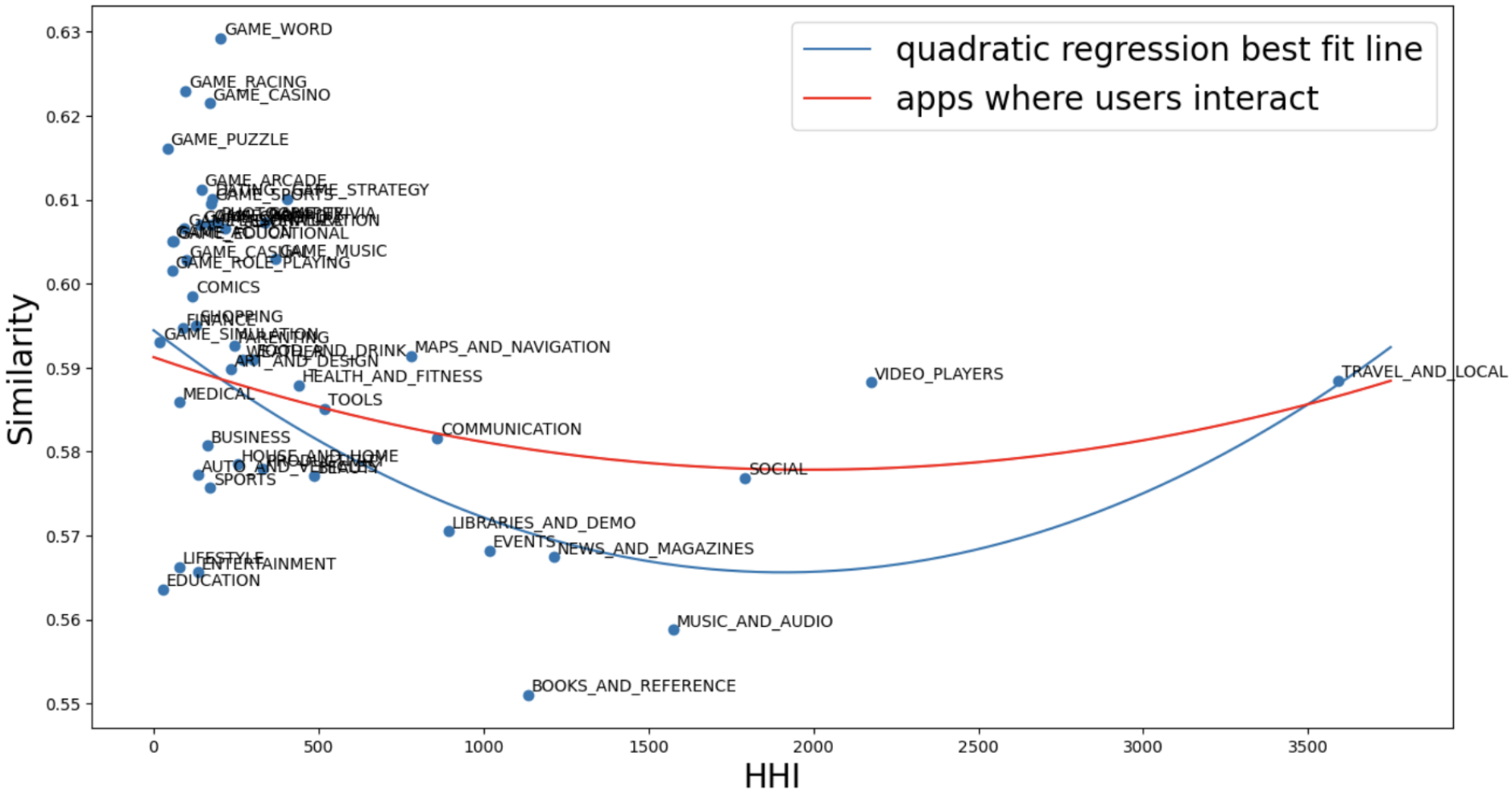
quadratic regression best fit line
apps where users interact
Similarity
HHI
0.63
0.62
0.61
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Results

Concentration Dummies, Outcome: Similarity

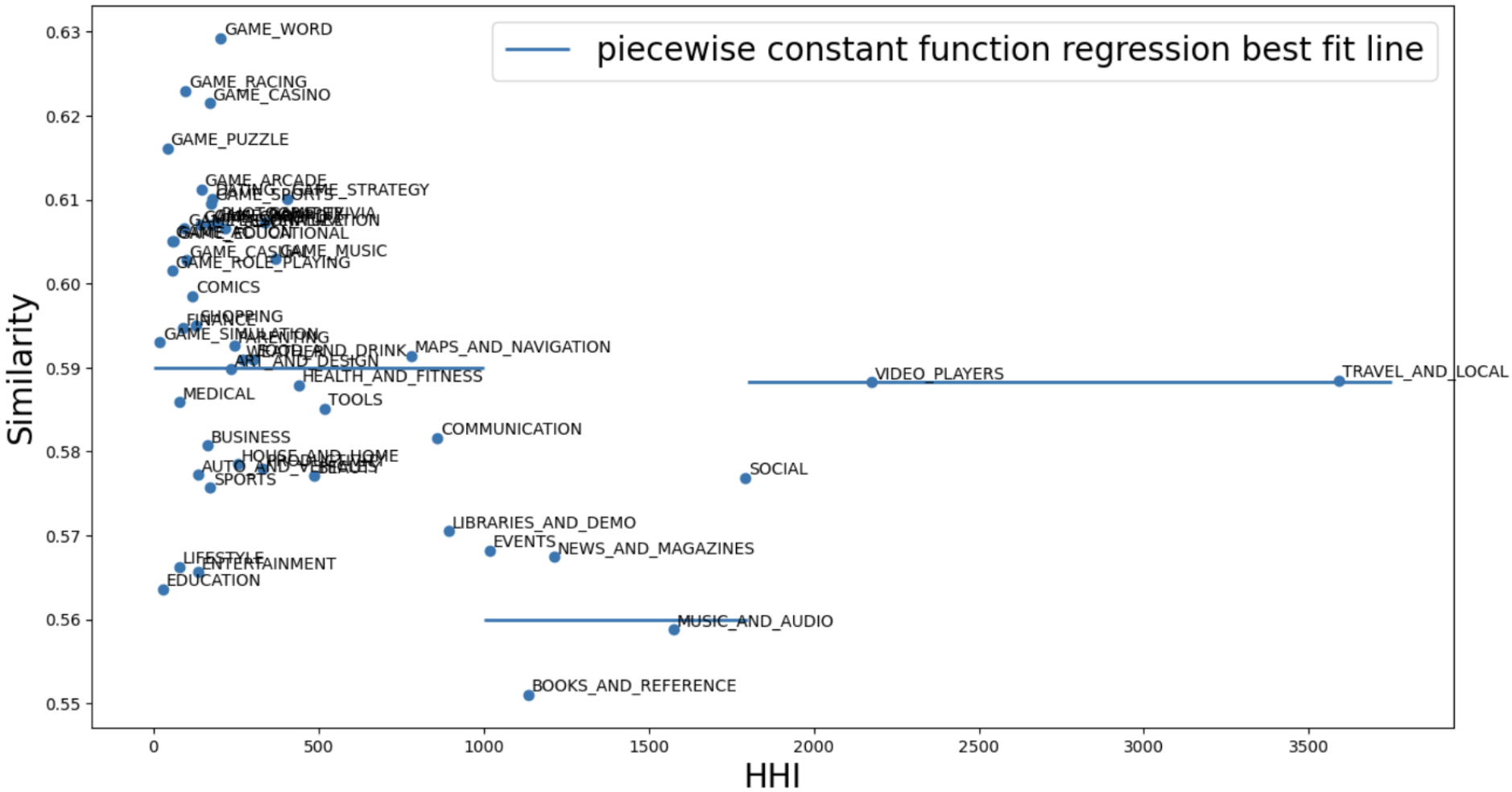
	Concentration Dummies
HHI low	0.030047***
	(0.005925)
HHI high	0.028482***
	(0.004150)
Constant	0.559957***
	(0.004150)
R-squared	0.0362

425,817 observations; Google Playstore 2019

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results


piecewise constant function regression best fit line
Similarity
HHI
0.63
0.62
0.61
0.60
0.59
0.58
0.57
0.56
0.55
0
500
1000
1500
2000
2500
3000
3500
GAME_WORD
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GAME_CASINO
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Results

Category Level, Outcome: Similarity

	Category Level
HHI/10k	-0.338***
	(0.091)
HHI/10k squared	0.865***
	(0.300)
Constant	0.602***
	(0.003)
n	49
R-squared	0.2588

425,817 observations; Google Playstore 2019

Standard errors in parentheses

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HHI is divided by 10k to scale the results

Result Summary

We observe a U-shaped relationship between similarity and HHI with significance in both HHI and HHI squared.

The interpretation of the main result is that the apps become less similar as the HHI increases through the low and moderate category concentration range, but become more similar as HHI increases through the high category concentration range.

The incentive for apps to imitate the market leader hoping to be bought out is the dominant effect only in already concentrated markets.

Conclusion

- There is an ideal range of competition in the app market that results in more differentiated products.
- Result may be useful for considering cases such as FTC v. Meta
- Questions