



# Does Entry Into Complementary Markets Crowd Out Innovation? Evidence from Google Photos

**Jens Foerderer\***, Thomas Kude\*, Sunil Mithas<sup>+</sup>, Armin Heinzl\*

\*Business School, University of Mannheim, Germany

<sup>+</sup>Robert H. Smith School of Business, University of Maryland



UNIVERSITY OF MANNHEIM  
BUSINESS SCHOOL

# Motivation



# Is Google's entry good or bad for complementors?

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BUSINESS

## EU Set to Charge Google Over Android Phone Apps

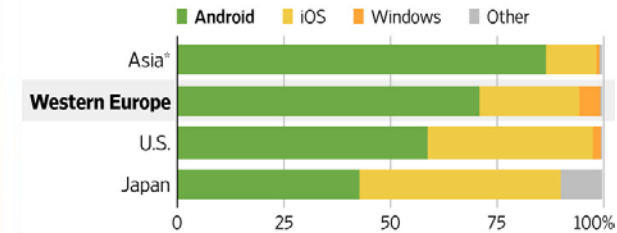
European Commission focusing on demand that phones load Google apps



A smartphone running the Android mobile-operating system displays a Google app. EU competition chief Margrethe Vestager on Tuesday said the commission was focusing on Google's demand that smartphone makers and mobile carriers using Android load Google apps on their devices. PHOTO: BLOOMBERG NEWS

### Android Ascendancy

Smartphone operating system market share by region, 2015



\*Doesn't include Japan Source: IDC

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### EU Antitrust Probes Into Google

A scorecard of where each case stands. Halfway marks mean the commission is advancing towards the next stage.



\*European Court of Justice †Formal charges are set to be filed

Source: European Commission, staff reports

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# Does entry crowd out innovation?

- Yes, economics literature on tying, first party content, vertical integration or squeezing (e.g., Farrell and Katz 2000)
- But:
  - Competitive dynamics literature: **Racing effect** / Red Queen effect (Barnett and Hansen 1996)
  - Marketing literature: **Attention spillover effect** (Liu et al. 2014; Li and Agarwal forthc; Sahni forthc)
- Mostly descriptive studies, focus on pricing decisions and say little about complementary innovation

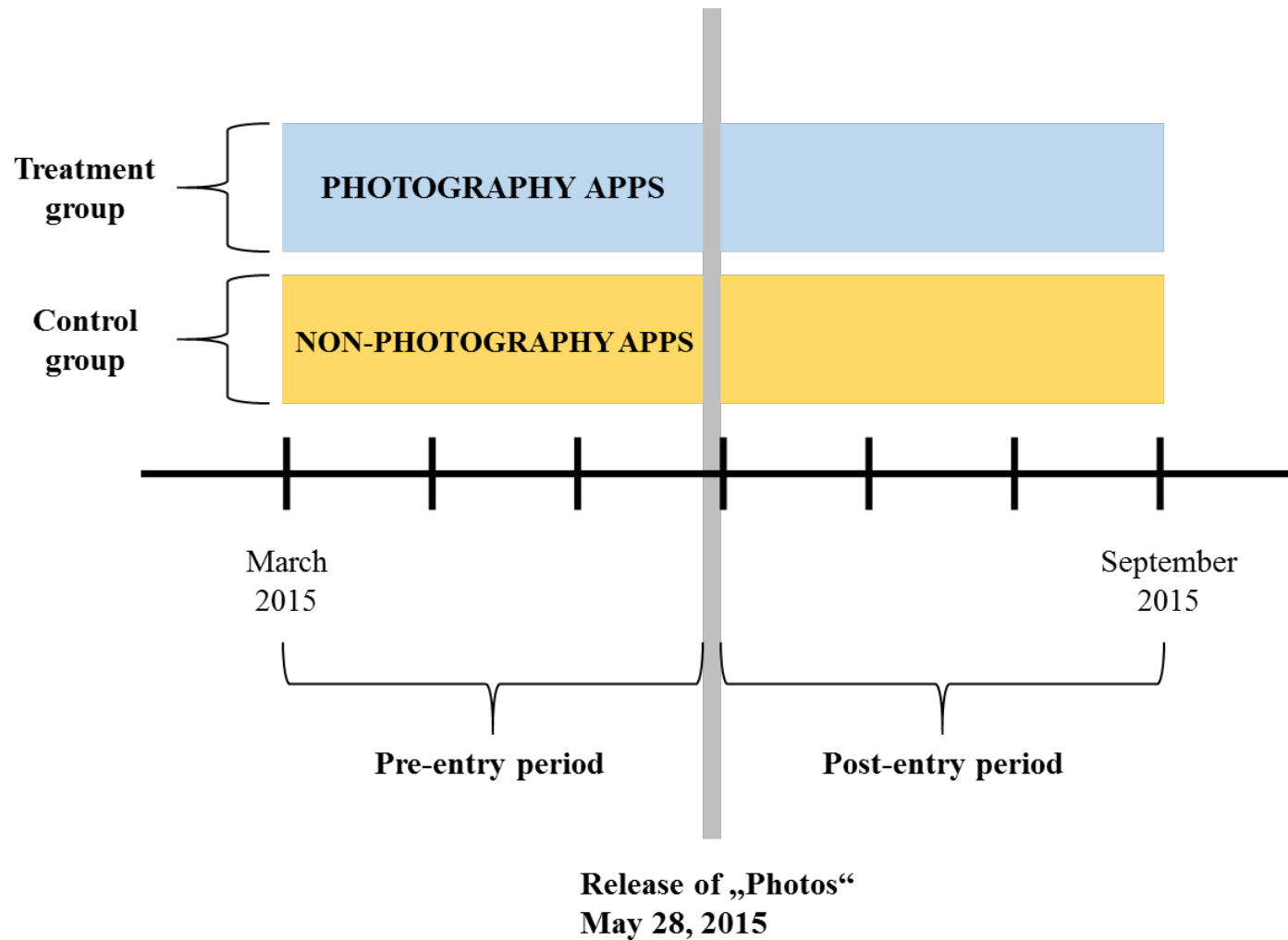
# Related work

- Li and Agarwal (2016, Forthcoming): Facebook's integration of Instagram increases overall demand for entire photo-sharing ecosystem
- Ghazawneh and Henfridsson (2013): Managing boundary to complementors
- Huang et al. (2013): Complementors safeguard against entry

No study that examines impact on innovation and underlying mechanisms of racing and attention spillover

# Research design and identification strategy

- Entry as quasi-experiment



# Dataset

1

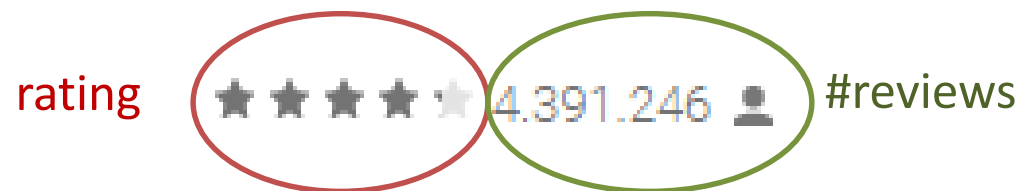
All apps on Google Play store US  
(indexed between July 2014-  
December 2014)

2

Random sample of 100,000  
apps, freezed in January  
2015 and observed  
monthly

# Data and method

- DV: Major update
  - Major updates are not security patches, bug fixes!
  - Examples: Tesla pilot, Apple iOS
  - We text-analyze release notes (Slaughter and Kemerer 1999)
- IVs:
  - Photo x After Entry: diffdiff estimator
  - Racing effect: difference in app rating as mediator
  - Attention spillover effect: difference in #reviews as mediator
  - Price: price in USD





# Results: Entry → Major Update

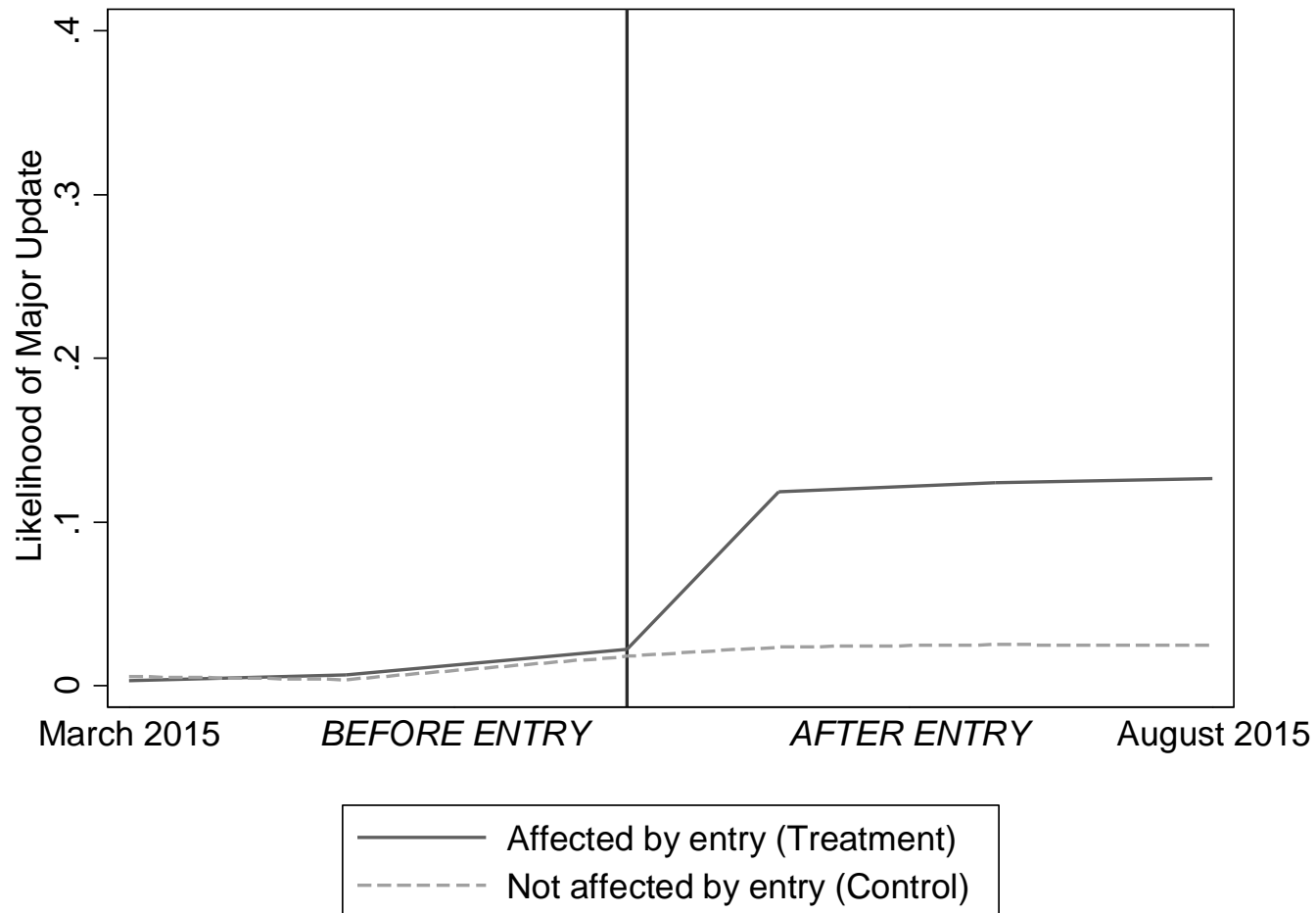
$$\text{MAJOR UPDATE}_{i,t} = \beta_0 + \beta_1 \text{PHOTOS}_i \times \text{AFTER ENTRY}_t + V_i + T_t + p_{it} + \epsilon_{i,t}$$

**Table 2: Regression Models of the Consequences of Entry on Major Update**

	<b>Major update</b>	
	<b>Model 1</b>	<b>Model 2</b>
Specification	LPM	Logit
<b>Predictors</b>		
Photos		.159 (.177)
Photos x After entry	.096*** (.009)	1.567*** (.190)
<b>Controls</b>		
App fixed effects	Yes	No
Time fixed effects	Yes	Yes
Constant	.005*** (.001)	-5.319*** (.177)
Adj. / Pseudo R-squared	.038	.116
N	41,616	41,616
* p < .05, ** p < .01, *** p < .001 Note: Heteroskedasticity-robust, clustered standard errors are in parentheses. N is given in app months.		

# Results: Entry → Major Update

## Likelihood of Major Update (linear)



# Results: Entry → Price, Rating, Reviews

	Difference in rating	Difference in reviews	Price
	Model 3	Model 4	Model 5
Specification	Linear	Linear	Linear
<b>Predictor</b>			
Photos x After entry	-.002 (.003)	.086*** (.014)	.002 (.003)
<b>Controls</b>			
App fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Constant	-.000 (.000)	.002 (.002)	.115*** (.001)
Adj. R-squared	.008	.214	.000
N	41,616	41,616	41,616
F-test	31.434***	1351.109***	.790***
<p>* <math>p &lt; .05</math>, ** <math>p &lt; .01</math>, *** <math>p &lt; .001</math>            Note: OLS coefficients presented. Heteroskedasticity-robust, clustered            standard errors are in parentheses. N is given in app months.</p>			

# Results: Mechanisms

	Major update			
	Model 6	Model 7	Model 8	Model 9
Specification	LPM	LPM	LPM	LPM
<b>Predictors</b>				
Photos x After entry	.096*** (.009)	.094*** (.009)	.037*** (.005)	.036*** (.005)
Difference in rating		.004 (.008)		.009 (.008)
Difference in reviews			.482*** (.032)	.474*** (.032)
<b>Controls</b>				
App fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Constant	.005*** (.001)	.004** (.001)	.005*** (.001)	.004** (.001)
Adj. R-squared	.038	.032	.170	.151
N	41,616	41,616	41,616	41,616
F	67.134***	61.446***	96.285***	88.919***
<p>* p &lt; .05, ** p &lt; .01, *** p &lt; .001</p> <p>Note: Heteroskedasticity-robust, clustered standard errors are in parentheses. N is given in app months.</p>				

# Robustness

1. Heterogeneity in pre-entry trends (time trend + characteristics)
2. Falsification tests
3. Alternative measure of innovation (new chart entrants)
4. Alternative continuous identification: Treatment intensity using the Hoberg and Phillips (2010) measure



# Contributions and implications

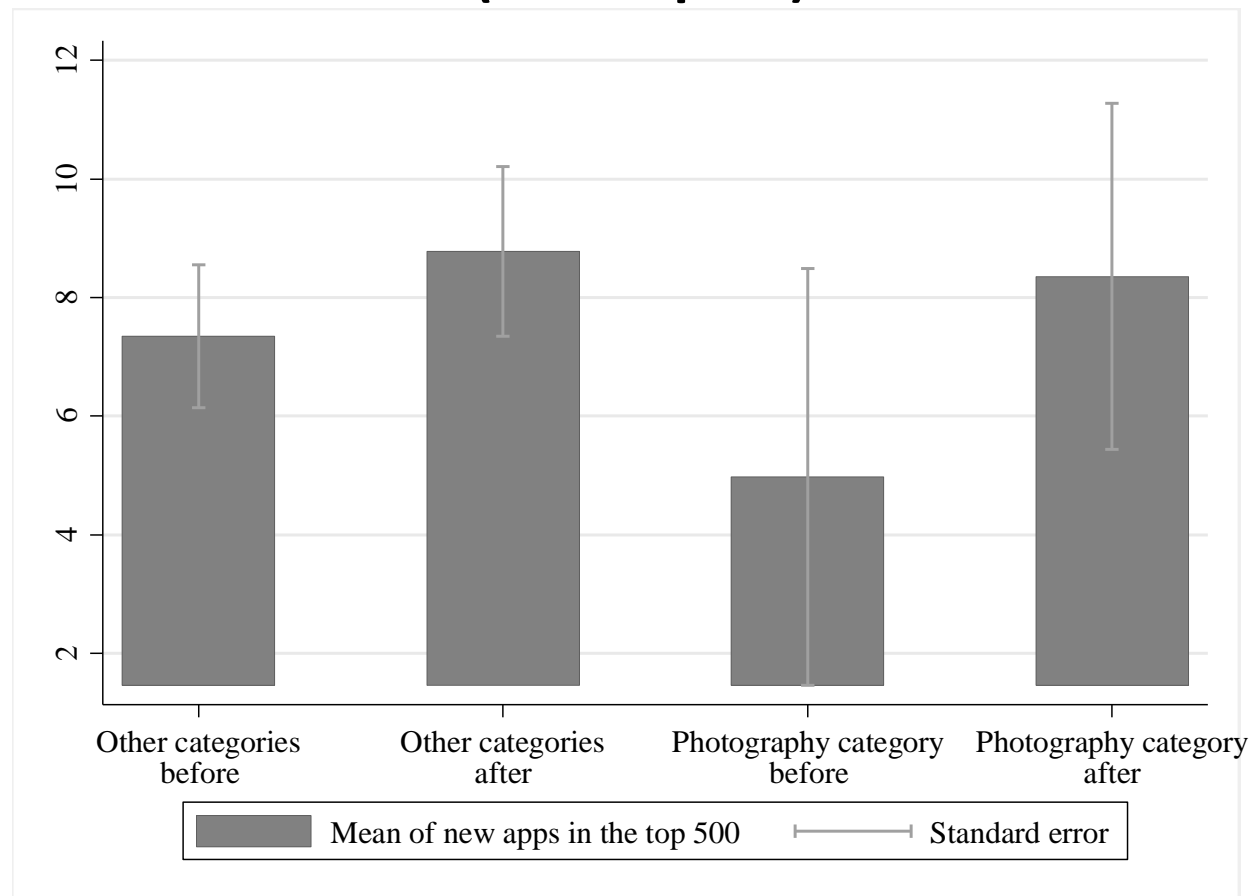
- Extend work on two-sided markets which largely focused price mechanisms (e.g., complementor royalties) by looking at innovation, a particular non-price mechanism
- Implications for platform governance: entry does not always crowd out innovation, it may be possible for platform owners to improve the ecosystem through entry through attention spillover
- Lack of support for racing mechanism: is it due to market munificence?

# Discussion

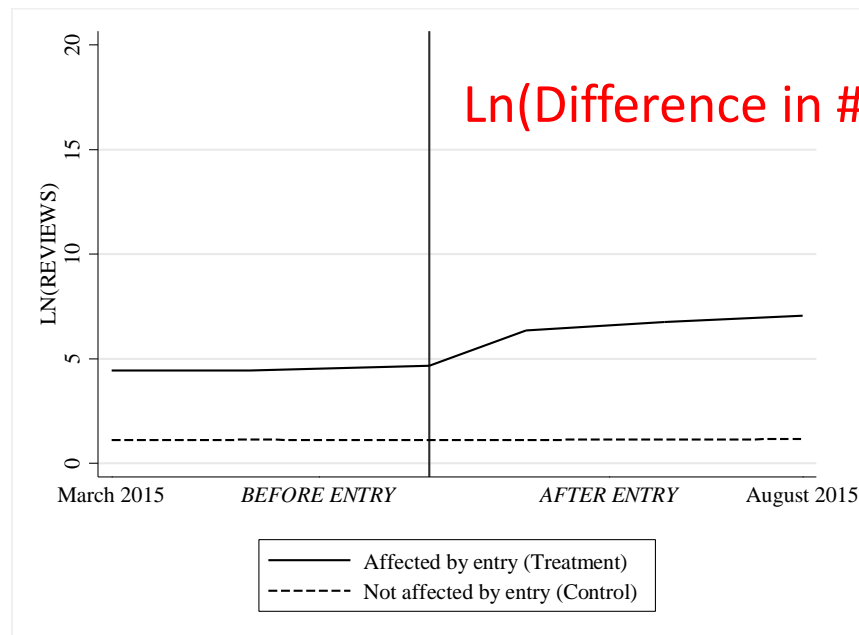
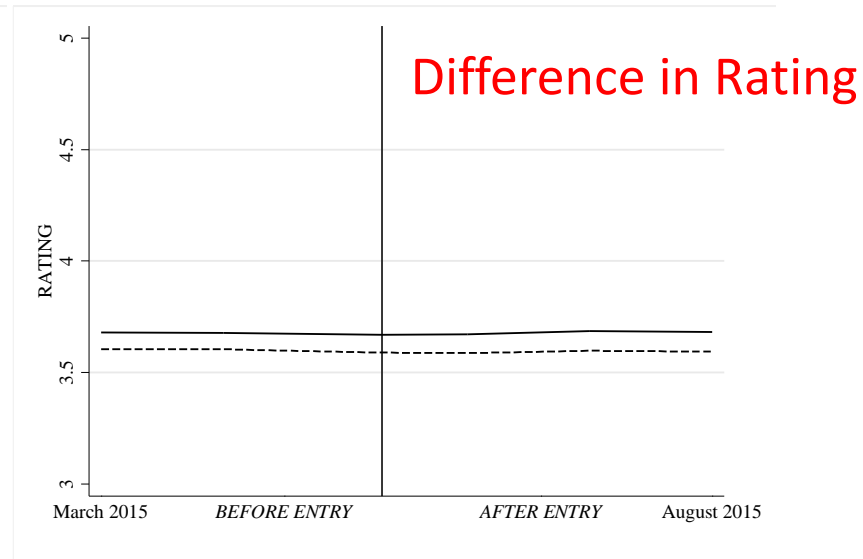
- Thank you!

# Results: Entry → New apps

**Entrants in the Top 500 new apps released  
and/or updated in the past 30 days  
(free & paid)**



# Results: Entry → Price, Rating, Reviews



- Backup



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# Summary Statistics and Correlations

**Table 1: Summary Statistics and Correlations**

Variable	Mean	S.D.	Min.	Max.	1	2	3	4	5
1. Major update	.0183	.134	0	1	1				
2. Number of reviews (in thousands)	1.68	13.7	.011	818	.068***	1			
3. Average rating	3.61	.423	1.2	4.4	.039***	.060***	1		
4. Price	.114	.775	0	42.6	-.003	-.014*	-.051***	1	
5. Difference in rating	0	.13	-1.07	.8	.018**	.026***	.338***	-.005	1
6. Difference in reviews	.246	3.24	0	243	.079***	.825***	.054***	-.010	.035***
* p < .05, ** p < .01, *** p < .001									

# Major update discussion

- Major update = innovation
  - Innovation is context-specific
  - Software is „flexible“: producers can innovate them entirely after release
  - Major updates != security patches, bug fixes
  - Novelty: **New** features, **new** functionality
- Examples
  - Tesla autopilot
  - Apple iOS, Mac OSX
  - World of Warcraft

# Text analysis for Minor/Major update distinction

Release note	Code
With springtime comes bugs, and we've squashed quite a few! In particular, we've improved all-day events and the appearance of the splash screen as well as added some fun capabilities to the app bar.	Minor
Sorry to rush this new version out so quickly, but it fixes several crashes that were occurring after the release of version 8.1. Version 8.1 contains a redesign of [B]. It also allows you to login with your twitter account now. Enjoy and make sure you let us know if there are anything you want to see on the app.	Minor
Fixed kiosk mode after reboot, improved battery lifetime, limited network traffic consumption, other bug fixes and improvements, compatibility to our servers. Thank you for your feedback! We are permanently improving the experience for our users. if you have suggestions to improve [C], please write us [email]	Minor
The new horizons mission is reaching Pluto! Celebrate this historic occasion with your own space voyage—a brand new episode based on our corner of the universe—the solar system! 15 new levels: visit planets, comet, satellites and more. Watch unique videos directly from NASA experts. Learn about the solar system with fascinating trivia tidbits. Harness the power of s.p.a.r.k., literally a smart bomb, drops knowledge and destruction. Keep tapping for Pluto!	Major
New features! Native quizzes supporting 6 questions types. Bookmarks allow you to navigate somewhere with as little as one click. Inbox has been redesigned and makes communication so much easier. Colors now sync between your android device and canvas.	Major

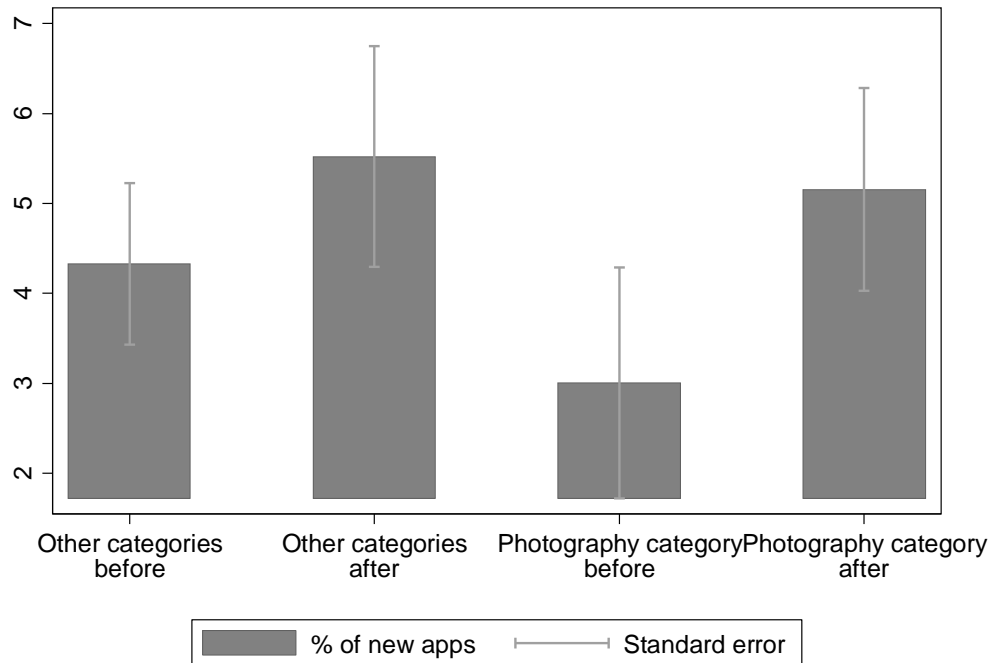


# Results: Price split

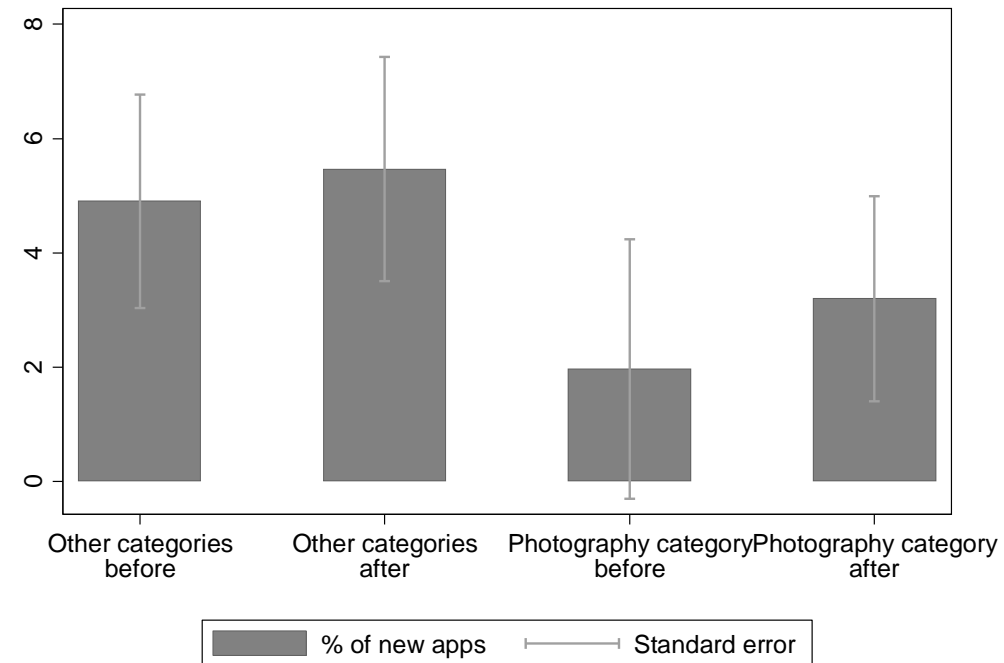
	<b>Major update</b>		
	<b>Model 10</b>	<b>Model 11</b>	<b>Model 12</b>
Specification	Linear	Linear	Linear
<b>Predictor</b>			
Photos x After entry	.096*** (.009)	.096*** (.009)	.006 (.012)
Free		-.014*** (.002)	-.014*** (.002)
Photos x After entry x Free			.098*** (.015)
<b>Controls</b>			
App fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Constant	.005*** (.001)	.018*** (.002)	.018*** (.002)
Adj. R-squared	.038	.038	.040
N	41,616	41,616	41,616
F-test	67.134***	57.542***	50.588***
<p>* <math>p &lt; .05</math>, ** <math>p &lt; .01</math>, *** <math>p &lt; .001</math>            Note: OLS coefficients presented. Heteroskedasticity-robust, clustered standard errors are in parentheses. N is given in app months.</p>			

# Chart entrants

Entrants in the Top 500 new apps released  
and/or updated in the past 30 days  
**(free only)**



Entrants in the Top 500 new apps released  
and/or updated in the past 30 days  
**(paid only)**



# Robustness 2a

	Major update	Price	Number of reviews	Average rating
	Model 11	Model 12	Model 13	Model 14
	Before entry	Before entry	Before entry	Before entry
Specification	LPM	Linear	Linear	Linear
<b>Predictor</b>				
Photos	.008 (.007)	.009 (.017)	.069 (.058)	.029 (.034)
<b>Controls</b>				
Complementor fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Constant	.004* (.002)	.113*** (.004)	.681*** (.011)	3.612*** (.007)
Adj. R-squared	.04	.90	.78	.72
N	20,898	20,898	20,898	20,898
* $p < .05$ , ** $p < .01$ , *** $p < .001$ Note: Heteroskedasticity-robust, clustered standard errors are in parentheses. N is given in app months.				

# Robustness 2b

**Table 7: Robustness: Treatment-Control Time Trends Before Entry**

	Major update	Price	Number of reviews	Average rating
	Model 15	Model 16	Model 17	Model 18
	Before entry	Before entry	Before entry	Before entry
<b>Predictors</b>				
Photos	.001 (.008)	.008 (.018)	.350 (.200)	.024 (.034)
Time trend	.006*** (.001)	-.001 (.001)	.073*** (.001)	-.007*** (.001)
Photos x Time trend	.003 (.003)	.001 (.002)	-.005 (.003)	.003 (.002)
<b>Controls</b>				
Complementor fixed effects	Yes	Yes	Yes	Yes
Specification	LPM	Linear	Linear	Linear
N	20,898	20,898	20,898	20,898
<p>* <math>p &lt; .05</math>, ** <math>p &lt; .01</math>, *** <math>p &lt; .001</math>            Note: Heteroskedasticity-robust, clustered standard errors are in parentheses. N is given in app months.</p>				

# Robustness 3

**Robustness: Effect of Entry on Non-Photography Apps\***

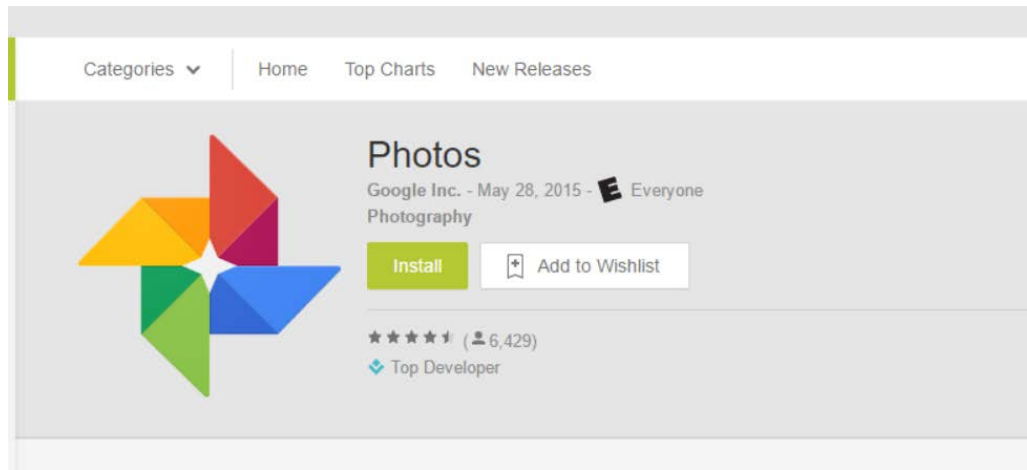
	(1)	(2)	(3)	(4)	(5)	(6)
	Major update	Major update	Major update	Major update	Major update	Major update
<b>Panel A</b>						
Category / Subsample	Business	Communication	Education	Finance	Health and Fitness	Lifestyle
After entry	.013 (.009)	.010 (.008)	.002 (.004)	.011 (.008)	.000 (.007)	.006 (.005)
Constant	-.002 (.006)	.001 (.005)	.003 (.002)	.002 (.005)	-.003 (.004)	.002 (.003)
App fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Specification	LPM	LPM	LPM	LPM	LPM	LPM
N	9,750	9,510	28,086	11,532	10,824	22,290
<b>Panel B</b>						
	(10)	(11)	(12)	(13)	(14)	(15)
	Major update	Major update	Major update	Major update	Major update	Major update
Category / Subsample	Personalization	Productivity	Shopping	Social	Sports	Tools
After entry	-.003 (.005)	.003 (.007)	.000 (.013)	.013 (.008)	.004 (.006)	.004 (.003)
Constant	-.003 (.003)	.001 (.004)	-.005 (.008)	.001 (.006)	-.000 (.004)	.005* (.002)
App fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Specification	LPM	LPM	LPM	LPM	LPM	LPM
N	24,486	13,224	6,222	6,828	11,598	35,220

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

Note: Heteroskedasticity-robust, clustered standard errors are in parentheses. N is given in ap



# Robustness 4



## Description

Google Photos is the home for all your photos and videos, searchable and organized by the people, places, and things that matter.

- VISUAL SEARCH: Your photos are now searchable by the people, places and things that appear in your photos. Looking for the Just search "Hawaii" or "food" to find it even if it doesn't have a description. Note: Face grouping is not available in all countries.
- AUTO BACKUP: Keep all your photos and videos safe and accessible from any device. Choose free, unlimited cloud storage available up to 15GB original size for free (shared across your Google account).
- SAVE SPACE ON YOUR DEVICE: Google Photos can help you clear safely backed up photos and videos from your device so you can delete a photo to make space.
- BRING PHOTOS TO LIFE: Automatically create montage movies, interactive stories, collages, animations, and more.
- EDITING: Transform photos with the tap of a finger. Use simple, yet powerful, photo and video editing tools to apply filters, adjust, and more.
- SHARING: Share hundreds of photos instantly with shareable links and use whichever apps you'd like to share.

## Reviews

4.6

★ 5 4,955  
★ 4 751



Harshil Parikh ★★★★★

*Not good, But excellent! Excellent!  
The best one can get on Android.*



Mark Edwards

*Super s  
animat*

Cosine  
similarity  
(Hoberg and  
Phillips 2010)



Description of focal  
app

# Terminology

- Integration: Platform owner makes a particular feature part of the core platform
  - Flashlight on Apple iOS, Parental control feature
- Bundling: Sell platform together with the own complement
  - Internet explorer
- Envelopment: One platform eats another platform
  - iOS vs Adobe Flash (Eaton et al. 2015)

# Motivation

