

Money and Privacy - Android Market Evidence

Michael Kummer*[°] (kummer@zew.de)

Patrick Schulte* (schulte@zew.de)

* ZEW, Mannheim

[°] soon: Georgia Tech, Atlanta

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Motivation / Questions



Demand Side: permission-greedy apps

- Do users avoid installing such apps?

Supply side: money vs. privacy?

- Do suppliers charge extra money for more privacy?

Data / Methods

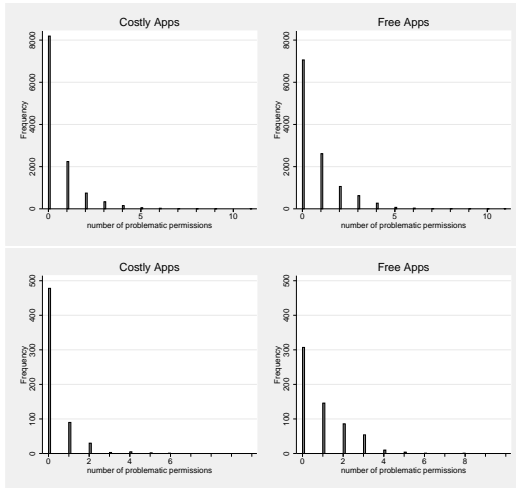
Data:

- Google Play Store - All apps from 2012
- Cross-Section ($N > 300000$), pairs, 5-month panel, 2-year difference variables:
 - Installations (17 levels), avg. rating, # ratings, app characteristics, price
 - All permissions: critical permissions (Sarma et al. 2012), malicious permissions (Google 2012)
 - Set of competitors → instruments

Regression analysis:

- Cross-Section: OLS with all apps available in 2012
- Panel with all apps showing changes in permission usage
- 'Difference-in-Difference' for app-pairs

Free/Paid Twins and Permissions.



- Even on distributions of free/paid twins:
 - 20-30% of the free apps use more sensitive permissions.

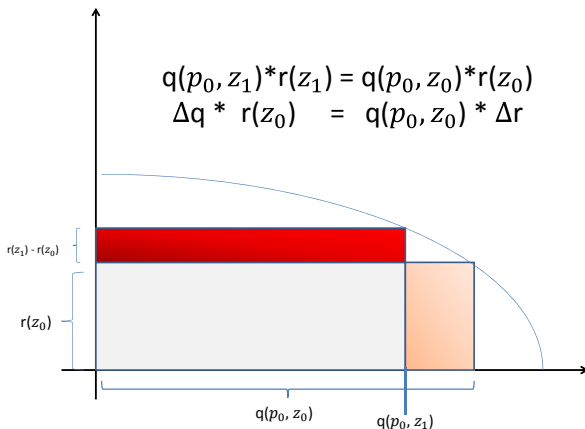
App Success and Permissions

- Privacy endangering permissions are:
 1. associated with fewer downloads. (cross section + panel).
 2. associated with lower growth and/or survival.
 3. more likely free or cheaper.

App Success and Permissions

	1.) Installations/Est. Installs.(Panel)			2.) App Growth & Survival		3.) Supply	
	Crossect. (Logs)	(Panel Free)	(Panel Paid)	Δ Log(Inst.)	$D_{Survival=1}$	$D_{Price>0}$	Log. Price
Total Permissions	0.033*** (0.003)	-0.004*** (0.001)	-0.010* (0.005)	0.000 (0.002)	-0.004*** (0.001)	0.008*** (0.000)	0.022*** (0.002)
D_{ID}	-0.078*** (0.013)	-0.011 (0.007)	-0.001 (0.019)	-0.002 (0.008)	-0.061*** (0.003)	-0.055*** (0.002)	0.119*** (0.010)
$D_{Location}$	-0.274*** (0.018)	-0.008 (0.009)	0.065** (0.032)	-0.090*** (0.013)	-0.030*** (0.004)	-0.152*** (0.003)	-0.058*** (0.014)
$D_{Communication}$	-0.178*** (0.020)	0.008 (0.008)	0.036 (0.027)	0.003 (0.014)	-0.018*** (0.004)	-0.041*** (0.004)	0.080*** (0.017)
$D_{Profile}$	-0.069*** (0.016)	0.024** (0.011)	-0.022 (0.022)	-0.068*** (0.013)	-0.085*** (0.003)	-0.081*** (0.003)	-0.138*** (0.016)
D_{Ads}	0.073*** (0.012)	-0.013 (0.008)	-0.008 (0.017)	0.087*** (0.008)	-0.012*** (0.003)	-0.141*** (0.002)	-0.034*** (0.009)
D_{Price}	-2.383*** (0.123)			-0.473*** (0.081)	-0.184*** (0.024)		
Log(Price)	-0.066*** (0.010)		0.020 (0.035)	0.014** (0.007)	0.020*** (0.002)		
Log(Installations-1000s)					0.003*** (0.000)		
Constant	2.854*** (0.213)	0.641*** (0.093)	0.318 (0.515)	-1.666*** (0.139)	1.451*** (0.045)	-0.099*** (0.036)	-0.039 (0.107)
Category	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	233810	26391	4938	167100	233810	233810	85570
Adjusted R ²	0.692	0.031	0.004	0.066	0.192	0.407	0.272

Quantifying the value of permissions



- At the optimum the additional revenue and the reduction in downloads for adding a permission must offset each other.

(Selected) Mediating Factors

1. Sensitivity to privacy endangering apps smaller on paid apps.
2. Well known App Developers → Effect vanishes
3. High maturity level-Apps, users are more sensitive.
4. (Also: Google-flagged permissions matter/non-flagged don't.)

Mediating Factors (Cross-Section)

Log. Installations	Price	Privacy Policy	HighNumRat	Alexa.com	Google	Maturity
Total Permissions	0.011*** (0.002)	0.008*** (0.002)	-0.006*** (0.002)	0.011*** (0.002)	0.022*** (0.002)	0.007*** (0.002)
$D_{Privacy}$	-0.049*** (0.014)	-0.031* (0.012)	-0.034** (0.011)	-0.019 (0.013)	0.086*** (0.014)	-0.045*** (0.012)
D_{Ads}	0.105*** (0.011)	0.099*** (0.011)	0.049*** (0.010)	0.082*** (0.012)	0.074*** (0.012)	0.101*** (0.011)
D_{Price}	-2.307*** (0.123)	-2.380*** (0.122)	-1.875*** (0.115)	-2.263*** (0.130)	-2.279*** (0.123)	-2.364*** (0.123)
Log. Price	-0.074*** (0.011)	-0.064*** (0.010)	-0.080*** (0.010)	-0.074*** (0.011)	-0.074*** (0.010)	-0.065*** (0.010)
$D_{Privacy} \times D_{Price}$	0.112*** (0.021)					
$D_{PrivacyPolicy}$		0.302*** (0.033)				
$D_{Privacy} \times D_{PrivacyPolicy}$		0.535*** (0.046)				
$D_{HighNumRat}$			3.011*** (0.013)			
$D_{Privacy} \times D_{HighNumRat}$			0.220*** (0.018)			
$D_{HighAlexaRank}$				1.176*** (0.112)		
$D_{Privacy} \times D_{HighAlexaRank}$				0.830*** (0.151)		
$D_{GoogleMalicious}$					-0.129*** (0.025)	
$D_{Privacy} \times D_{GoogleMalicious}$					-0.159*** (0.029)	
$D_{HighNoMaturity}$						0.340*** (0.017)
$D_{Privacy} \times D_{HighNoMaturity}$						-0.106*** (0.028)
Category Controls	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Observations	233810	233810	233810	206502	233810	233810
Adjusted R ²	0.69	0.69	0.76	0.70	0.69	0.69

Main Findings

Supply Side:

1. Free apps ask for more privacy sensitive permissions
2. Profile and location permissions ~ lower price

Demand Side:

1. Switching 'harmless' for 'malicious' ~ fewer installations
2. **BUT:**
 - effect **smaller**, if app: is paid; provides a privacy policy; has > 100 ratings; has a high rank at Alexa.com;
 - effect **bigger**, if permissions are described as 'potentially malicious' by google and if users are of 'high maturity (older)'
3. Permission-greedy apps less likely to survive and grow slower

Outlook / Discussion / Contribution

Discussion:

- Problem: Quality as confounding factor
 - Expect bias (towards 0) for permission-installation relationship
- Solution approaches:
 - FE-Regressions: but little variation over time & selection
 - App pairs: (free and paid version of same app)
 - Weak results: share of paid hardly related with Δ (permissions)
 - Power issues?

Contribution:

- Comprehensive analysis of privacy in the mobile app market
- Analysis of demand AND supply side
- We cover the full Android App market (2012)

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