Did Apple's App Tracking Transparency Framework Harm the App Ecosystem?

Cristobal Cheyre[*], Benjamin Leyden[*], Sagar Baviskar[**], Alessandro Acquisti[***]

* Cornell University ** Carnegie Mellon University *** MIT Sloan

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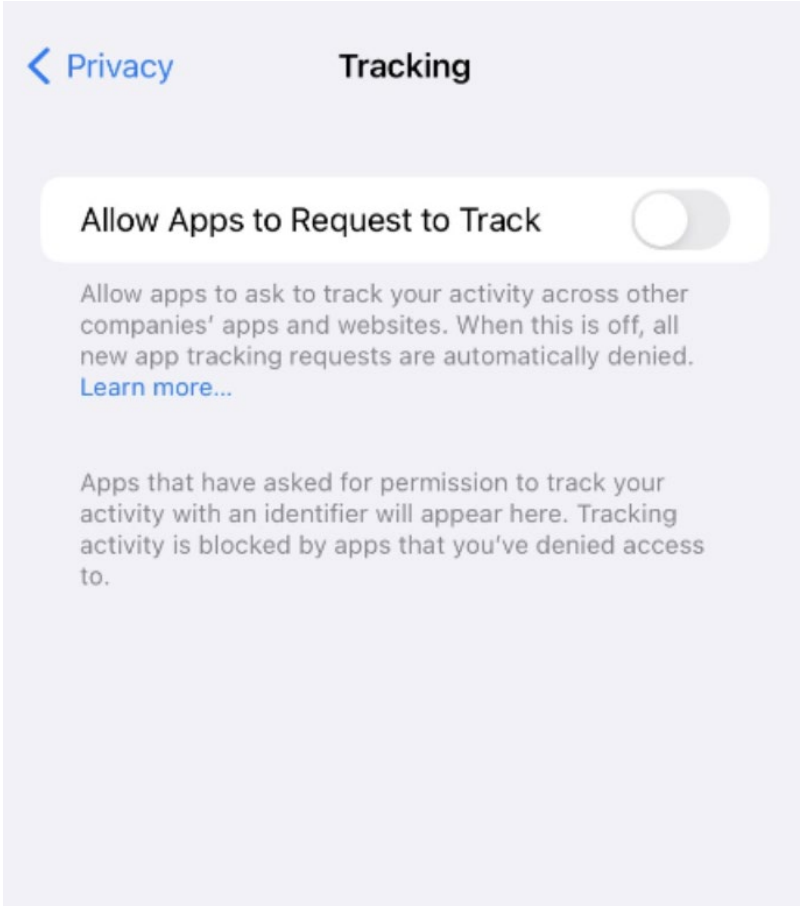
Motivation

- On April 26, 2021 Apple introduced its App Tracking Transparency Framework (ATT)
  - Effectively shifts behavioral tracking (used in targeted advertising) from **opt-out** to **opt-in**
  - Users can block apps from even requesting permission to track
  - Anecdotal evidence suggests ATT greatly reduced percentage of users consenting to tracking
- Opportunity to study the relationship between tracking, data, and the provision of ad-supported goods



Apple vs. the free internet

Apple plans to roll out a forced software update that will change the internet as we know it—for the worse.

Take your favorite cooking sites or sports blogs. Most are free because they show advertisements.

Apple's change will limit their ability to run personalized ads. To make ends meet, many will have to start charging you subscription fees or adding more in-app purchases, making the internet much more expensive and reducing high-quality free content.

Beyond hurting apps and websites, **many in the small business community say this change will be devastating for them too, at a time when they face enormous challenges.** They need to be able to effectively reach the people most interested in their products and services to grow.

Forty-four percent of small to medium businesses started or increased their usage of personalized ads on social media during the pandemic, according to a new Deloitte study. Without personalized ads, Facebook data shows that the **average small business advertiser stands to see a cut of over 60% in their sales for every dollar they spend.**

Small businesses deserve to be heard.
We're standing up to Apple for our small business customers and our communities.

Get the full story at fb.com/ApplePolicyUpdate

FACEBOOK

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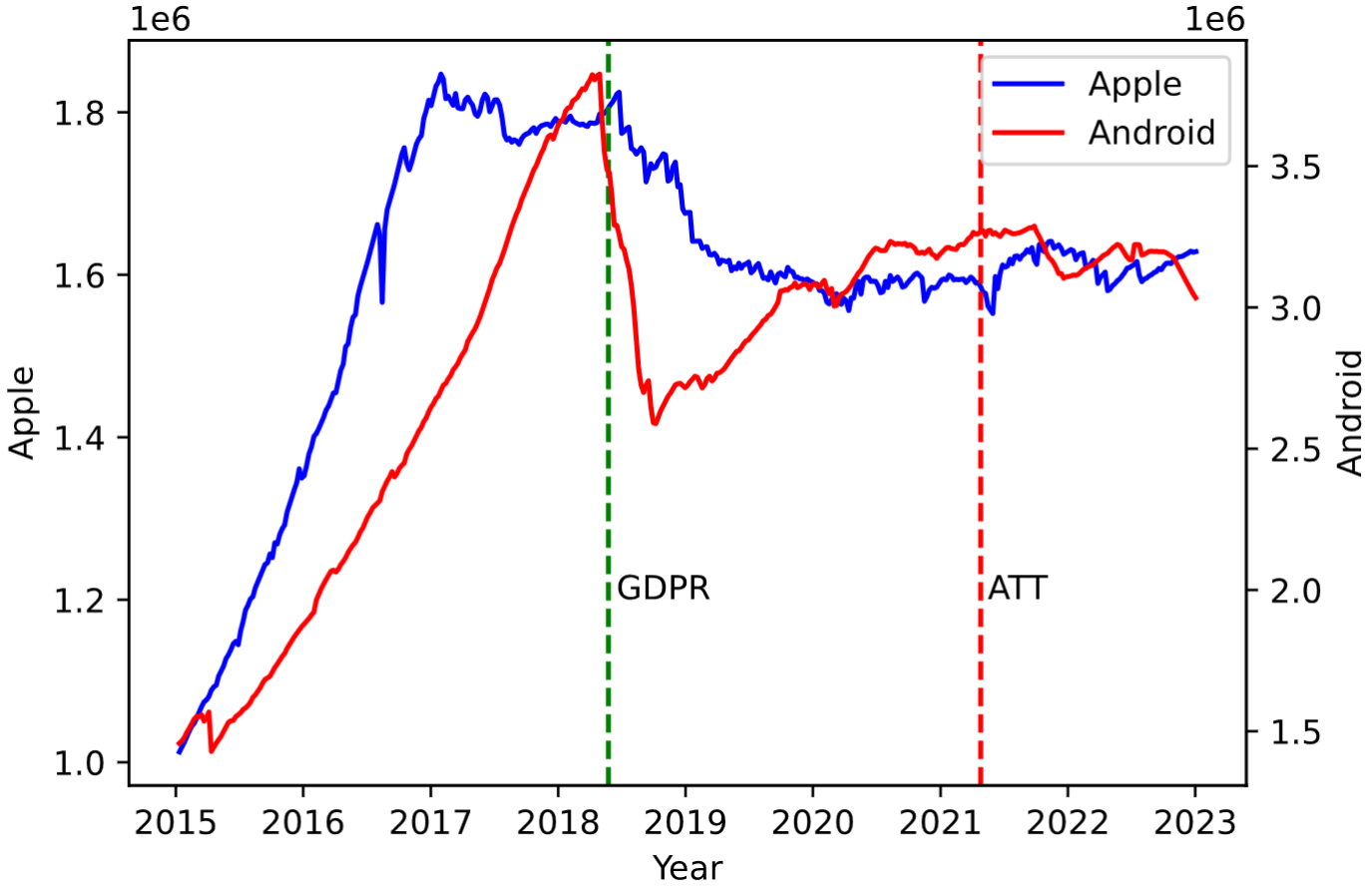
Apple's ATT and the App Ecosystem

- If the profitability of app developers that rely on advertising is affected, **incentives to participate in the ecosystem** will be affected:
  - Will we see an **increase in exit**?
  - Will there be a **decrease in updates**?
  - Will the **business model of apps** change (ad-supported to in-app purchases)?
  - For apps that remain, **how does the valuation of Apps by users change**?
  - How does valuation for users differ for **apps introduced after/before ATT**?
  - Will **demand for apps** decrease or increase?
- Ultimately, what are the **costs of this policy in terms of the availability and quality of "free" apps**?

Data and Timeframe

- Use data from a provider (AirNow) that tracks all apps in **both the App Store (Apple) and Google Play**
- Data period: **Eighteen-month window** around April 2021 policy change
  - Minimizes confounding effects on either ecosystem
  - Long enough to capture **pre-trends, and short- and long-term effects**
- We study the **universe of apps** on the App Store and Google Play
- Also analyze **heterogenous effects** across types of apps:
  - Freemium, multi-homing, single-homing, and top apps.

Number of Apps in Each Ecosystem Over Time



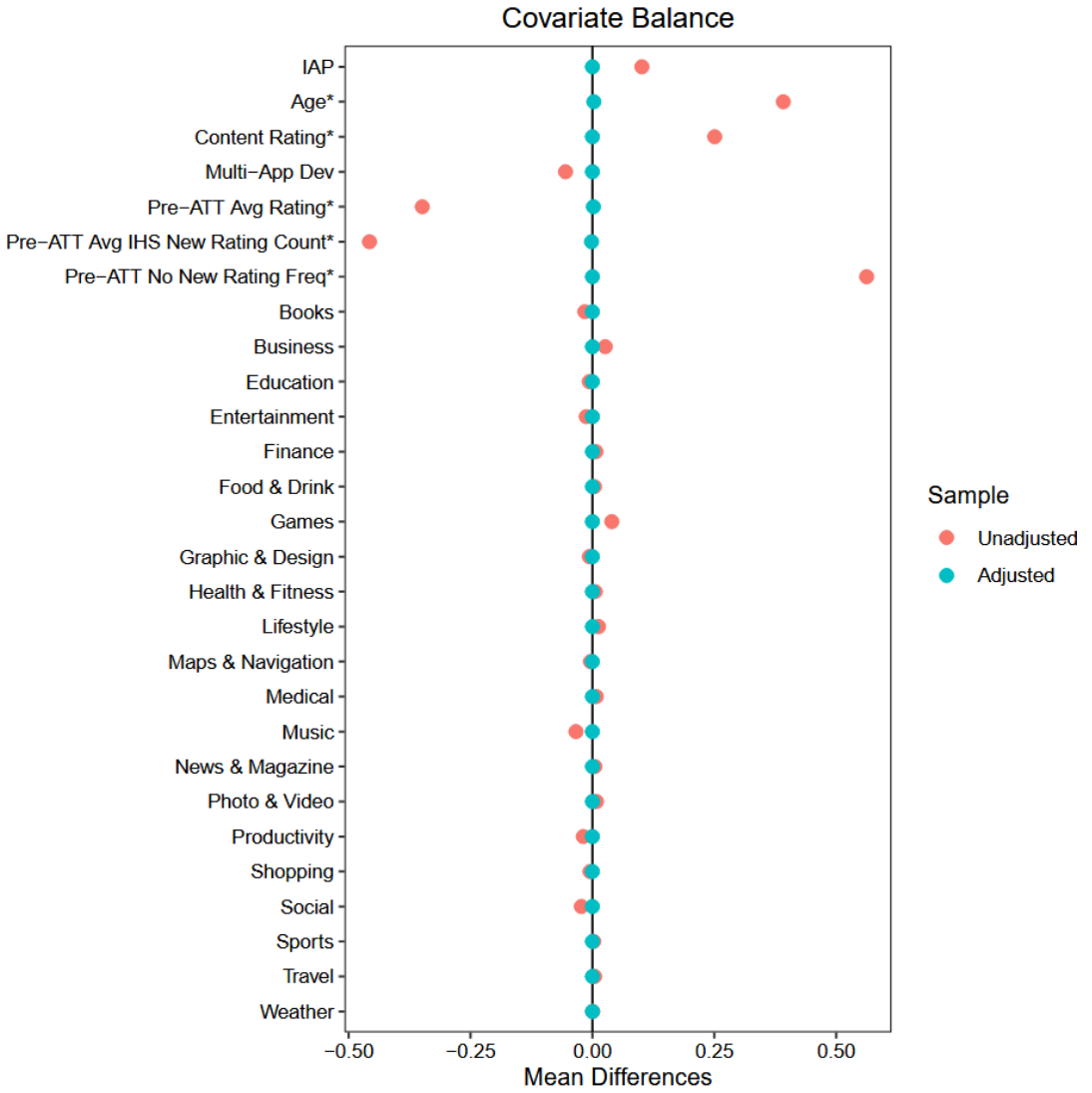
Methodology

- We assume ATT is an exogenous shock that only affects the Apple ecosystem
- **Difference-in-difference framework with coarsened exact matching**
  - Compare evolution of comparable apps in the App Store vs Google Play
- Multiple robustness analysis and alternative specifications:
  - Unmatched sample estimations
  - Event-study analysis to check for parallel trends, short-term, long-term, and delayed effects
  - Potential effects to parallel trends violations using HonestDiD
  - Synthetic DiD

Coarsened Exact Matching (CEM)

- We want to study how treatment (App Store) vs control (Google Play) apps evolve after ATT is introduced
- **Apps in each ecosystem may exhibit some systematic differences**, so direct comparison may not be ideal
- CEM coarsens continuous variables and then performs exact matchings on the discretized variables
- We match on characteristics one month before ATT
- Match on: Presence of in-app purchases, age since release, content rating, developers with multiple apps, average ratings, number of ratings, and app category

Coarsened Exact Matching (CEM)



Outcomes of Interest

- **Market Dynamics**: Entry, Exit, and Update
  - Related to incentives to keep investing and innovating in the ecosystem
- **Use of Software Developer Kits by Apps**
  - Allow us to measure if developers have changed how developers adjust functionalities included in their Apps
- **Number of New Ratings and Average Rating**
  - Proxy for demand side effects

Exit, Entry, and Updates

- If the ability to monetize investments in app development is negatively affected by ATT, we should expect to see less entry
- Similarly, if keeping an app in the market is costly, we should expect increased exit
- In general, cost of keeping an app listed is low. Past research has looked at updates as a measure of continued commitment of developers with the app. However, this measure has limitations:
  - If the app is stable and well liked, incentives to updates may be lower
  - If app is poorly rated, there are more incentives to update

Exit, Entry, and Updates

- For entry and exit we calculate genre-level entry and exit counts:

$$Y_{p,g,t} = \alpha_1 * PostATT_t * Apple_p + \delta_t + \mu_{g,p} + \epsilon_{g,t}$$

  - p = platform, g = genre, t = month
  - $Y_{p,g,t}$ = IHS (Count of Entry/Exit by platform, genre, time)
  - $PostATT_t$ and $Apple_p$ are dummy variables
  - δ_t and $\mu_{g,p}$ are time and genre-platform fixed effects
  - α_1 is the coefficient of interest. Measuring degree at which entry and exit on Apple's platform respond to the introduction of ATT

Exit, Entry, and Updates

- For updates we use app-level data:

$$Y_{i,t} = \beta_1 * PostATT_t * Apple_i + \omega_i + \mu_t + \epsilon_{i,t}$$

  - $Y_{i,t}$ is equal to 1 if app i was updated during time t

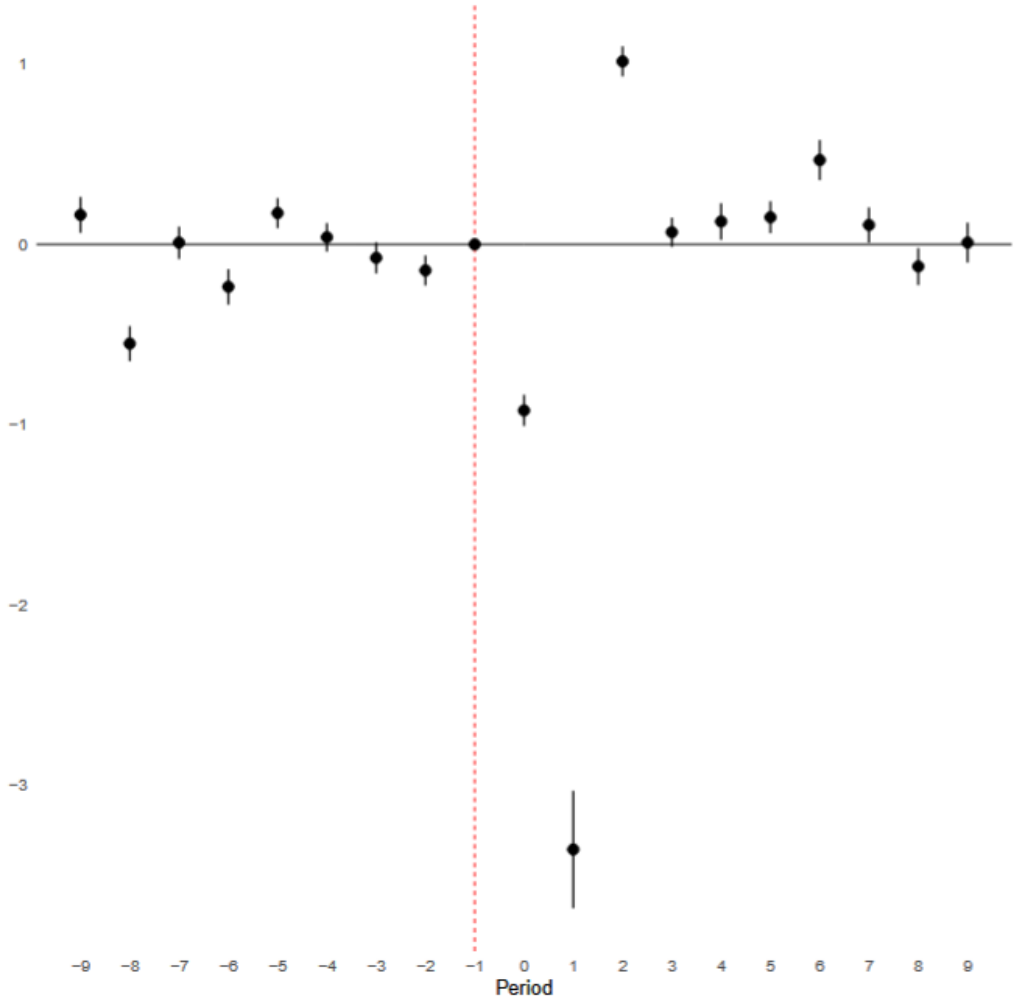
Interpreting Coefficients and Significance

- With very large samples, we can estimate coefficients precisely and **detect statistically significant effects even when they are very small**
- We therefore **evaluate effect sizes and equivalence**, not only p-values
- **Cohen's D** benchmarks the estimated effect relative to the overall variability of the outcome
  - We treat effects with $|D| < 0.3$ as economically trivial (conventional threshold)
- We use **two one-sided equivalence tests (TOST)** to assess whether effects are meaningfully different
- Same logic applies for pre-trends: We use **Dette and Schumann (2024) pre-trends equivalence test**

Market Dynamics

	IHS Entry Count	IHS Exit Count	Update
Apple x Post ATT	**-0.177*** **	**0.072** **	**-0.007*** **
	(0.063)	(0.035)	(0.003)
Age			-0.003**
			(0.001)
Platform-Genre F.E.	Yes	Yes	
Period F.E.	Yes	Yes	Yes
App F.E.			Yes
Pre Trend Eq. Test	Pass	Pass	Pass
Cohen's D	-0.380	0.299	-0.036
Dependent Variable Mean	7.717	7.981	0.068
R^2	0.917	0.972	0.339
Observations	798	798	38,720,081

Reduced Entry After ATT?



Looking at the event study plot of Entry shows that:

- Right after ATT is introduced, there is a sharp drop in entry
- Entry recovers a few weeks after
- More than a decrease in interest by developers, this is more consistent to an adaptation period

Use of Software Development Kits (SDKs)

SDKs are third-party tools developers can use to incorporate functionalities in their apps. We focus on:

- **Monetization**: Use to monetize apps through advertising
  - Examples: Facebook audience network, Google AdMob, ironSource…
- **Ad Mediation**: Similar to monetization, but connects to multiple platforms trying to allocate impressions to the platform offering higher price
  - Examples: AdMob Mediation Adaptor, ironSource Mediation Adaptor, …
- **Payment:** Used for securely processing card transactions
  - Examples: Mastercard CBP, Stripe, Square, Venmo, …
- **Authentication:** Allow apps to let users log in using credentials from different platforms
  - Examples: Facebook login, Firebase Auth, Google Sign In, Validator, …

Use of SDKs

	Monetization	Ad Mediation	Authenticate	Payments
Apple x Post ATT	**-0.094*** **	**-0.041*** **	**0.023*** **	**0.011*** **
	(0.003)	(0.003)	(0.002)	(0.002)
Age	0.001	0.009***	0.0006*	-0.0001
	(0.001)	(0.002)	(0.0003)	(0.0002)
Period F.E.	Yes	Yes	Yes	Yes
App F.E.	Yes	Yes	Yes	Yes
Pre Trend Eq. Test	Pass	Pass	Pass	Pass
Cohen's D	-0.157	-0.068	0.074	0.048
Dependent Variable Mean	1.092	0.206	1.046	0.537
R^2	0.889	0.849	0.892	0.896
Observations	3,187,727	3,187,727	3,187,727	3,187,727

Use of Software Development Kits (SDKs)

- Decrease in the use of Monetization and Ad Mediation SDKs, along with increase in Authentication and Payments SDKs, suggest a **shift towards revenue models less centered on advertising**
- However, while **effects are statistically significant, they are small and indicate trivial differences (Cohen's D, TOST)**
- Not all apps rely on advertising to the same degree
  - Effects are larger for top apps (those that make it into the top 200 charts in their category)

Changes in Users' Valuation of Apps

- ATT may lead to changes that decrease users' valuations of Apps:
  - Less frequent update can lead to unsolved bugs outdated Apps
  - If there are more in-app payments or increasing the number of ads, users may dislike the change
  - Ads, recommendations, and functionalities may become less relevant
- ATT could also lead to positive changes in users' valuations, for example if it leads to a reduction in predatory privacy practices
- We study the **new number of ratings** received by apps (which is a proxy for the number of downloads, and thus of demand), and the **average rating** of new ratings received (as a proxy for quality)

Changes in Ratings

	IHS # New Ratings	Avg. Rating	No New Ratings
Apple x Post ATT	**-0.064*** **	**0.033*** **	**0.031*** **
	(0.0010)	(0.010)	(0.002)
Age	-0.005*	0.004*	0.001*
	(0.003)	(0.002)	(0.001)
Period F.E.	Yes	Yes	Yes
App F.E.	Yes	Yes	Yes
Pre Trend Eq. Test	Pass	Pass	Pass
Cohen's D	-0.183	0.034	0.174
Dependent Variable Mean	0.241	3.885	0.894
R^2	0.825	0.421	0.592
Observations	38,660,898	4,081,512	38,660,898

Declining Ratings?

- After ATT, apps on the App Store receive fewer new ratings and are more likely to receive no ratings in a given month
- Changes in update frequency and SDK usage indicate that developers are adapting their behavior in response to ATT
- Apps introduced after ATT may be designed with the framework in mind from the outset and therefore be valued differently by users
- Empirical approach:
  - We analyze user ratings during the first month an app is available
  - We compare the first-month performance of apps introduced before ATT to those introduced after ATT

Ratings – First Month of Sales

	IHS # New Ratings	Avg. Rating	No New Ratings
Apple x Post ATT	**0.069*** **	**-0.014**	**-0.026*** **
	(0.018)	(0.036)	(0.005)
Period F.E.	Yes	Yes	Yes
App F.E.	Yes	Yes	Yes
Pre Trend Eq. Test	Pass	Pass	Pass
Cohen's D	0.053	-0.014	-0.072
Dependent Variable Mean	0.513	4.142	0.836
R^2	0.059	0.033	0.062
Observations	2,140,618	350,289	2,140,618

Heterogenous Effects

- We look at whether freemium, multi-homing, single-homing, and top apps are affected differently
- Freemium apps appear to be less affected than free apps in terms of entry/exit. Also, more likely to move away from ads
- Multi-homing apps are less affected in terms of entry/exit than single-homing apps
- Top apps exhibit stronger SDK adjustment behaviors
  - Move away from Monetization, Ad Mediation, and Authentication, and increase use of payments
- After ATT, **new apps become more likely to make it to the top charts**

Limitations

- We do not directly observe developer profitability. Our findings are based on ecosystem-level outcomes such as entry, exit, and updates
- SDK data skews toward popular apps, so SDK results may not generalize to the long tail of less prominent apps
- We do not observe or address how ATT affected advertisers or advertising revenues
- Residual probabilistic identification or first-party tracking may have substituted for IDFA-based tracking
- ATT has attracted anticompetitive scrutiny in the advertising market, which is outside the scope of this paper

Conclusions

- **Market Dynamics:** Short-run disruption, rapid stabilization
- **Developer Behavior:** Developers adapt rather than exit
  - Shift away from ad monetization SDKs toward payments and authentication. Effects statistically significant but economically small
  - Adaptation is heterogeneous: Freemium and multi-homing developers adjust more smoothly. New entrants appear better positioned
- **Consumer Valuations:** Ratings largely preserved
  - Incumbent apps see a small decline in new ratings
  - Post-ATT entrants perform at least as well and become more likely to make it to the top charts
- **Privacy interventions need not come at the cost of platform vitality**