The Hidden Costs of Fairness in Platform Markets: The Dynamics of Lowering Developer Royalty Rates*

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Abstract

Multisided platforms crucially rely on indirect network effects. When trying to strengthen these effects, platform owners face a fundamental challenge, namely designing incentives to enhance developer effort and simultaneously ensuring the release of high-quality products on the platform. This paper highlights the costs associated with lowering royalty rates to boost developer effort, as such reductions increase the relative supply of lower-quality offerings, worsening information congestion problems, and amplifying the importance of visibility-enhancing investments. We leverage the quasi-random announcements made by Apple and Google, declaring their intention to reduce the royalty rate applied to small app developers from 30% to 15%. We analyze the implications of these reforms using a difference-in-differences approach, finding a substantial increase in small developers' likelihood of releasing lower-quality and less original apps on iOS and Android after the announcements. These effects are neither paralleled by a comparable increase in high-quality app releases nor by an increase in small developers' likelihood of launching venture-backed apps. Consistent with worsening information congestion problems due to an influx of low-quality apps, our findings show an increase in the marginal value of experienced user certifications and developers' app store optimization efforts post-announcement. Additionally, we observe that VCs are increasingly concentrating their investments in ventures with higher (observable) quality.

Keywords: Platforms, Product Innovation, Royalty Rates, Information Congestion, Venture Capital

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1 Introduction

"This [Apple's Small Business Program] is a great incentive for small app makers. I'm glad they decided to reduce their revenue to encourage more people to develop."
(Developer 1)[1]

"Lowering the bar to entry will not improve quality. It will increase the amount of cheap software. It would increase the amount of malicious software [...]. Such a move would increase the quantity but not the quality. Given the current state of play raising the cost of the program might be a smarter move." (Developer 2)[2]

Multisided platforms are ubiquitous in today's economy, regulating transactions in emerging as well as in traditional sectors (Li and Zhu, 2021; Zhu et al., 2021). They create value by bringing buyers and developers together, reducing search and transaction costs (Spulber, 2006). The fundamental characteristic of platforms is the existence of indirect network effects such that one group is more likely to get on board when more members of the other group do so (Parker and Van Alstyne, 2005; McIntyre and Srinivasan, 2017; Farronato et al., 2023; Seamans and Zhu, 2014). As profits of platform owners depend on the strength of these network effects, one fundamental challenge they face is how to design incentives that increase developer effort and maintain high product quality standards on the platform.

Platforms have tried to boost developer innovative effort through various revenue-sharing mechanisms, such as *ad valorem* royalties (Bhargava et al., 2022). While these incentives may mitigate classical moral hazard problems in settings where platform owners' revenue hinges on producers' unobservable effort, identifying the optimal royalty rate presents a complex challenge in practice, as the impact of this decision on product quality is inherently difficult to predict *ex ante*. Nonetheless, this decision can have profound implications for the entire platform ecosystem.

[1] `https://www.reddit.com/r/apple/comments/jwdt85/apple_cuts_app_store_commission_rate_to_15_for/`, accessed November 13, 2023.
[2] `https://www.quora.com/Will-Apple-ever-make-the-iOS-Developer-Program-free`, accessed November 13, 2023.

In a classical setting with limited pass-through between producers and consumers, one might expect that lowering royalty rates would increase developer effort, as developers could now retain a larger share of the revenue they generate. This would, in turn, enhance product quality, assuming that quality depends on developer effort and is not a fixed characteristic drawn from a predetermined probability distribution.[3] However, this outcome is not guaranteed. If product quality is a fixed characteristic[4] and production entails positive fixed costs, a reduction in royalty rates could incentivize the release of products with both lower expected and realized quality, as the increased portion of revenue developers can now appropriate makes such products financially viable (Branstetter et al., 2014). This assumes that developers can reasonably predict their product's quality; if they cannot, the average quality of newly released products would align with that of the existing products on the platform (Aguiar and Waldfogel, 2018).

This paper is the first to empirically analyze the consequences of lowering *ad valorem* royalties charged to developers of applications (”apps”) for mobile platforms. We use large scale data on apps, their developers and investors. In doing so, we examine the implications of reducing royalties for the quality of released products and, more broadly, for the platform ecosystem.

Our empirical analysis leverages the introduction of new programs by Apple and Google, which reduced the royalty rates for small app developers in an effort to encourage innovation. Apple announced the App Store Small Business Program in November 2020, cutting the royalty rate for small developers from 30% to 15%. A few months later, Google implemented a similar reform. We exploit the quasi-random timing of the reform announcements in a unique dataset of apps for the iOS and Android platforms, which we extracted from Product Hunt and AppTweak and matched with venture outcomes from Crunchbase.

In a developer-platform panel, we estimate a staggered difference-in-differences model by comparing platform app releases from smaller developers before and after Apple's and Google's announcements, relative to releases from larger developers. To allow for treatment effect heterogene-

[3] In this scenario, the revenue R a developer appropriates could be represented as $(1-t)R(e,q(e))$, where t is the royalty rate, e is developer effort, and $q(e)$ is the quality of a product, which would be increasing in e.

[4] In this case, a developer's appropriated revenue would be $(1-t)R(e,q)$, where q is a fixed characteristic drawn from a certain probability distribution.

ity depending on the length of time a small developer has been treated since the announcements of the royalty rate cuts by Apple and Google, we use the two-way Mundlak regression approach proposed by Wooldridge (2021, 2023).

The results are striking. Based on Product Hunt data, our findings show that following Apple's and Google's announcements, there was an approximate increase of 27% in the likelihood of small developers—measured as solo developers—launching an app on iOS or Android, compared to the never-treated group of larger developers. Furthermore, we show that the launched apps are disproportionately in the lowest quartile in terms of upvotes and ratings received, and are self-"hunted" (i.e., self-certified), indicating a surge in low-quality apps. Specifically, the likelihood of a solo developer launching a low-quality app in a given platform increases by approximately 60% after the announcements, relative to larger developers. Consistently, we find that the likelihood of small developers releasing a product that turns into an entrepreneurial venture is 94% lower post-announcement. This decline is even more accentuated (112%) when we consider ventures that raised venture capital (VC). The findings on lower-quality launches are confirmed using data on game apps from AppTweak, a complementary dataset of iOS and Android apps and developers. Leveraging the characteristics of these data, we alternatively define small app developers as individual developers, contrasting them to incorporated businesses. This analysis shows that after Apple and Google announced royalty rate reductions, individual developers were 68% more likely than businesses to launch apps with no downloads within the first four months. This increase in lower-quality apps is not offset by a rise in high-quality ones. Further, our analysis using Natural Language Processing (NLP) to examine game app descriptions shows that apps released by small developers after the announcements are less likely to stand out as original compared to those from larger developers. This analysis rules out the possibility that our results are driven by smaller developers launching more niche, yet not necessarily lower-quality, apps due to limited resources, which would likely receive fewer upvotes, ratings, and downloads.

Overall, these results suggest that developers have a reasonable understanding of the quality of their apps and are more likely to release lower-quality apps when royalty rate cuts increase their expected revenue, enabling these releases to at least break even. Consistently, we find no evidence of "pass-through," indicating that developers did not fully transfer their increased share of revenue from the reduced royalty rate to consumers in the form of lower app prices. This is a necessary condition for a royalty rate cut to impact the release of lower-quality products (Rochet and Tirole, 2003).

What are the implications of these findings for the iOS and Android platforms? The increased prevalence of lower-quality apps might not pose a major issue if platform owners, investors, and consumers could easily differentiate between high- and low-quality offerings, ensuring that each product is correctly valued. However, a large influx of apps—particularly lower-quality ones—can exacerbate information congestion. With limited attention and time, platform owners, investors, and consumers may struggle to effectively differentiate between offerings (Simon, 1955; Bai et al., 2022), and may be reluctant to do so, especially if they expect the market to be inundated with lower-quality options. While mobile app platforms are generally vulnerable to these issues, hosting millions of apps from numerous developers with a vast array of options for each consumer need (Ershov, 2024), lower royalty rates for small developers could further exacerbate the problem.

These considerations motivate the second part of our analysis, in which we examine how the increased prevalence of low-quality apps impacts the broader platform ecosystem. First, we show that, all else being equal, VCs concentrate their investments in ventures with higher (observable) quality. Second, we find that the marginal value of certification from experienced "hunters" rises following Apple's announcement. Lastly, we demonstrate that the marginal value of developers' app store optimization (ASO) investments on iOS and Android increases after the announcement. Together, these findings suggest a worsening of information congestion on the iOS and Android platforms. As a result, we observe VCs adopting more risk-averse investment strategies, an increased role of certification by reputable third parties, and a heightened value of targeted investments to improve app visibility.

Our paper contributes to the growing literature on the functioning and governance of two-sided platforms (Hagiu, 2006b; Hagiu and Jullien, 2011; Armstrong, 2006; Eisenmann et al., 2011;

Kretschmer et al., 2022; Foerderer et al., 2021; Rong et al., 2024; Cheng et al., 2024). This research has explored topics such as the role of complementors in enhancing the value platforms can generate for consumers (and partially appropriate), as well as the tradeoff between maximizing product variety and maintaining quality. For example, studies have examined the conditions under which platform owners benefit from supporting and nurturing complementors (Cennamo, 2021) and when they engage in competition with them (Rietveld and Schilling, 2021; Padilla et al., 2022). Studies have additionally investigated the conditions under which limiting buyer choice can create value (Halaburda et al., 2018), optimal product quality thresholds (Zheng and Kaiser, 2013), and the relationship between product breadth, competition among developers, and innovation incentives (Boudreau, 2012; Cennamo and Santalo, 2013). Extending these studies, we demonstrate that enhancing "fairness" by reducing royalty rates applied to small developers comes with associated costs for platforms. Notably, it exacerbates information congestion problems, pushing developers to rely on third-party certification and ad hoc investments to boost their visibility.

Further, our paper extends the literature on the optimal payment systems for regulating platform transactions (Rochet and Tirole, 2003). For example, Hagiu (2009) shows how *ad valorem* fees (for example, royalties) charged to developers help address a tradeoff between reducing platform hold-up problems and avoiding curbing developers' innovation efforts. Hagiu and Wright (2019) analyze how *ad valorem* fees can mitigate the channel coordination problem in a setting where consumer demand relies on investments from both platforms and developers, with the latter possessing superior information regarding this demand. Bhargava et al. (2022)'s theoretical model shows that a revenue-sharing design with a differential rate favoring small developers can benefit the platform as this measure may spur competition among developers and strengthen network effects. In contrast, we provide insights into how lowering royalty rates can exacerbate information congestion, thus generating negative externalities for the overall platform ecosystem.

Our results hold clear implications for platform owners, indicating that lowering platform royalties without concurrently raising entry fees to screen out lower-quality offerings may worsen information congestion problems and result in negative externalities for the entire platform. Our findings are also relevant in light of the ongoing regulatory reforms affecting the tech industry. Regulators have expressed concerns regarding the market power of major tech corporations and the high *ad valorem* fees they levy on platform developers. These fees could dissuade developers from making investments in innovation. For example, the 2020 US Congress report about the state of competition in digital markets mentions: "[T]he more money Apple takes from developers, the fewer resources developers have. When developers have to cut costs, they stop updating apps, skimp on customer support, put off hiring a graphic designer [...] They decide not to make apps at all that they might have made were it easier to be profitable" (US House of Representatives, 2020). Our findings indicate that higher royalty rates can raise the quality threshold for developers to introduce new apps and reduce negative externalities associated with information congestion and limited attention. The improvement in the average app quality underscores the necessity for policymakers and platform owners to carefully balance the potential adverse effect of elevated royalty rates on innovation. This must be weighed against the positive effects stemming from this mechanism reducing the screening and monitoring burden on both platforms and consumers.

2 Empirical Setting

The App Store and Google Play are classic examples of two-sided markets, as described by Rochet and Tirole (2003). These platforms connect developers and consumers, facilitating interactions between them. Their value hinges on "getting both sides on board" by fostering indirect network effects. These platforms not only lower search costs for developers (supply) and users (demand) but also reduce transaction costs by streamlining product distribution, enhancing trust by minimizing scam risks, and simplifying payment processing (Hagiu, 2014).

In a setting where fostering indirect network effects is important, deciding which side to entice in order to attract the other is crucial. This implies that, in multisided platforms, the choice of price decomposition is at least as relevant as the choice of the price level for the services offered by the platform, assuming limited pass-through between sellers and consumers (Rochet and Tirole, 2003). Until recently, Apple and Google charged a 30% *ad valorem* fee on the revenue developers generated through the platforms, justifying this commission rate on the ground that developers benefit from the demand brought by the platform (Cheng et al., 2024). Developers generate revenue through three primary models: (i) "fee-supported," which involves charging consumers for downloads, subscriptions, or in-app purchases, with Apple and Google taking a commission; (ii) "ad-supported," where apps are offered for free or at a reduced price, generating revenue through advertising; and (iii) "freemium," which combines elements of both the fee and ad-supported models by providing users with a basic, ad-supported version of an app at no cost while charging fees for access to enhanced functionality (Sokol and Zhu, 2021). These revenue sources allow developers to recoup their total costs.[5]

In recent years, the 70/30 revenue split between developers and platforms has come under considerable scrutiny, with many developers viewing it as unfair. Epic Games has been at the forefront of this opposition, culminating in a highly publicized legal battle against both Apple and Google in August 2020 (Alderman and Blair, 2023). In the aftermath of this battle, Apple surprisingly announced the launch of the App Store Small Business Program on November 18, 2020, effective January 1, 2021. Under this initiative, any developer generating less than $1 million in annual sales across all their apps qualifies for a reduced App Store commission of 15%, half of Apple's standard 30% fee, applied to all paid app revenue and in-app purchases. In its announcement, Apple stated: "*We believe that small businesses are the backbone of our global economy and the beating heart of innovation and opportunity in communities around the world. Launching January 1, 2021, the industry-leading new App Store Small Business Program is designed to accelerate innovation and help propel your small business forward. The program has a reduced commission rate of 15% on paid apps and in-app purchases, so you can invest more resources into your business and continue building the kind of quality apps your customers love.*"[6] In essence, by modifying

[5] According to Appwrk, the development costs of an iOS app, which are mostly fixed costs, range from $75,000 to $500,000, while the development costs of an Android app range from $50,000 to $500,000, depending on app complexity (`https://appwrk.com/app-development-cost#h-an-overview-of-average-mobile-app-development-cost-estimate`). These costs arise from sources such as the acquisition of hardware and software, cloud services and backend infrastructure, third-party SDKs and APIs, program memberships for Apple and Google Play, as well as legal and compliance expenses.

[6] `https://developer.apple.com/news/?id=i7jzeefs`.

its pricing structure in favor of small suppliers, Apple aimed to broaden the range–and potentially enhance the quality–of apps available to consumers. Shortly after, on February 26, 2021, Google Korea announced that it was considering reducing the 30% commission fee for small developers.[7] This announcement was followed by Google's official declaration on March 16 2021, that it would reduce the commission rate from 30% to 15% for small app developers starting July 1, 2021.[8]

In what follows, we will leverage the quasi-random timing of the reform announcements made by Apple and Google to assess the impact of the royalty rate reduction on app launches by small developers, their quality, and the implications for the overall app ecosystem. We will consider December 2020 and March 2021 as the beginning of Apple's and Google's new pricing regimes, respectively, as small developers anticipated the implementation dates, enrolling ahead of time in Apple's and Google's programs.[9]

3 Data

The data used in this paper is assembled from three primary sources: Product Hunt, Crunchbase, and AppTweak.

3.1 Product Hunt & Crunchbase

Product Hunt is a website where individuals launch and discover new products. The venture was founded in 2013 and acquired in 2016 by AngelList, which saw in Product Hunt a natural

[7] `https://koreatechtoday.com/google-korea-discusses-lower-in-app-purchase-commission-rate/`, last accessed in June 2025.

[8] Specifically, Google applies the reduced commission to the first $1 million in total revenue earned by a developer on Android.

[9] In the case of Apple, refer to: `https://forums.macrumors.com/threads/apple-starts-accepting-developers-into-small-business-program.2276957/`. Small developers began enrolling in the Small Business Program starting in early December. As for Google, refer to `https://support.google.com/googleplay/android-developer/answer/10632485?hl=en`. In the case of Google, developers had to enroll in the program before July 1st to benefit from the reduced rates for the period from July 1, 2021, through the end of December 2021. It is unlikely that developers faced negative consequences from launching their apps between the announcement and implementation dates of Apple's and Google's programs, as it generally takes several months for apps to start generating positive revenue. See, for example, `https://proxify.io/articles/how-long-does-it-take-to-develop-an-app`. Calculations using estimated revenue data from AppTweak show that the median time for a game app to start earning positive revenue is 8 months on Android and 20 months on iOS. On the other hand, developers are likely to benefit from launching their apps ahead of competitors, as they can reap the typical advantages of being first movers.

complement to its main activity of matchmaker between early-stage companies and investors.[10]

The products makers launch on Product Hunt can be web apps, mobile apps, hardware products, games, and even books and podcasts. Makers submit products, which are then listed on the website. These products can receive comments, upvotes, and ratings from other users, similar to other websites like Hacker News or Reddit. Products receiving the most upvotes rise to the top of each day's list. With thousands of products listed every year, Product Hunt has become the website where innovators launch their innovations and scouters assess the state of the art (Cao, 2020).

For each product, we have information on the title, technology keywords describing the product, whether the launch concerns a new product or an updated version of an existing product, URL, the platform in which the product was launched–namely iOS, Android, and the Web–, the launch date, and the identity of the launchers. One important feature of this dataset is that it contains information regarding whether the product was externally "hunted," that is, recommended by a Product Hunt member other than the makers. We additionally collected the number of upvotes and ratings obtained as of September 30th, 2022. To assess the type of apps listed in Product Hunt, we matched the list of Product Hunt products with the list of 200 top apps on iOS and Android available from *appfigures.com*. Approximately 50% of the apps launched on Product Hunt appear in the list of top apps. This exercise indicates that Product Hunt is primarily a website targeting early-stage apps.

We linked product data from Product Hunt with startup data from Crunchbase, leveraging company URLs for the matching process. Crunchbase is a repository of startups that provides detailed information on these companies' founding dates, technologies, funding rounds, participating investors, and exit outcomes (Conti and Roche, 2021). These data enabled us to assess which product launch ultimately translated into a new venture.

We analyze 7,331 developer teams that launched at least one app on iOS, Android, or both starting in January 2019, spanning various categories. Among them, 3,087 developers released

[10] "AngelList just bought Product Hunt, the website that Silicon Valley uses to discover the hottest startups," available at https://www.businessinsider.com/angellist-buys-product-hunt-for-around-20-million-2016-12, Accessed on April 18, 2024.

apps exclusively on iOS, 892 exclusively on Android, and 3,234 released the same apps on both platforms. Moreover, 118 developers launched at least one app on one platform and also released either an additional app on the other platform or a different app on both platforms.[11] Additionally, 724 developers (10%) launched more than one app, and 716 released multiple apps on the same platform.

We focus our empirical analysis on the period encompassing 12 months before, the month of, and 12 months after the announcement of a royalty rate cut. During this focal period, 4,727 of the 7,331 developer teams released at least one app on either iOS, Android, or both platforms,[12] and 402 (9% of the active developers) released more than one app on the same platform.[13]

Of the 4,727 developer teams that launched at least one app during the focal period, 3,993 released at least one app on iOS between November 2019 and November 2021, resulting in a total of 4,540 apps on the platform, of which 3,079 were new versions, 3,442 were "hunted" by the makers (i.e., certified by the makers as opposed to external users), and 285 turned into startups.[14] Additionally, 2,631 launched at least one app on Android between February 2020 and February 2022, for a total of 2,835 apps. Of these apps, 1,769 were new versions, 2,120 were hunted by the makers, and 237 turned into startups. Of the 7,331 developer teams, 4,133 consist of solo developers, while the remainder are made up of more than one developer. As shown in Panel A of Table 1, the mean team size is 2.

[11]Specifically, 72 developers released at least one of the same app on both iOS and Android, along with at least one additional app on iOS only. Similarly, 28 developers released at least one same app on both platforms, plus at least one more on Android. Additionally, 14 developers released at least one app on iOS and at least another one on Android. Finally, 4 developers launched at least one same app on both platforms, as well as at least one additional app on iOS and another on Android.

[12]In this dataset, we observe only one release date per app. Therefore, we assume that the release dates for apps launched on both iOS and Android coincide. Clearly, this is a limitation of our approach. To mitigate concerns that the same app could be released on the two platforms at significantly different times, we extracted a random sample of 100 multihomed apps from our AppTweak dataset, for which we have precise launch dates. Our analysis revealed that 50 of these apps were released simultaneously on both platforms, while an additional 28 were launched on the second platform within two months of the first release.

[13]This is a conservative estimate, as it assumes that the composition of developer teams remains constant over time. For example, when ignoring team composition, 20% of individual developers appear to have developed more than one app.

[14]After examining the LinkedIn profiles of a random sample of 100 external hunters, we found that most of these individuals either have entrepreneurial experience or have worked as product managers in high-tech industries. It is important to note that external hunters are not compensated for certifying a product.

As described in the next section, we will conduct our main analyses at the developer-platform level. In practice, we will observe the release strategies of the 7,331 app developers across platforms. Developers are associated with each of the platforms on which they launched at least one app between January 2019 and February 2022, for a total of 10,683 developer-platform combinations. The underlying assumption is that developers are at risk of launching apps on those platforms where they released at least one app during the analyzed period. These developer-platform combinations are observed for the focal period encompassing 12 months before, the month of, and 12 months after the announcement of a royalty rate cut. Panel A of Table 1 shows that each developer released, on average, 0.62 apps on iOS (maximum number = 13) and 0.39 apps on Android (maximum number = 12) during the focal period. In robustness checks, we will modify our approach by considering a fictitious third platform—and, correspondingly, a third developer type—iOS&Android. This category includes developers who release at least one specific app on both iOS and Android.[15] Additionally, we will pursue an alternative approach in which each developer is at risk of launching an app on both platforms and is therefore observed twice—once per platform.

⟨ Insert Table 1 about here ⟩

3.2 AppTweak data

Product Hunt allows us to build a representative sample of apps primarily created by early-stage developers, possibly accessing Product Hunt to seek financing for their projects. However, not all developers active on iOS and Android are early-stage developers. Thus, we build an additional sample that is more representative of the universe of apps on the iOS and Android ecosystems using data from AppTweak. This is a pioneering company that uses machine learning to provide App Store Optimization (ASO) services to developers.

The advantage of using AppTweak data lies in its fine-grained performance metrics, such as app downloads, for all apps that ranked among the top 500 daily downloads in any country at least

[15] In implementing this approach, we will treat December 2020 as the key announcement date for the royalty rate reduction in the case of apps launched on both iOS and Android.

once. Additionally, AppTweak offers accurate information on developers and the launch dates of apps for each platform. Furthermore, this company gathers data on app pricing schemes, enabling us to distinguish between apps offering subscription options (3%) and others (97%),[16] as well as between apps with in-app purchase options (73%) and those without (27%).[17] We will utilize these distinctions in our robustness analyses. Finally, this data provider collects information on ASO activities for iOS and Android apps by country. ASO entails enhancing an app's visibility and appeal within the app stores, thereby increasing the likelihood of app downloads. ASO activities encompass tasks such as optimizing an app's keywords, title, description, screenshots, and icon. Due to data download limitations, we focused on game apps developed for the iOS and Android platforms and marketed in China, France, Germany, the Russian Federation, the UK, and the United States. We prioritized game apps because these apps contribute the majority of revenue on both iOS and Android platforms.[18]

We observe 18,061 developers over time—incorporated businesses and individual developers—who were active on iOS, Android, or both starting in January 2019. Among them, 6,635 developers released apps exclusively on iOS, 9,631 exclusively on Android, and 1,663 released at least one of the same app across both platforms. Of the 1,663 developers, 914 also released additional apps on either iOS or Android.[19] Moreover, 132 developers launched at least one app on one platform and also released an additional app on the other platform. Notably, 3,984 developers (21%) released multiple apps on the same platform.

We will conduct our main analyses at the developer-platform level, observing the release strategies of the 18,061 developers across platforms. Developers are associated with each of the plat-

[16] These percentages align with those observed among the population of game apps during the period we study. The percentage of subscription apps has increased since then to approximately 30% in 2023. Please refer to: `https://www.statista.com/statistics/1320734/subscription-apps-share-by-category`.

[17] This information is available for 50% of the apps in our sample. The percentage of game apps offering in-app purchases is 81 on Android and 63 on iOS. The percentage of Android game apps offering in-app purchases, as computed from our sample, aligns with the overall trends observed in the population of Android game apps. The percentage of iOS apps offering in-app purchases is likely underestimated, as it should be at least as high as that of Android apps. Please refer to `https://www.businessofapps.com/guide/in-app-purchases`.

[18] Refer, for example, to `https://www.gamesindustry.biz/62-percent-of-all-app-store-revenue-is-generated-from-game-transactions`.

[19] Specifically, 464 developers released at least one other app on Android. Similarly, 180 developers released at least one other app on iOS. Finally, 270 developers released at least one app on iOS and at least another one on Android.

forms on which they launched at least one app between January 2019 and February 2022, resulting in a total of 19,856 developer-platform combinations. These developer-platform combinations are observed for the focal period encompassing 12 months before, the month of, and 12 months after the announcement of a royalty rate cut. During this period, 9,542 developers released at least one app.[20] Specifically, 4,616 developers released at least one app on iOS between November 2019 and November 2021, resulting in a total of 7,813 game apps on the platform. Moreover, 5,844 launched at least one app on Android between February 2020 and February 2022, for a total of 9,792 apps. During the sample period, approximately 10% of the apps were released on both iOS and Android.[21] Among the 9,542 developers that released at least one app during the sample period, 2,029 (21%) launched more than one app on a given platform. As shown in Panel B of Table 1, each developer released, on average, 0.43 iOS apps and 0.54 Android Apps during the focal period.

Information on ASO activities is accessible for roughly 80% of AppTweak game apps. We use these data to assess whether and how the marginal productivity of ASO activities changes following the announcements made by Apple and Google regarding a reduction in the royalty rate applied to transactions by small app developers. For these analyses, we leverage data from 5,302 iOS game apps and 4,198 Android game apps, all of which were initially launched between January 2017 and December 2018. Our observation of their ASO activities will cover the 12 months before and after the announcement months for the iOS and Android reforms.

4 Econometric methodology

In the first part, we examine how reductions in the royalty rates imposed by iOS and Android on app revenues affect developers' incentives to release new apps on a given platform, as well as the quality of those apps. To this end, we exploit the staggered announcements by Apple and

[20]We will conduct the same robustness checks as we did with *Product Hunt*, adapting our main approach to include a hypothetical third platform—along with a corresponding third type of developer, labeled *iOS&Android*. This category encompasses developers who have released at least one app on both iOS and Android. Additionally, we will explore an alternative approach in which each developer is at risk of launching on both platforms and is therefore represented twice in the data—once for each platform.

[21]To identify which game apps are multihomed, we used probabilistic record linkage to match the titles of iOS apps with those of Android apps, as well as data provided by AppTweak.

Google regarding reductions in royalty rates for small app developers, analyzing their effects in a developer-platform-level panel. Specifically, we estimate a variant of a standard two-way fixed effect (TWFE) model, exploiting variation in the timing of Apple's and Google's announcements as a source of identification. TWFE models with unit and time fixed effects have come under scrutiny as they may deliver inconsistent estimates if treatment effects are heterogeneous across groups or time (De Chaisemartin and d'Haultfoeuille, 2020; Callaway and Sant'Anna, 2021; Goodman-Bacon, 2021). To address this issue, we follow Wooldridge (2021, 2023) and estimate a two-way Mundlak regression model,[22] which allows for substantial treatment effect heterogeneity. Specifically, for developer-platform i, observed in year-month t, belonging to treatment cohort g, we estimate:

$$Y_{i,t} = \alpha + \sum_{g \in G} \sum_{t=t_0}^{g-1} \theta_{g,t}^{pre} D_{i,g,t} + \sum_{g \in G} \sum_{t=g}^{T} \theta_{g,t}^{post} D_{i,g,t} + \rho_i + \rho_t + \varepsilon_{i,t} \quad (1)$$

where Y_{it} is a (0/1) indicator that takes value 1 the month a developer launches an app on either iOS or Android.[23] In extensions to our baseline analysis, we explore variations of this outcome to gain a deeper understanding of the characteristics of the products being launched. Specifically, we differentiate launches based on the underlying quality of the apps. Low-quality apps are those falling within the lowest quartile of the distribution of the number of upvotes received as of September 2022 by products launched in the same year-month. Conversely, high-quality apps are those in the highest quartile of the distribution. As an alternative, we replace these definitions of quality, using instead the ratings that apps received and whether a product is certified–i.e., "hunted"–by an external user. We also consider launches that turn into entrepreneurial ventures and VC-funded ventures as a complementary measure of product quality. Additionally, we categorize apps based on the number of downloads they received in the initial four months following their release. Finally, having applied NLP methods, we distinguish apps by their level of "uniqueness" relative to

[22] The results remain qualitatively invariant when using the staggered difference-in-differences estimator proposed by Callaway and Sant'Anna (2021). However, we opt for the two-way Mundlak regression model because of the flexibility and speed of this approach.

[23] Please refer to: `https://friosavila.github.io/app_metrics/app_metrics11.html`.

existing offerings.

The $D_{i,g,t}$ is a treatment cohort dummy taking the value of 1 if a developer-platform belonging to cohort g is in the treatment group in t and zero otherwise. G is the set of small developer cohorts g identified by when small developers were first treated with either Apple's (December 2020) or Google's (March 2021) announcements, and T is the last period in the dataset. The ρ_i represents developer-platform fixed effects, while ρ_t is a year-month fixed effect. The $\theta_{g,t}^{post}$ coefficients represent the average treatment effects (ATE) that small developers experience in t after either Apple's or Google's announcements, which in the expression above are weighted by g's exposure to treatment at time t. Conversely, the $\theta_{g,t}^{pre}$ coefficients represent the effects of being a small developer in the year-months prior to either announcement. In this expression, the control group is the never treated, namely, the larger developers. We will also present results using the not-yet-treated as a comparison group, although this is not our preferred specification, as Android platform developers after November 2020 may have adjusted their strategies in anticipation of Google's royalty rate cut, which occurred a few months later.[24] Similar to Callaway and Sant'Anna (2021), having estimated the $\theta_{g,t}^{post}$, for each cohort g and time t, it is possible to calculate the aggregated average treatment effects on the treated (AGGTE) for all observations that were treated at some point in time as a weighted average of these effects. This method – which has been shown to deliver consistent estimates – allows for substantial treatment effect heterogeneity, depending on the length of time a small developer has been treated since Apple's or Google's announcement.

We employ several measures to identify small developers to ensure that our results are not driven by one specific definition. Utilizing Product Hunt data, we classify small developers as solo developers, contrasting them with team developers. Alternatively, using AppTweak data, we define small developers as individual developers, comparing them to incorporated businesses.[25]

[24] This requires slightly modifying Eq. 1 as $Y_{i,t} = \alpha + \sum_{g \in G} \sum_{t=g}^{T} \theta_{g,t} D_{i,g,t} + \rho_i + \rho_t + \varepsilon_{i,t}$.

[25] Calculations using AppTweak estimated data on app revenues reveal that individual developers are 13 percentage points more likely to produce apps in the lowest quartile of revenue generated and 18 percentage points less likely to produce apps in the top quartile. However, it is important to point out that some solo or individual developers may generate more than $1 million in revenue, just as some team developers or incorporated businesses may be less successful. Given that both type I and type II classification errors are likely to be equally possible, this represents a classical case of measurement error, which biases our estimates toward zero. Consequently, the estimations we will discuss in the next session reflect lower bounds of the true effects.

As a robustness check, we will distinguish small developers by their revenue, as estimated by AppTweak.

For our approach to be valid, developers who release only one app during the sample period must not be intrinsically predisposed to releasing a single app; rather, they should potentially release multiple apps. Here, we note that within a time span of just two years, a non-negligible proportion of active developers released multiple apps on a given platform—9% in the *Product Hunt* dataset and 21% in the *AppTweak* dataset. Moreover, 46% of developers in *Product Hunt* and 10% of developers in *AppTweak* were multi-homers[26]. To corroborate our approach, we conducted interviews with several developers on Product Hunt who had released one or more apps. These interviews consistently revealed that the decision to launch an app hinges on factors influencing expected revenues and costs. Developers who had released only one app noted that they would consider launching additional apps if the perceived benefits exceeded the associated costs. Notably, several part-time developers indicated that they tend to release new apps as a way to supplement their income. Others emphasized the hope of attracting even a few "whales"—users who spend large amounts on in-app purchases—as a key driver of their decision to develop new apps.

Another fundamental assumption for our approach to be valid is that, in the absence of Apple's announcement, the difference between small and larger developers in their propensity to launch a product in a particular month would have been constant over time. Descriptive evidence reported in Figure 1 for solo and team developers using Product Hunt data is consistent with this assumption. In Panel A of Figure 1, we observe that prior to the announcements by Apple and Google, the number of apps released by both small and large developers follows a similar trend. However, after the announcements, the monthly number of app releases by small developers increases, while the number of releases by larger developers remains relatively flat. As shown in the subsequent panels, these descriptive results are driven by the release of lower-quality apps (Panels B to D), rather than the launch of higher-quality apps (Panels E to G). In Figure 2, we note very similar trends to those depicted in Figure 1. Here, we employ download information from AppTweak to

[26]These shares are non-trivial, but a limitation of our approach is that we cannot definitively exclude the possibility that developers are inherently inclined to release just one app.

distinguish between high- and low-quality app launches. Specifically, low-quality apps are now defined as those that do not receive any downloads in the first four months after their launch. This descriptive evidence is confirmed by the findings reported in Panels A (*Product Hunt* dataset) and C (*AppTweak* dataset) of Table A1, where we estimate Poisson quasi-maximum likelihood models for the monthly number of app launches on iOS and Android in a developer-type-platform panel. Developers can be of two types: small and large. The platforms are iOS and Android. Each developer-type-platform is observed for the 12 months preceding the announcement of the royalty rate cut, the month of the announcement itself, and the 12 months following the announcement. The descriptive evidence displayed in the figures is further confirmed by the findings reported in Panels B (*Product Hunt* dataset) and D (*AppTweak* dataset) of Table A1, where we further distinguish the apps by the categories to which they belong. Overall, this descriptive evidence provides a first glance into the phenomenon we plan to investigate. In essence, following Apple's and Google's announcements of the new royalty rate regimes, we observe an uptick in the number of (lower-quality) launches for small app developers, who are more likely to have been affected by the reforms.

⟨ Insert Figure 1 and Figure 2 about here ⟩

In the second part of the empirical analysis, we will assess whether, and how, the announcements of a royalty rate cut impacted the relationship between app quality and attracting VC funds, the marginal value of ASO activities, and the role of experienced certifiers. The aim of this analysis is to evaluate to what extent the reductions in royalty rates implemented by Apple and Google for small app developers may have resulted in negative externalities within the platform ecosystem by exacerbating information congestion problems. To assess this aspect, we will estimate ad hoc models, which we will describe in detail in the next section.

5 Results

5.1 Effects of Apple's and Google's royalty rate cuts on app launches using Product Hunt data

We begin our exploration by assessing how Apple's and Google's announcements of a royalty rate cut might have affected the opportunity costs of launching an app for developers most impacted by the reform. For this scope, we estimate the two-way Mundlak regression model in Eq.1, controlling for developer-platform and time fixed effects, and clustering standard errors at the developer-platform level. The resulting AGGTEs are reported in Table 2, having used data from Product Hunt and defined small developers as solo developers.

In Panel A, the control group consists of larger developers, i.e. the never treated group. In Panel B, the control group is represented by the not-yet treated, comprising both the never treated developers and those that have not been treated yet. As reported in column 1 of Panel A, there is a 0.7 percentage point increase in the likelihood of an app release by small developers relative to larger developers after the announcements. This figure corresponds to a 27% increase in the outcome mean. As shown in column 1 of Panel B, the effect increases to 34% when we use the not-yet treated as the comparison group. Moreover, Table A2 shows that the effects are slightly larger when we examine the likelihood of launching a new app as opposed to the follow-on version of an existing app.

In columns 2 to 4 of Table 2, we delve into launches of lower-quality apps. Here, we show that after the announcements, developers became more likely to launch lower-quality apps on iOS and Android. The effects are large and precisely estimated, regardless of the comparison group. For example, the effect reported in column 2 of Panel A on the likelihood of launching an app in the lowest quartile of upvotes received corresponds to a 63% increase in outcome mean. The effects on the likelihood of launching an app in the lowest quartile of ratings (column 3 of Panel A) and the likelihood of launching a self-"hunted" app (column 4 of Panel A) are 60% and 36%, respectively. As reported in Panel B, these effects become consistently larger in magnitude when the comparison group is represented by the not-yet treated. In columns 5 to 7 of Table 2, we examine the effects of Apple's and Android's announcements on developers' launches of higher-quality apps on the platforms. This time, the effects are small in magnitude, sometimes negative, and mostly insignificant, regardless of whether the control group is represented by larger developers (Panel A) or the not-yet treated (Panel B).

⟨ Table 2 about here ⟩

Figure 3 reports event studies for the effects of Apple's and Google's announcements on the outcomes analyzed in Table 2, having considered larger developers as the comparison group. Four fundamental messages can be extrapolated. First, there are no significant pre-trends regardless of the outcome examined. This suggests that our empirical design allows us to at least partially address the concern that developers might have anticipated Apple's and Google's reforms. Second, we observe in Panel A a sizable increase in the likelihood that a developer launches an app in a given platform, starting from the second month after either Apple's or Google's announcement. This evidence is consistent with developers both developing entirely new apps and rushing existing prototypes to the platforms after the announcements. Third, we observe in Panels B to G that the effects are driven by launches of lower-quality apps on either platform. Finally, the effects displayed in Panels A to D persist for at least 10 months, declining thereafter.[27] While the immediate increase in the *flow* of apps entering a given platform may be temporary, these apps often remain available on the platform for an extended period, leading to a sustained increase in the *stock* of apps. This growth in app stock could contribute to platform congestion.[28]

[27] Table A3 and Figure A1 show larger effects compared to those just mentioned. To derive these results, we built a developer-platform panel, considering the following three platforms: iOS, Android, and iOS&Android. The iOS&Android case refers to situations where an app is released on both iOS and Android platforms. For the iOS&Android platform, we consider December 2020 as the beginning of the new pricing regime. Moreover, the effects remain comparable to those displayed in Table 2, when we assume that all the 7,331 developers are potential candidates for launching an app on either the iOS or Android platform. The corresponding results are presented in Table A4 and Figure A2. Furthermore, the effects remain very similar to those reported in Table 2 when we adopt Callaway and Sant'Anna's approach to estimate the AGGTEs (Table A5). Finally, the findings remain qualitatively unchanged when we adopt an alternative approach and estimate multi-failure Cox proportional hazard models for the risk that a developer releases a (lower-quality) app on a given platform. The corresponding results are reported in Table A6.

[28] Figure A3 reports the event studies from two placebo tests where we examine the effects of Apple's (Panel A) and Google's (Panel B) announcements on developer releases of Web products. The effects are all close to zero.

⟨ Figure 3 about here ⟩

In columns 8 and 9 of Table 2 and Panels H and I of Figure 3, we examine app quality measures constructed from Crunchbase venture data. Specifically, we estimate versions of Eq. 1 where the outcomes are: (1) whether an iOS/Android app had become a startup by December 2022, and (2) whether an iOS/Android app had become a *VC-backed* startup. In column 8 of Table 2, Panel A—where the never-treated serve as the comparison group—we find that, following Apple's and Google's announcements, the likelihood that a small developer launched an app that eventually became a startup decreased by 0.19 percentage points. This corresponds to 94% decline in the outcome mean. The detected effect becomes stronger in magnitude in column 9, where we examine the likelihood of launching an app that turned into a VC-backed startup. The displayed coefficient implies a 112% decline in the outcome mean. The effects of the announcements are more precisely estimated in Panel B, where the control group is the not-yet treated. The negative effects of the royalty rate cuts on the creation of new ventures are finally confirmed by the event studies displayed in Panels H and I of Figure 3. Overall, these results provide an indication that the royalty rate cuts led to an uptick in app launches by lower-ability developers. As a result, the launches were less likely to turn into successful ventures.

5.2 Replicating the analyses using AppTweak data for game apps

To ensure that the effects we have observed are not specific to the types of early-stage developers active on Product Hunt, we replicated our analysis using the AppTweak dataset, focusing on the initial releases of game apps on both iOS and Android platforms. Additionally, the data provide an alternative definition of small app developers, further ensuring that our findings are not dependent on the previously discussed classification. In a developer-platform panel, we estimate the same model as in Eq. 1 for a developer's 1) first launch on iOS or Android, 2) lower-quality launch, and 3) higher-quality launch.

This time, we use information about downloads to distinguish between high and lower-quality game apps. Specifically, low-quality apps are those that have not received any downloads in the first four months after launch, while higher-quality apps are those that are in the top quartile of downloads obtained in the same period. Moreover, we define small developers as individual developers, distinguishing them from incorporated businesses.[29]

The results are reported in Table 3, having clustered standard errors at the developer-platform level. The comparison group is the never treated in Panel A and the not-yet treated in Panel B. As reported in column 1 of Panel A, following Apple's and Google's announcements of a royalty rate cut, there is a 3% increase in the likelihood of small developers releasing a new app on either iOS or Android platforms (relative to the outcome mean); however, this effect is not significant at conventional levels. The coefficient magnitude reported in Panel B is larger than that in Panel A, although still insignificant.

Moving to lower-quality launches in column 2, post-announcements, the likelihood of small developers launching a new app that did not receive any downloads increases by 68% relative to the outcome mean when the control group is the never treated (Panel A). The effect remains similar when the control group is the not-yet treated (Panel B). Conversely, the results in column 3 show that the probability of individual developers launching a highly downloaded app decreases by 55% post-announcements in Panel A and 42% in Panel B. The event studies in Figure 4 confirm that the flow of lower-quality game apps launched by small developers increases in the months following Apple's and Google's announcements, remains elevated through the eighth month, and declines thereafter.

To ensure that our results are not driven by our definition of small developers, panel specification, quality measure, or empirical specification, we conduct a battery of robustness checks, which we report in the Appendix. Among these analyses, we highlight those presented in Table A7, where we define the treatment group based on estimated revenue earned in 2018. In columns 1 to 3, we

[29]To make this distinction, we classified as incorporated businesses those containing the following abbreviations in their names: "Corp.", "Inc.", "LLC", "Ltd.", "S.A.", "Group", and "GmbH." Since some incorporated businesses (e.g., Voodoo, Playtika) do not include these identifiers in their names, we refined this classification by cross-referencing a list of game companies from sources such as `https://www.goodfirms.co/game-development-companies/ios`, `https://builtin.com/media-gaming/mobile-game-companies`, `https://www.gamedesigning.org/gaming/mobile-companies/`, and `https://en.wikipedia.org/wiki/List_of_video_game_developers` to minimize misclassification.

classify small developers as those who did not generate positive revenue in 2018. Conversely, in columns 4 and 6, we compare developers near the $1 million revenue threshold used by Apple and Google to define small developers. The results consistently indicate an increase in the likelihood of smaller developers launching lower-quality game apps following the royalty rate cuts.[30]

⟨ Table 3 and Figure 4 about here ⟩

The results suggest that a reduction in the royalty rate for small developers encouraged the release of lower-quality apps, as the larger portion of revenue developers can now appropriate makes these products financially viable in a scenario where app quality can be reasonably represented as a characteristic drawn from a fixed probability distribution, and developers generally have a good understanding of their app's quality. While this is a feasible explanation, another possibility is that our results are driven by smaller developers launching more niche yet not necessarily lower-quality, apps due to limited resources, which would likely receive fewer upvotes, ratings, and downloads. In the next subsection, we explore this issue by assessing the originality of new product releases relative to existing apps to determine whether small developers indeed launched more niche apps in the market following the new royalty rate regimes.

5.3 Effects of the royalty rate cuts on new apps' originality

We apply natural language processing methods to assess whether and how the level of originality of new apps launched by small developers on iOS and Android changes following the an-

[30]Table A8 and Figure A4 report results from building a developer-platform panel and considering the following three platforms: iOS, Android, and iOS&Android. These results are similar to those displayed in Table 3 and Figure 4. Table A9 and Figure A5 display results under the assumption that all 18,061 developers are potential candidates for launching an app on either the iOS or Android platform, further confirming our main findings in Table 3 and Figure 4. Table A10 shows that the effects remain very similar to those reported in Table 3 when we adopt Callaway and Sant'Anna's approach to estimate the AGGTEs. In Table A11 and Figure A6, we classify game apps into high- and low-quality categories based on ratings information, yielding results that are very similar to those in Table 3 and Figure 4. Similarly, in Table A12 and Figure A7, we conducted a robustness check by considering only the launches of apps that do not offer a subscription option (subscription apps represent 3% of the total game apps), as Apple had already reduced the royalty rate to 15% for these types of apps in 2016. In Table A13, we present results that define launches as those of apps featuring in-app purchase options, as these apps are likely to be most affected by royalty rate cuts for small developers. Finally, the findings remain qualitatively unchanged when we adopt an alternative approach and estimate multi-failure Cox proportional hazard models for the risk that a developer releases a (lower-quality) app on a given platform. The results are reported in Table A14. In general, all the results remain very similar to the main findings discussed so far.

nouncement of a royalty rate cut. We use AppTweak data because it offers a more comprehensive description of apps launched on both iOS and Android. Similar to Taeuscher and Rothe (2021), we limit the sample to game apps released in the US and the UK for which we have accurate descriptions, identifying the primary language of each app's description to ensure that only English apps are included. We then remove stop words (e.g., 'the,' 'and,' 'for') and stem words to their root forms. The ultimate goal is to evaluate the originality of the apps released 12 months before, the month of, and the 12 months after Apple's and Google's announcements, relative to the corpus of apps launched during the pre-sample period. For iOS apps, the pre-sample period is November 2018 to October 2019, while for Android apps, it is February 2019 to January 2020.

Following Conti et al. (2024), we apply the Term Frequency–Inverse Document Frequency (TF-IDF) procedure to turn each document into a vector where the entries are the TF-IDF scores assigned to the words in the document. A TF-IDF score is defined as the frequency with which a given word occurs in a certain document divided by the frequency with which that word is present in the corpus of all app descriptions. We then generate a matrix where each row corresponds to a given app description i and each column corresponds to a word j from the app descriptions' entire corpus of words. Each cell in this matrix contains the TF-IDF score of word j. If the word is not present in an app description, a value of zero is assigned.

Lastly, we compute the text similarity between app description pairs using the cosine similarity, which measures the cosine of the angle between the two vectors, each representing an app description. The similarity score is bounded between 0 and 1, with values close to 0 representing original apps and values close to 1 representing apps similar to the existing offering. Having calculated the similarity score for every description pair, each app is assigned a final score corresponding to its average similarity relative to the five (ten) most similar apps (Guzman and Li, 2023). Apps in the lowest quartile of these scores are classified as original. We then estimate a variant of Equation 1, aggregating the release of original apps at the developer–platform–year–month level and constructing an indicator for whether a developer released at least one original app in a given month. The sample is restricted to developers who launched at least one app during the focal period—defined as the 12 months before, the month of, and the 12 months after Apple or Google's royalty rate cut announcement. The corresponding AGGTEs are reported in Table A15.

As shown in Panel A, small developers are less likely to release original apps post-announcements than larger developers. In Panel B, the effects continue to be negative, although they are no longer statistically significant, suggesting that apps released on iOS during the first three months after Apple's announcement may exhibit a similar level of originality as apps released on Android during the same period. Overall, this analysis suggests that small developers did not release more original apps following Apple's and Google's royalty rate cut announcements, thus ruling out the possibility that our results are driven by small developers launching more niche, though not necessarily lower-quality, apps.

5.4 The No-passthrough Condition

As mentioned earlier, a key condition for the observed adjustments in app quality on iOS and Android platforms after the royalty rate cuts is that developers do not fully pass on their increased share of revenue to consumers through lower app prices. If perfect passthrough occurred, app prices would adjust, undoing the redistributive impact of the lower royalty rates and neutralizing the incentives for small developers to release new apps on the platforms.

In this section, we verify this condition using available price data for game apps released in the US, sourced from AppTweak. We conduct a simple cross-sectional analysis to examine whether the prices of apps released by small developers after Apple's and Google's announcements are lower than those of apps released before. Lower prices would imply that developers pass at least partially the increased portion of the revenue they can appropriate after the royalty rate cuts to consumers.

The results are reported in column 1 of Table A16, with the regression including platform-by-release-date dummies and standard errors clustered by platform. As shown, although small developers generally charge lower prices for their apps, those who released apps on a given platform after the announcements did not set lower prices than those who released apps before the announcements. In column 2 of Table A16, we perform an analysis focusing on those 447 game apps released 12 months before, the month of, and the 12 months after Apple's and Google's announcements by developers who changed the original price of their app at least once. After distinguishing between smaller and larger developers, we show that smaller developers are no more likely to lower the price of their apps released after these announcements. These results reinforce the correlations reported in column 1, suggesting that smaller developers not only refrain from setting lower initial prices after the royalty rate cuts, but also do not reduce prices once the apps are launched.[31]

5.5 The influence of Apple's and Google's royalty rate cuts on the overall platform ecosystem

The increased inflow of lower-quality apps documented so far would not pose a major concern if platform owners, investors, and consumers could easily distinguish between high- and low-quality offerings, allowing each product to be correctly valued. However, limited attention and time constraints make this differentiation more challenging. With less time to screen each new product, platform owners, investors, and consumers may become reluctant to do so, especially if they expect the market to be flooded with lower-quality options. Therefore, if the market becomes inundated with such apps, information congestion could intensify. Without ad hoc strategies from platform actors, investors may be deterred from investing, and consumers less inclined to try new apps. In this context, we empirically examine whether Apple's and Google's reforms have exacerbated information congestion on their platforms and explore the associated implications. Specifically, we investigate how one particular group of platform actors—VCs—may react, whether the influx of lower-quality apps has increased the value of experienced certifiers, and how the value of investments app developers make to enhance their apps' visibility has changed.

[31] Overall, these results align with the fact that the marginal costs of producing an app are negligible compared to the fixed costs. As a result, maximizing developer profits equates to maximizing total revenue. This implies that an increased revenue share available to small developers under the new royalty rate regimes does not lead to lower prices for consumers.

The association between an app's quality and receiving VC funds

We begin by assessing whether we observe a change in the marginal value of (observed) measures of app quality in securing venture capital funds subsequent to a reduction in royalty rates for small app developers. If the influx of lower-quality apps worsens congestion and makes it harder to distinguish between high- and low-quality offerings, startup quality would be expected to play a more prominent role in securing VC funding, as VCs may become more risk-averse and place greater emphasis on observable measures of app quality.

To evaluate this possibility, we utilize Product Hunt data and estimate a cross-sectional model examining the relationship between an app's probability of securing VC financing and observable quality metrics. We interact these metrics with a binary (0/1) indicator identifying whether an app was launched on a specific platform following Apple's or Google's announcements. The model includes platform $\times$ release date $\times$ technology keywords dummies, which absorb time-varying shocks at the platform-technology level. The rationale is to assess how the relevance of an app's quality might change following the royalty rate cut announcements, while controlling for aggregate shocks that might be correlated with the announcements.

Our analysis focuses on apps released on a given platform within 12 months before, during, or after each announcement. The results are displayed in Table 4, where we employ three distinct app quality metrics: (1) being in the upper quartile of upvotes received (column 1); (2) being in the upper quartile of user-weighted ratings (column 2); and (3) certification by external users (column 3). We cluster standard errors at the platform-launch-date level.

In the absence of royalty rate cuts, there is a positive association between each of the observed quality metrics and the likelihood of securing VC financing, though the coefficients are not statistically significant at conventional levels. Post-announcement, the relationship between our app quality metrics and the probability of receiving VC funding strengthens and becomes highly significant, all else being equal. This suggests that as more lower-quality apps were released on the platforms, the importance of startup quality in securing VC funding increased. This shift aligns with VCs moving away from a spread-and-pray strategy after the royalty rate cuts for small developers, instead focusing on ventures of higher observable quality (Amore et al., 2023).

⟨ Table 4 about here ⟩

The association between an app's ASO and its download numbers

Next, we investigate whether the relationship between the number of app downloads on iOS and Android and developers' app store optimization (ASO) activities changed following Apple's announcement of a royalty rate cut. As discussed earlier, app store optimization, or ASO, refers to an ensemble of tasks, such as optimizing an app's keywords, title, description, screenshots, and icon, allowing developers to improve their apps' visibility and increase downloads.[32] This analysis is motivated by the idea that, if the new royalty rate regimes have intensified information congestion, consumers may pay greater attention to developers' ASO efforts.

AppTweak gathers daily data on the following ASO activities on iOS: icon, long description, promotional text, screenshots, title, subtitle, promotional text, and videos. Note that while the keywords developers select for their apps are an important element in boosting an app's conversion rate on iOS, they are not observable to the public. For Android, AppTweak collects information on icon, long and short descriptions, screenshots, title, and videos. We retrieved ASO information for game apps released between January 2017 and December 2018 in China, France, Germany, the Russian Federation, the UK, and the United States. By considering apps released prior to 2019, we ensure that they are immune to developer launch strategies that the new royalty rate regime had affected. Regrouping these data, we built a longitudinal dataset at the app-month level, encompassing the 12 months before, the month of, and the 12 months after Apple's and Google's announcements of a new royalty rate regime. Descriptive statistics for the 5,302 iOS game apps and 4,198 Android game apps for which ASO data is available are reported in Table A17.[33]

To evaluate whether and how the marginal value of ASO activities changed following the announcements of the new royalty rate regimes, we estimate two separate Poisson Quasi Maximum

[32] The latter is typically measured with an app's conversion rate, which represents the percentage of users who download an app after viewing its page.

[33] In cases where an app is released in multiple countries with varying release dates (an infrequent occurrence), we retain the earliest release date.

Likelihood (PQML) count models for the cumulative number of downloads an app received on iOS and Android in a given month t. The key regressor is the interaction between the post-announcement period indicator—identifying the introduction of reduced royalty rate for small app developers on either iOS or Android —and a (0/1) dummy that equals one starting from the month in which a developer made an ASO investment. In addition to controlling for app and year-month fixed effects, each model also includes interactions between the post-regime indicator and (0/1) dummies taking on the value one from the month in which a developer made a change to an app's size and version. These latter interactions control as much as possible for app-specific trends that could be correlated with changes in ASO investments post-regime.

The results are reported in Table 5, where we cluster standard errors at the app level. In columns 1 and 2, we investigate ASO investments on iOS, while in columns 3 and 4, we investigate ASO investments on Android. As indicated in column 1, the hazard of an app receiving a new download on iOS rises by an additional 0.09 after a developer initiates their first ASO investment, following the announcement. That is, the number of monthly downloads when a developer engages in ASO increases by 10% after Apple's announcement.[34] In column 3, where we examine downloads on the Android platform, the number of monthly downloads when a developer engages in ASO increases by 17% after Google's announcement.[35]

In columns 2 and 4, we dissect ASO investments into their distinct components, revealing that the impact of ASO on downloads stems from alterations in the apps' screenshots. This result aligns with the crucial role that screenshots play in enhancing the visibility of game apps.[36] Overall, this exercise suggests that the marginal value of ASO activities, particularly modifications in screenshots, rose following the reduction in the royalty rate charged by Apple and Google to small app developers.

⟨ Table 5 about here ⟩

[34] The number of observations reported at the bottom of Table 5 reflects the fact that singletons are dropped when PQML count models are estimated in Stata.

[35] As reported in Table A18, the results do not qualitatively change when we regress the monthly number of downloads over the monthly number of ASO investments lagged by one period.

[36] Refer to: https://www.apptweak.com/en/aso-blog/what-is-app-store-optimization-and-why-is-aso-important.

The certification role of experienced hunters

We conclude the empirical analysis by examining whether the certification value of external hunters, particularly those with experience in certifying better-quality products, might have increased following the royalty rate cut. To perform this analysis, we estimate panel models at the external-hunter-platform-month level using Product Hunt data, limiting the analysis to the 12 months before, the months of, and the 12 months after Apple's and Google's announcements of royalty rate cuts. To begin, we identified all the external hunters and classified them into more- and less-experienced. The more-experienced hunters are those who certified at least one product in the 2016-2018 pre-period, in the top percentile for the number of upvotes received. Less-experienced hunters are the remainder.

Building on this classification, we assess: (i) whether experienced hunters might become less inclined to certify products on a given platform given the increased prevalence of lower-quality apps we detected so far and (ii) whether, conditional on hunting, experienced hunters become relatively more likely to certify higher-quality apps after Apple's and Google's announcements of a royalty rate cut.[37] To evaluate (i), we estimate how the probability of hunting an app for a given platform changes post-announcements for experienced relative to less-experienced hunters in a within-hunter-platform regression model with hunter-platform and time fixed effects. We report the results in Table 6, showing that after Apple and Google announced a 15% cut in the royalty rate applied to small developers, more experienced hunters became significantly less inclined to certify apps for the iOS and Android platforms.

⟨ Table 6 about here ⟩

To evaluate (ii), we estimate the probability that a hunter certifies a high-quality app in the iOS and Android platforms as a function of: 1) whether the hunter is experienced; 2) a (0/1) indicator $Post_t$ that takes the value 1 starting from December 2020 for the iOS platform and March 2021

[37]Note that showing (i) alone does not allow us to conclude that lower royalty rates have exacerbated information congestion. The increased supply of lower-quality apps should be mechanically associated with a lower propensity of experienced hunters to certify products.

for the Android platform; 3) an indicator for whether a hunter certified at least one product in month t; and 4) interactions between these variables. The indicator of interest in this model is the triple interaction between 1), 2), and 3), whose associated coefficient measures the difference in the change in the probability that a hunter certifies a high-quality app after Apple's and Google's announcements, between experienced and less-experienced hunters and conditional on hunting. This interaction provides a measure of how the certification value of experienced hunters changes: if its coefficient is positive, it suggests that experienced hunters might have become more valuable for attenuating congestion problems. By conditioning on hunting, we can at least partially account for the differential propensity of hunters to hunt after the change in the supply of apps following Apple's announcement.

The results are reported in Table 7. We control for hunter-platform and year-month fixed effects and cluster standard errors at the hunter-platform level. As displayed in column 1, post-announcements, experienced hunters become more likely to certify apps on the iOS and Android platforms falling within the top percentile of the number of upvotes relative to less-experienced hunters, conditional on hunting. The effect is strong when compared to the outcome mean and highly significant. We confirm the same pattern in columns 2 and 3, where the examined outcomes are the certification of a product that turned into a startup and the certification of a product that turned into a VC-backed startup, respectively.[38]

⟨ Table 7 about here ⟩

Taken together, these results suggest that the royalty rate cuts may have generated negative externalities by exacerbating information congestion on the iOS and Android platforms. In response, VCs might have concentrated their investments on safer bets, while both VCs and consumers could have placed greater emphasis on developers' second-best strategies to enhance app visibility, such as ASO investments and certification by experienced hunters. Consequently, the marginal value of ASO and certification from experienced hunters may have increased.

[38] The corresponding event study is reported in Figure A8. In Figure A9, we perform a placebo test where we investigate the certification of Web apps by experienced hunters. In this last case, the post-announcements coefficients are all clustered around the zero line, regardless of whether we examine Apple's or Google's announcements.

6 Conclusions

What role do royalty rates play in governing platform transactions? This paper presents evidence that there are positive costs associated with lowering royalty rates to boost innovation, as such reductions may exacerbate information congestion problems. We estimate two-way Mundlak regression models, exploiting a reform that first Apple and subsequently Google implemented, which lowered the royalty rate charged to small app developers. Consistent with the fundamental non-neutrality condition of multisided platforms, we find no evidence that small developers passed on the greater portion of the revenue they appropriated to consumers through lower app prices.

Remarkably, our analysis indicates that the reforms have resulted in an increase in lower-quality launches by small developers following the introduction of the new regimes and a consequential decrease in the average quality of apps released on the iOS and Android platforms. These patterns are consistent with the notion that the quality of apps produced by small developers post-announcement is relatively straightforward to evaluate. Consequently, a reduction in royalty rates elicits the release of apps with both lower expected and realized quality, as the increased portion of revenue developers can now appropriate makes such products financially viable.

As lower-quality apps became more prevalent, our findings indicate that app quality has become increasingly essential for reaching VC funding milestones, all else equal. We also show that the marginal value of ASO investments has risen, as developers may turn to these strategies to improve visibility. Consistent with this, we find that the certification value of more-experienced hunters has grown following the new royalty rate regimes. Overall, our results suggest that information congestion has intensified with mobile platforms becoming flooded with (lower-quality) apps after Apple's and Google's royalty rate reductions. Given that consumers and VCs now likely face greater challenges in distinguishing between high- and low-quality offerings due to constraints on attention and time, VCs may have adjusted their investment strategies, while both consumers and VCs may increasingly rely on developers' ASO investments and the certification role of experienced hunters to guide their decisions.

Our paper has implications for platform owners, users, and policymakers. First, it informs the design of incentives to encourage developers to offer high-quality products on platforms. While prior studies have shown that lowering royalty rates can encourage innovators' efforts and better align their goals with those of their principals (Jensen and Thursby, 2001), our analysis within mobile platforms shows that platform owners incur costs from being "fair" and allowing developers to claim a larger share of their revenues. Although lower royalty rates may encourage greater effort from developers, especially those of higher quality, the risk is an Atari-like effect (Boudreau and Hagiu, 2009; Hagiu, 2006a), whereby platforms are saturated with lower-quality apps. This influx might escalate platform owners', investors', and consumers' inattention problems and time constraints, producing negative externalities for the whole platform. To incentivize developer effort while mitigating negative externalities, platform owners could consider implementing a combination of positive fixed fees for launching products on a platform and reduced royalty rates, akin to a two-part tariff pricing scheme (Png and Wang, 2010). While the former would deter the influx of lemons, the latter would offer suitable incentives to enhance the efforts of platform participants. Although the Apple App Store currently charges $99 per year per developer and the Google Play Store a one-time registration fee of $25 per developer, these fees might not be enough to discourage the release of lower-quality apps.

By examining a key instrument that platform owners use to regulate platform transactions —royalties—and demonstrating how lowering royalty rates exacerbates information congestion problems in mobile platforms, our study extends Ershov (2024)'s work. That study shows that heightened congestion leads to a decline in app demand and reduced developer participation. Our findings complement Ershov (2024), highlighting that one potential consequence of increased congestion is a greater marginal value for ad hoc instruments, such as ASO investments and experienced certifiers, to mitigate information problems.

By shedding light on the "costs of fairness" within platform markets, our findings further contribute implications to the literature advocating differential rates for smaller and larger developers (Bhargava et al., 2022). Although this strategy could improve platform competition and foster network effects, the risk is that platforms are inundated with low-quality products. These products may not effectively compete with existing offerings, but instead exacerbate congestion problems.

Additionally, our paper holds implications for platform users, that is, app developers, consumers, and investors. Developers of higher-quality apps should consider expanding their networks of potential certifiers, as this could help them stand out, especially when the prevalence of lower-quality apps escalates. In line with this, we observe a growing number of blogs and websites informing product developers about the more experienced certifiers who could add the most value to the launch of their new products.[39] Concurrently, developers should strategically invest in activities that enhance the visibility of their offerings to distinguish them from lower-quality products. Similarly, investors and consumers could rely on the judgment of experienced evaluators as a complement or in substitution for other strategies, including scouting for possible signals that high-quality developers may send to reveal their type (Conti et al., 2013a,b).

Finally, our paper has relevant policy implications. Regulators have voiced concerns that the high *ad valorem* fees major tech corporations levy on platform developers might deter the latter's innovative efforts. Yet, our findings indicate that increasing royalty rates might have beneficial effects. The higher average app quality and the reduced negative externalities observed when royalty rates are not lowered underscore the necessity for policymakers to carefully balance the potential adverse effects of elevated royalty rates on innovation.

Taken together, our results offer the fundamental insight that there are costs to lowering royalty rates, manifested in the increased congestion across the platform ecosystem. This insight raises a number of additional questions and opens avenues for future research. For example, as we briefly discussed above, it would be crucial to assess how platform owners could optimally combine fixed fees and royalty rates to enhance product innovation and platform revenue. Relatedly, while we have shown that reducing royalty rates led to a rise in the proportion of (lower-quality) apps raised by small developers, it would be intriguing to examine the alternative options these developers might have forgone. Additionally, it would be interesting to explore whether the dynamics uncovered in this study could be amplified by recent advances in generative artificial intelligence,

[39] See, for example, `https://www.getdefault.in/post/product-hunt-hunters` or `https://www.tealhq.com/certifications/mobile-developer`, last accessed in June 2025.

which may have diminished the marginal value of developer effort in producing quality innovations while elevating the importance of intrinsic idea quality. Finally, in a similar vein as Ershov (2024), it would be important to further explore the effects of reduced royalty rates on consumer demand. While we might expect consumers to gravitate toward apps of higher observable quality, much like VCs have paid increased attention to these apps, examining the broader impact of the new royalty rate regimes on total consumer demand presents a promising direction for future research. A deeper understanding of these dynamics would better equip platform owners to design effective incentives that attract top-tier developers and support their efforts.

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Figures

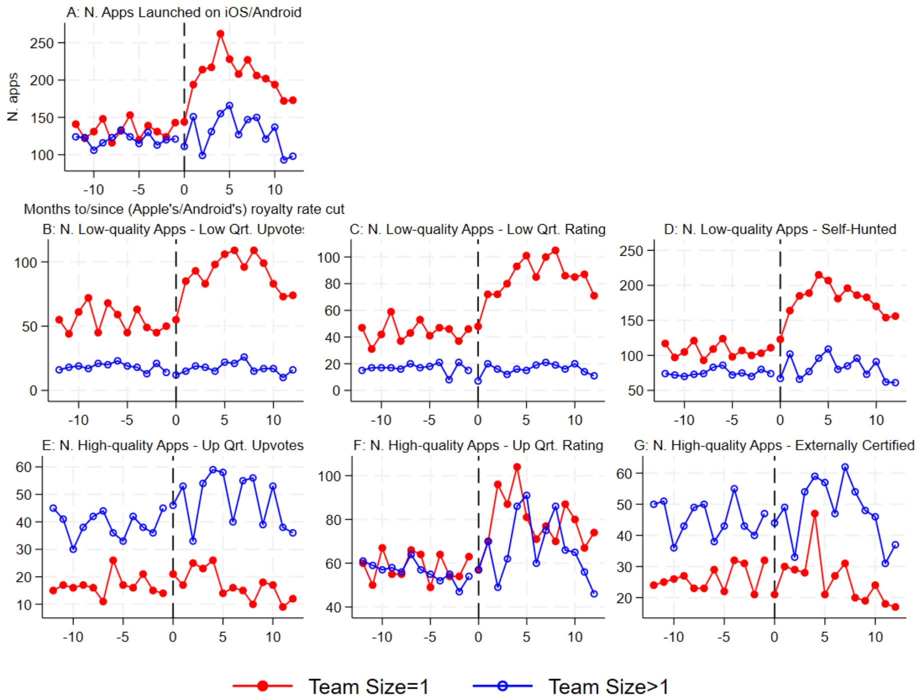

Figure 1: Number of app launches on iOS/Android over time

Panel A shows the monthly number of apps released on iOS or Android before and after Apple's and Google's announcements of royalty cuts for small developers. Panel B shows the monthly number of apps in the lower quartile for upvotes received by the Product Hunt community, while Panel C shows the monthly number of apps in the lower quartile for ratings. Panel D displays the monthly number of self-hunted apps. Panel E presents the monthly number of apps in the upper quartile for upvotes received, and Panel F shows the monthly number of apps in the upper quartile for ratings. Panel G shows the monthly number of externally certified apps. The data source is *Product Hunt*. Blue represents *developer teams with more than one member*, while red represents *solo developers*. The vertical dashed line indicates the month of Apple's or Google's announcements.

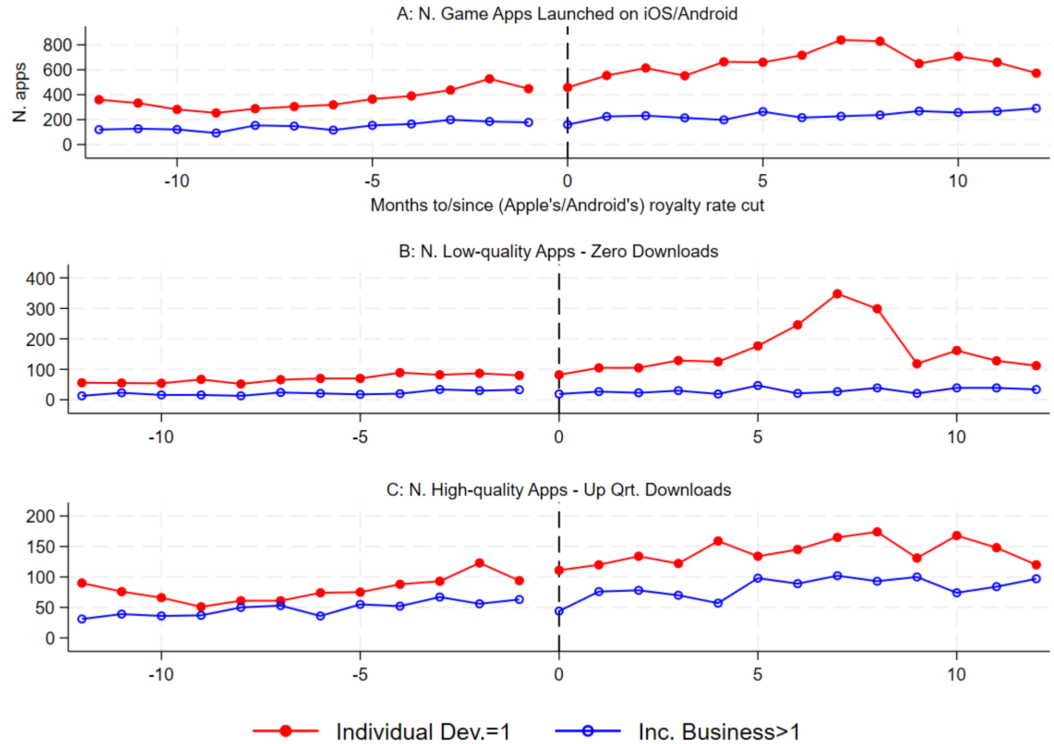

Figure 2: Number of *game* app launches on iOS/Android over time

Panel A shows the monthly number of *game* apps released on iOS or Android before and after Apple's and Google's announcements of royalty cuts for small developers. Panel B shows the monthly number of lower-quality apps, while Panel C shows the monthly number of higher-quality apps. We employ download information from *AppTweak* to distinguish between high- and lower-quality product launches. A lower-quality app is an app that has not received any downloads in the first four months after launch. Given the specific features of the data, we define *small developers* as *individual developers* (red line), distinguishing them from *incorporated businesses* (blue line). The vertical dashed line indicates the month of Apple's or Google's announcements.

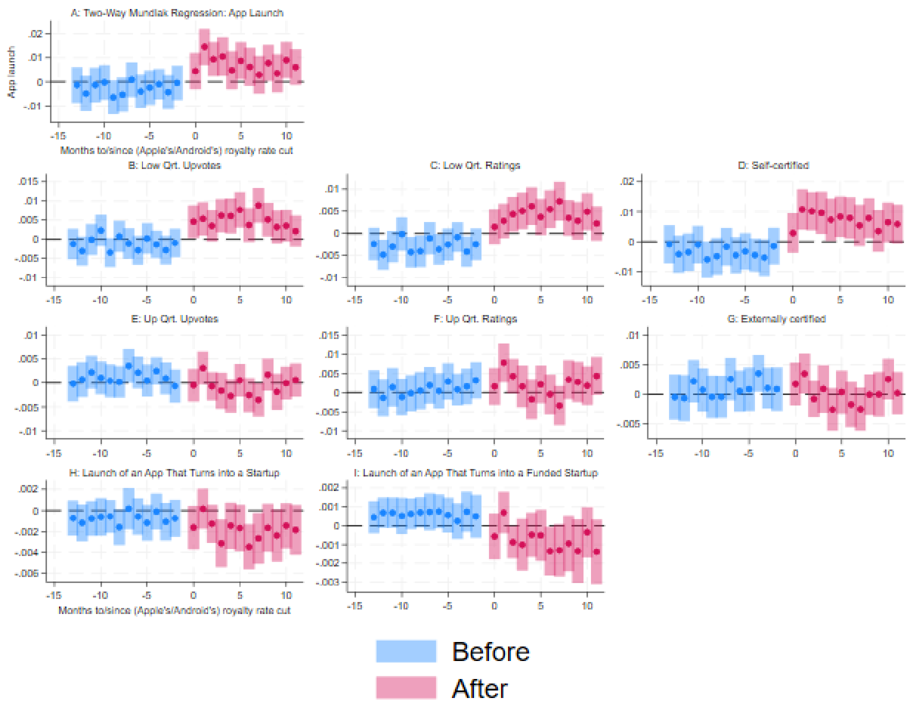

Figure 3: App launches: Event studies

We report event studies of the effects of Apple's and Google's royalty rate cuts on the launch of: an app on iOS and Android (Panel A), an app in the lowest quartile of upvotes (Panel B), an app in the lowest quartile of ratings (Panel C), a self-hunted app (Panel D), an app in the upper quartile of upvotes (Panel E), an app in the upper quartile of ratings (Panel F), an externally certified app (Panel G), app that becomes a startup (Panel H) and a VC-backed startup (Panel I). We display the dynamic treatment effects for each of the 12 months preceding and following Apple's and Google's announcements. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the developer-platform level.

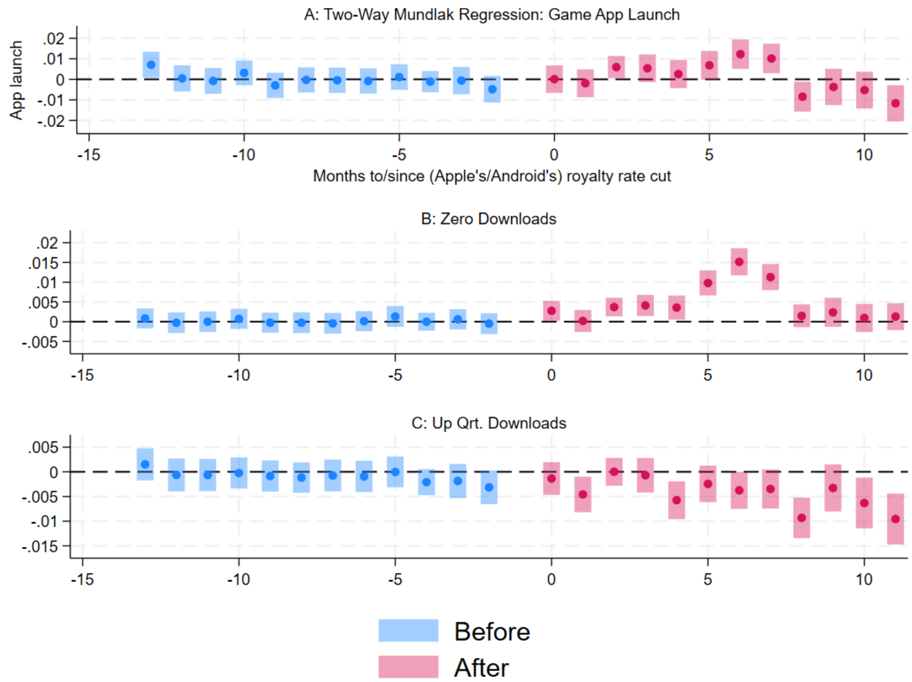

Figure 4: Launches of game apps: Event studies - Distinguishing by downloads and between individual developers and incorporated businesses

We report event studies of the effects of Apple's and Google's royalty rate cuts on the launch of: a game app on iOS and Android (Panel A), a game app that did not receive any downloads in the first four months after launch (Panel B), a game app in the upper quartile of downloads (Panel C). We employ download information from AppTweak. Given the specific features of the data, we define *small developers* as *individual developers*, distinguishing them from *incorporated businesses*. We display the dynamic treatment effects for each of the 12 months preceding and following Apple's and Google's announcements. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the developer-platform level.

Tables

Table 1: Summary statistics (At the developer level)

Variable	Mean	Std. Dev.	Min.	Max.	N
		Panel A: Product Hunt			
Team size	2.286	2.797	1	57	7331
N. apps released on iOS	0.619	0.719	0	13	7331
N. first-version apps released on iOS	0.41	0.625	0	12	7331
N. follow-on apps released on iOS	0.209	0.485	0	13	7331
N. apps released on Android	0.387	0.573	0	12	7331
N. first-version apps released on Android	0.234	0.448	0	5	7331
N. follow-on apps released on Android	0.153	0.424	0	12	7331
		Panel B: AppTweak			
Individual developer	0.802	0.399	0	1	18061
N. apps released on iOS	0.433	2.087	0	142	18061
N. apps released on Android	0.542	2.038	0	105	18061

Table 2: App Launches

	App Launch on iOS/Android	Lower-Quality Launch			Higher-Quality Launch				
		Low Qrt. Upvotes	Low Qrt. Rating	Self-Hunted	High Qrt. Upvotes	High Qrt. Rating	Externally Certified	App Turns into Venture	App Turns into Funded Venture
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PANEL A: Control group: Never treated									
AGGTE	0.00731***	0.00502***	0.00417***	0.00717***	-0.000633	0.00198	0.000126	-0.00187**	-0.000787*
	(0.00271)	(0.00146)	(0.00135)	(0.00238)	(0.00132)	(0.00179)	(0.00131)	(0.000745)	(0.000440)
PANEL B: Control group: Not-yet treated									
AGGTE	0.00909***	0.00593***	0.00648***	0.00988***	-0.00166***	0.000944	-0.000765	-0.00120***	-0.00130***
	(0.00125)	(0.000688)	(0.000653)	(0.00108)	(0.000567)	(0.000830)	(0.000627)	(0.000344)	(0.000209)
Developer-platform FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean D.V.	0.027	0.008	0.007	0.02	0.006	0.012	0.007	0.002	0.0007
Observations	267075	267075	267075	267075	267075	267075	267075	267075	267075

Notes: We estimate variants of Eq. (1) and report the AGGTEs. In column 1, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app on a given platform; in column 2, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the lowest quartile of the number of upvotes; in column 3, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the lowest quartile of ratings received; in column 4, the outcome is a (0/1) indicator that takes the value one in the month a developer launches a self-hunted app; in column 5, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the upper quartile of the number of upvotes; in column 6, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the upper quartile of ratings received; in column 7, the outcome is a (0/1) indicator that takes the value one in the month a developer launches an externally certified app. In column 8, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app on a given platform that later becomes a startup. In column 9, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app on a given platform that later becomes a VC-backed startup. The AGGTEs are obtained by aggregating the estimated ATEs for each cohort g of small developers and post-announcement year-month t. *Small developers* are measured as *solo developers*. We observe each developer-platform combination (N=10,683) over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after. In Panel A, the control group is represented by the never treated, namely, the larger developers. In Panel B, the control group is represented by the not-yet treated. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table 3: Game Apps

	Game Apps Launched on iOS/Android	Lower-Quality Apps: Zero Downloads	Higher-Quality Apps: High Qrt. Downloads
	(1)	(2)	(3)
PANEL A: Control group: Never treated			
AGGTE	0.00102	0.00472***	-0.00421***
	(0.00251)	(0.00100)	(0.00134)
PANEL B: Control group: Not-yet treated			
AGGTE	0.00126	0.00453***	-0.00317***
	(0.00141)	(0.000544)	(0.000811)
Developer-platform FEs	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes
Mean D.V.	0.0313	0.0069	0.0076
Observations	496400	496400	496400

Notes: We estimate variants of Eq. (1) and report the AGGTEs. In column 1, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches a game app on a given platform; in column 2, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that has not received any downloads in the first four months after launch; in column 3, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that is in the top quartile of downloads. We observe each developer-platform combination (N=19,856) over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after. *Small developers* are measured as *individual developers* as opposed to *incorporated businesses*. In Panel A, the control group is represented by the never treated, namely, the larger developers. In Panel B, the control group is represented by the not-yet treated. The AGGTEs are obtained by aggregating the estimated ATEs for each cohort g of small developers and post-announcement year-month t. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table 4: The association between upvotes, ratings, and being externally hunted with receiving VC funds post-announcements

	Launch of an app in iOS/Android turning a VC-funded startup:		
	Upvotes	Ratings	Certified
	(1)	(2)	(3)
App is in Upper Qrt. Upvotes	0.00482		
	(0.00488)		
App is in Upper Qrt. Ratings		0.00263	
		(0.00512)	
App is Externally Certified			0.00756*
			(0.00417)
Post $\times$ Upper Qrt. Upvotes	0.0486***		
	(0.0129)		
Post $\times$ Upper Qrt. Ratings		0.0437***	
		(0.0124)	
Post $\times$ Externally Certified			0.0515***
			(0.0164)
Release Year-month x Platform x Tech dummies	Yes	Yes	Yes
Mean D.V.	0.0254	0.0254	0.0254
Observations	7,375	7,375	7,375
R2	0.184	0.182	0.187

Notes: We utilize Product Hunt data and estimate a cross-sectional model examining the relationship between an app's probability of securing VC financing and observable quality metrics. These metrics are: (1) being in the upper quartile of upvotes received (column 1); (2) being in the upper quartile of user-weighted ratings (column 2); and (3) certification by external users (column 3). We interact these metrics with a binary (0/1) indicator identifying whether an app was launched on a specific platform following Apple's or Google's announcements. The model includes platform $\times$ release date $\times$ technology keywords dummies. The analysis encompasses apps released on a given platform 12 months before, the month of, and 12 months after either announcement. Standard errors are clustered at the platform-launch-date level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table 5: App Store Optimization (ASO): iOS & Android

	(1)	(2)	(3)	(4)
	Cum. Downloads: iOS		Cum. Downloads: Android	
Cum. ASO (0/1)	0.146		0.0123	
	(0.152)		(0.0326)	
Post × Cum. ASO (0/1)	0.0909**		0.156***	
	(0.0461)		(0.0426)	
Cum. Title Change (0/1)		0.0203		0.106**
		(0.0320)		(0.0453)
Post × Cum. Title Change (0/1)		-0.00486		-0.0349
		(0.0259)		(0.0412)
Cum. Description Change (0/1)		0.0549		-0.0407
		(0.0539)		(0.0296)
Post × Cum. Description Change (0/1)		0.0205		-0.00564
		(0.0235)		(0.0292)
Cum. Screenshot Change (0/1)		0.0893		0.0247
		(0.0751)		(0.0301)
Post × Cum. Screenshot Change (0/1)		0.0674**		0.0967**
		(0.0312)		(0.0399)
Cum. Icon Change (0/1)		-0.00713		-0.0162
		(0.0269)		(0.0240)
Post × Cum. Icon Change (0/1)		-0.0551		0.0211
		(0.0482)		(0.0275)
Cum. Video Change (0/1)		-0.00000578		-0.00599
		(0.0371)		(0.0289)
Post × Cum. Video Change (0/1)		0.0118		0.000769
		(0.0305)		(0.0285)
Cum. Size Change (0/1)	-0.0379	-0.0314	0.0569**	0.0591**
	(0.0452)	(0.0398)	(0.0290)	(0.0274)
Post × Cum. Size Change (0/1)	0.0825**	0.0837**	0.0444	0.0487
	(0.0367)	(0.0397)	(0.0430)	(0.0414)
Cum. Version Change (0/1)	0.00563	0.0404	-0.0551	-0.0442
	(0.0956)	(0.0659)	(0.0479)	(0.0441)
Post × Cum. Version Change (0/1)	-0.152***	-0.121***	-0.0996*	-0.116**
	(0.0454)	(0.0415)	(0.0522)	(0.0519)
App FE	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes
Observations	103975	103975	68750	68750

Notes: We report the results of PQML count models for the cumulative number of downloads an app received on iOS (columns 1 and 2) and Android (columns 3 and 4) in month t. In columns 1 and 2, *Post* is an indicator that takes the value one after November 2020, when Apple announced the new royalty rate regime. In columns 3 and 4, *Post* is an indicator that takes the value one after February 2021, when Google started announcing its new royalty rate regime. *Cum. ASO* $(0/1)$ is an indicator that takes on the value 1 from the month in which a developer has made an ASO investment. *Cum. Title Change* $(0/1)$ is an indicator that takes on the value 1 from the moment a developer has modified an app's title. For iOS apps, we have regrouped the title and the subtitle. *Cum. Description Change* $(0/1)$ is an indicator that takes on the value 1 from the moment a developer has modified an app's description. For iOS apps, we have regrouped the promotional text and the long description. For Android apps, we have regrouped the short and long descriptions. *Cum. Screenshot Change* $(0/1)$ is an indicator that takes on the value 1 from the moment a developer has modified an app's screenshot. *Cum. Icon Change* $(0/1)$ is an indicator that takes on the value 1 from the moment a developer has changed an app's icon. *Cum. Video Change* $(0/1)$ is an indicator that takes on the value 1 from the moment a developer has modified an app's video. *Cum. Size Change* $(0/1)$ is an indicator that takes on the value 1 from the moment a developer has changed the size of an app. *Cum. Version Change* $(0/1)$ is an indicator that takes on the value 1 from the moment a developer has changed an app's version. The number of observations reported reflects the fact that singletons are dropped when PQML models are estimated in Stata. Standard errors are clustered at the app level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table 6: Likelihood of hunting an app - By hunter experience

	Likelihood of hunting an iOS/Android app:
	(1)
Exp. Hunter × Post	-0.0710***
	(0.0159)
Hunter-platform FE	Yes
Year-month FE	Yes
Mean D.V.	0.0539
Observations	30675
R2	0.141

Notes: We estimate a panel model at the external-hunter-platform level for the likelihood of a hunter hunting an app on iOS or Android. We distinguish hunters by their experience. Experienced hunters are those who, in the pre-period 2016-2018, hunted at least one product in the top percentile of the number of upvotes received. Less-experienced hunters are the remainder. We observe 1,227 hunter-platforms over 25 months: the twelve months before, the month of, and the twelve months after Apple's and Google's announcements. Standard errors are clustered at the hunter-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table 7: Likelihood of hunting a higher-quality iOS/Android App - By hunter experience

	Likelihood of certifying a product:		
	Top pct. upvotes	Turned into startup	Turned into funded startup
	(1)	(2)	(3)
Exp. Hunter × Post	0.00126	-0.000116	-0.00146
	(0.00141)	(0.000682)	(0.00117)
Product is Hunted	0.123***	0.0645***	0.176***
	(0.0138)	(0.00955)	(0.0157)
Exp. Hunter × Product is Hunted	0.141***	0.00750	0.0505
	(0.0415)	(0.0190)	(0.0339)
Post × Product is Hunted	0.00842	0.0371**	0.0189
	(0.0206)	(0.0151)	(0.0229)
Exp. Hunter × Post ×Product is Hunted	0.171***	0.123***	0.109**
	(0.0505)	(0.0474)	(0.0515)
Hunter FE	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes
Mean D.V.	0.0111	0.00649	0.0128
Observations	30675	30675	30675
R2	0.375	0.256	0.341

Notes: We estimate a panel model at the external-hunter-platform level for the likelihood of certifying a higher-quality iOS/Android app. The outcomes are: the launch of an iOS/Android app in the top percentile of the number of upvotes received (column 1); the launch of an iOS/Android app that turned into a startup (column 2); the launch of an iOS/Android app that turned into a VC-backed startup (column 3). We distinguish hunters by their experience. Experienced hunters are those who, in the pre-period 2016-2018, hunted at least one product in the top percentile of the number of upvotes received. Building on this classification, we assess the probability that a hunter certifies a high-quality iOS/Android app as a function of: (1) whether a hunter is experienced (*Exp. Hunter*); (2) the indicator *Post*; (3) an indicator for whether a hunter certified at least one product in a given month t (*Product is Hunted*); and (4) interactions between these variables. Standard errors are clustered at the hunter-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Appendix Figures & Tables
The Hidden Costs of Fairness in Platform Markets: The Dynamics of Lowering Developer Royalty Rates

Annamaria Conti[1] and Juan Santalo[1]

[1]IE University

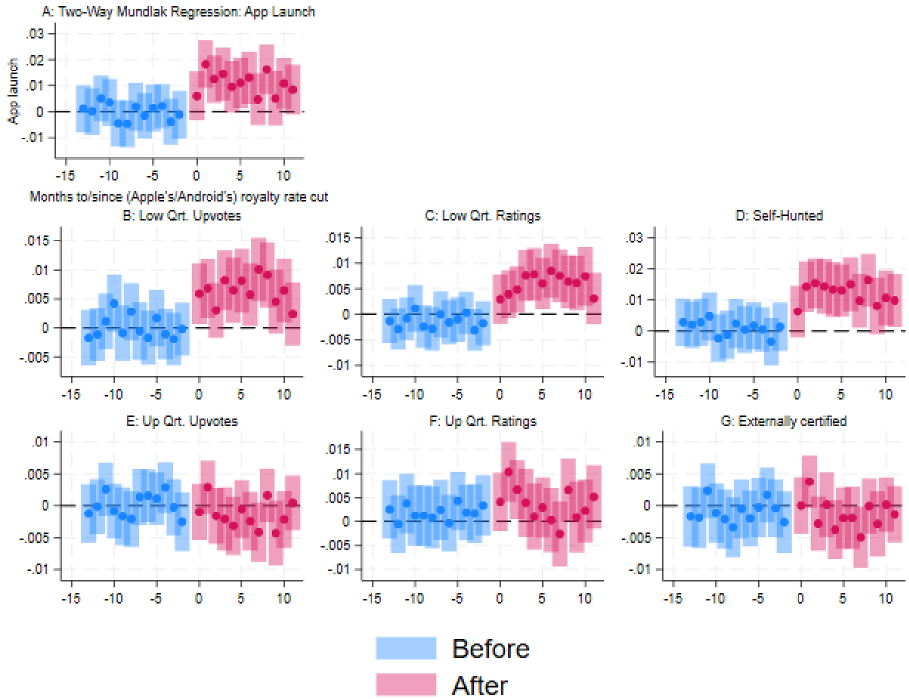

Figure A1: App launches: Event studies - Developer-platform Panel with iOS, Android, iOS&Android as Platforms

We report event studies of the effects of Apple's and Google's royalty rate cuts on the launch of: an app on iOS, Android, iOS&Android (Panel A), an app in the lowest quartile of upvotes (Panel B), an app in the lowest quartile of ratings (Panel C), a self-hunted app (Panel D), an app in the upper quartile of upvotes (Panel E), an app in the upper quartile of ratings (Panel F), an externally certified app (Panel G). We display the dynamic treatment effects for each of the 12 months preceding and following Apple's and Google's announcements. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the developer-platform level.

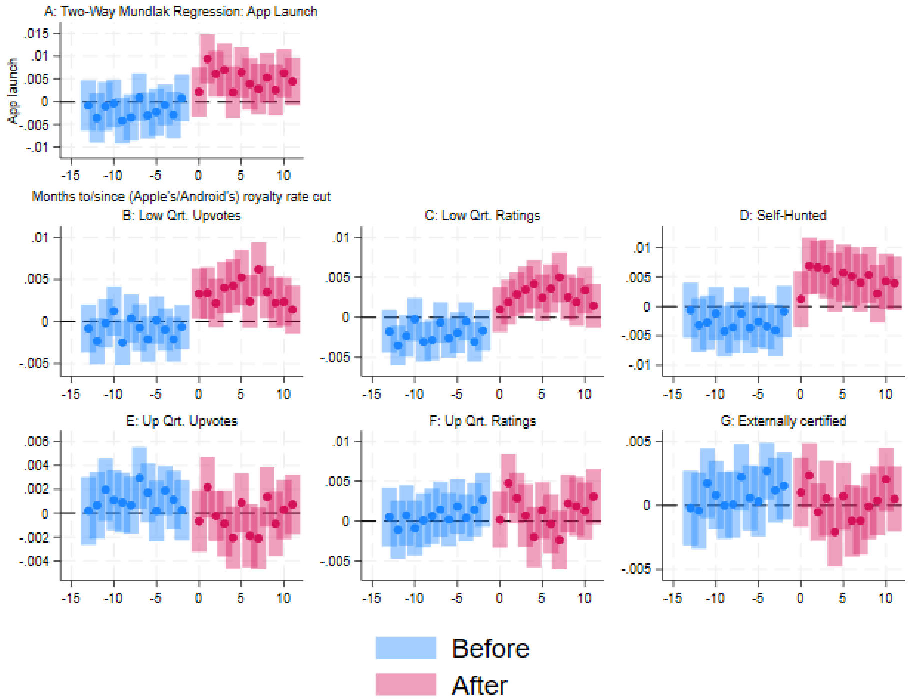

Figure A2: App launches: Event studies - Assuming that all developers are potential candidates for launching an app on either the iOS or Android platforms

We report event studies of the effects of Apple's and Google's royalty rate cuts on the launch of: an app on iOS and Android (Panel A), an app in the lowest quartile of upvotes (Panel B), an app in the lowest quartile of ratings (Panel C), a self-hunted app (Panel D), an app in the upper quartile of upvotes (Panel E), an app in the upper quartile of ratings (Panel F), an externally certified app (Panel G). We display the dynamic treatment effects for each of the 12 months preceding and following Apple's and Google's announcements. **We assume that all 7,331 developers are potential candidates for launching an app on either the iOS or Android platforms. We observe each developer-platform combination (N=14,662) over a period of 25 months: 12 months before either Apple's or Google's announcement, the month of the announcement, and 12 months after**. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the developer-platform level.

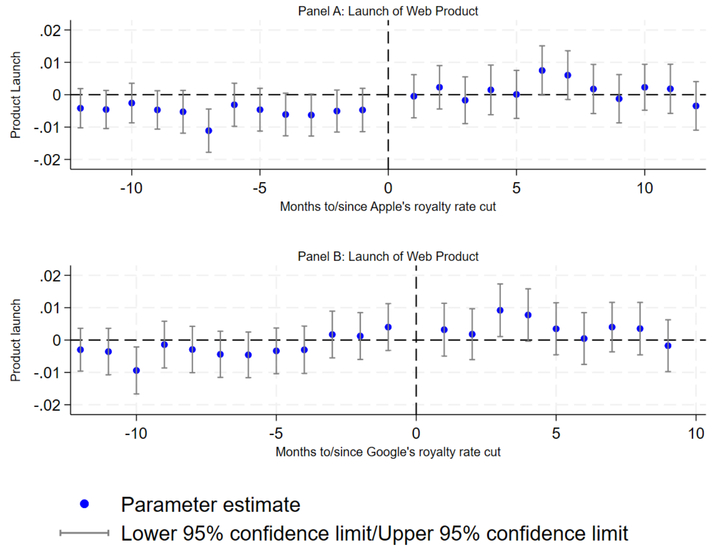

Figure A3: Launches of Web products: Event studies

We report event studies of the effects of Apple's (Panel A) and Google's (Panel B) royalty rate cuts on the launch of a Web product. We display the coefficients for each of the 12 months preceding and following Apple's (Panel A) and Google's announcements (Panel B). The vertical bars represent 95% confidence intervals. Standard errors are at the developer level.

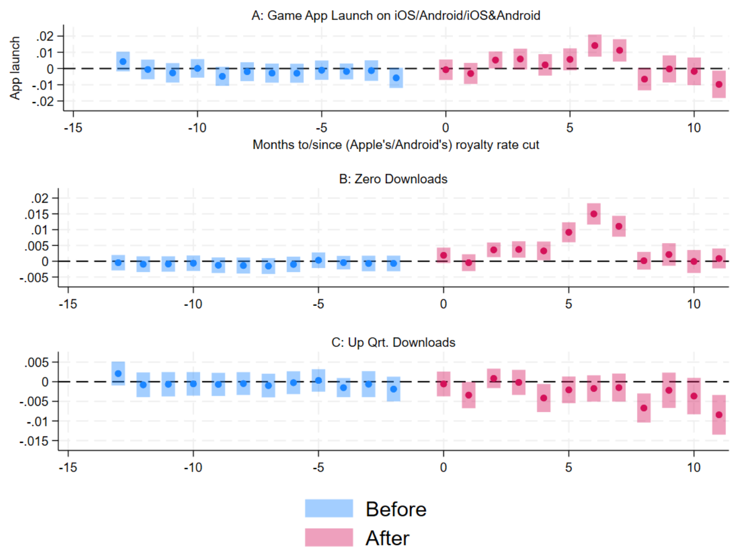

Figure A4: Launches of game apps - Event studies - Developer-platform Panel with iOS, Android, iOS&Android as Platforms

We report event studies of the effects of Apple's and Google's royalty rate cuts on the launch of: a game app on iOS, Android, iOS&Android (Panel A), a game app that received zero downloads (Panel B), and a game app in the upper quartile of downloads (Panel C). We display the dynamic treatment effects for each of the 12 months preceding and following Apple's and Google's announcements. We employ downloads information from AppTweak. Given the specific features of the data, we define *small developers* as *individual developers*, distinguishing them from *incorporated businesses*. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the developer-platform level.

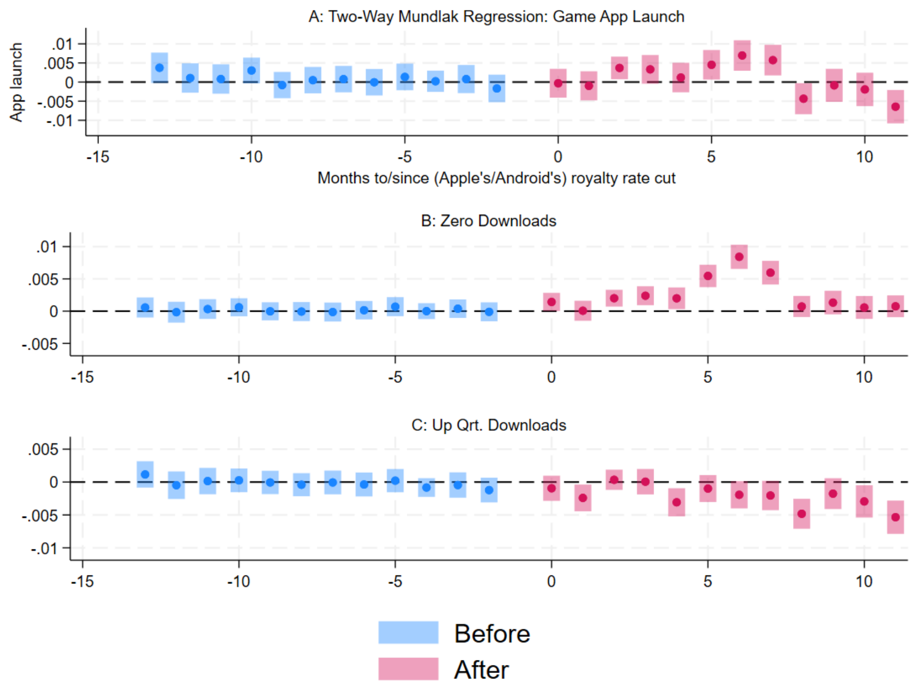

Figure A5: App launches: Event studies - Assuming that all developers are potential candidates for launching an app on either the iOS or Android platform

We report event studies of the effects of Apple's and Google's royalty rate cuts on the launch of: a game app on iOS and Android (Panel A), a game app that did not receive any downloads in the first four months after launch (Panel B), a game app in the upper quartile of downloads (Panel C). We employ download information from AppTweak. Given the specific features of the data, we define *small developers* as *individual developers*, distinguishing them from *incorporated businesses*. We display the dynamic treatment effects for each of the 12 months preceding and following Apple's and Google's announcements. **We assume that all 18,061 developers are potential candidates for launching an app on either the iOS or Android platforms. We observe each developer-platform combination (N=36,122) over a period of 25 months: 12 months before either Apple's or Google's announcement, the month of the announcement, and 12 months after**. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the developer-platform level.

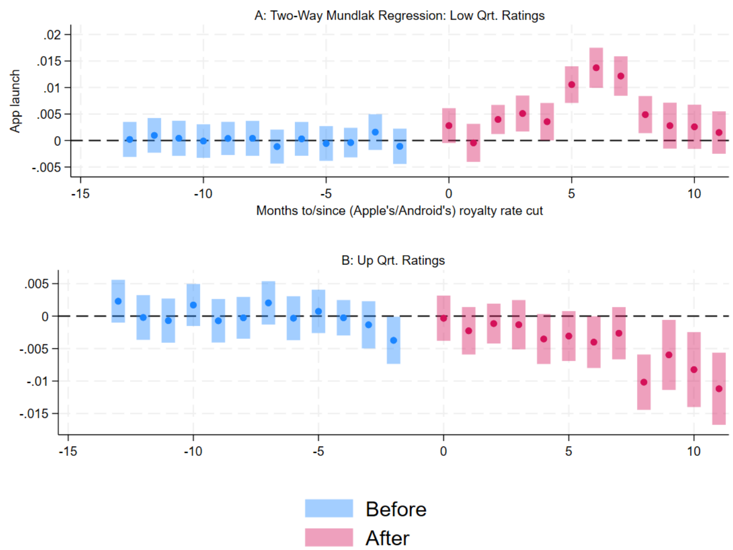

Figure A6: Launches of game apps: Event studies - Quality assessed using app ratings

We report event studies of the effects of Apple's and Google's royalty rate cuts on the launch of: a game app in the lowest quartile of ratings (Panel A) and a game app in the upper quartile of ratings (Panel B). We display the dynamic treatment effects for each of the 12 months preceding and following Apple's and Google's announcements. We employ ratings information from AppTweak. Given the specific features of the data, we define *small developers* as *individual developers*, distinguishing them from *incorporated businesses*. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the developer-platform level.

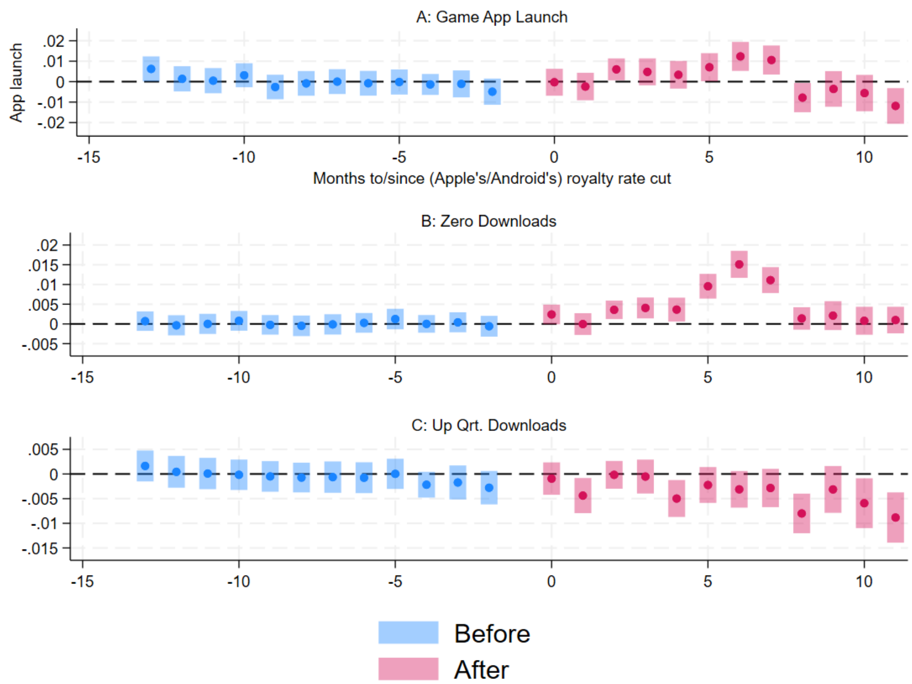

Figure A7: Launches of game apps: Event studies - Considering only launches of apps that do not offer subscriptions

We report event studies of the effects of Apple's and Google's royalty rate cuts on the launch of: a game app on iOS and Android (Panel A), a game app that did not receive any downloads in the first four months after launch (Panel B), a game app in the upper quartile of downloads (Panel C). We employ download information from AppTweak. Moreover, given the specific features of the data, we define *small developers* as *individual developers*, distinguishing them from *incorporated businesses*. We display the dynamic treatment effects for each of the 12 months preceding and following Apple's and Google's announcements. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the developer-platform level.

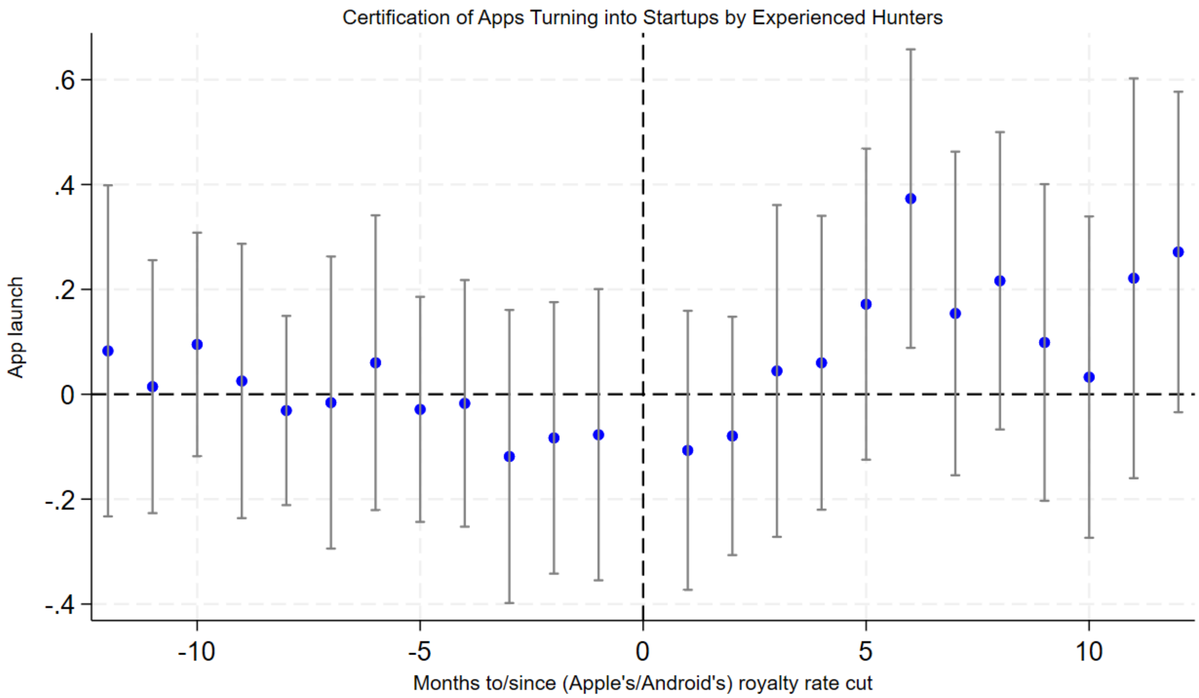

Figure A8: The certification of experienced hunters

We estimate a dynamic version of the equation estimated in column 2 of Table 7 for the likelihood that a hunter certifies an app that turns into a startup. We report the coefficients associated with the triple interaction between (1) whether a hunter is experienced, (2) whether the hunter hunts an app in a given month, and (3) indicators for each of the months preceding and following Apple's and Google's announcements. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the hunter-platform level.

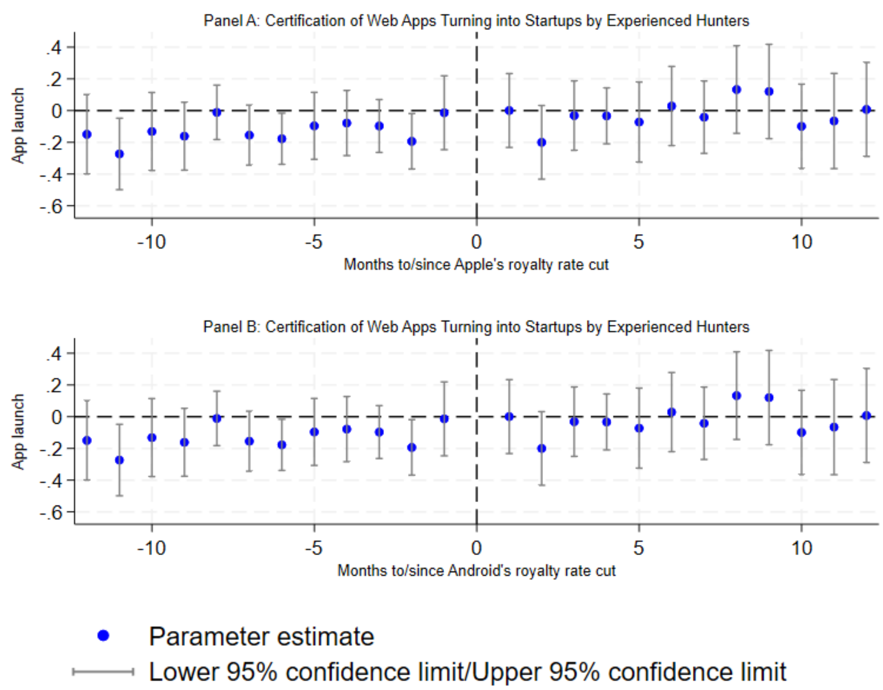

Figure A9: Placebo test: The certification of Web apps by experienced hunters

We reproduce similar event studies to the one displayed in Figure A8, this time examining the certification of Web apps by experienced hunters. In Panel A, the shock is represented by Apple's announcement of a royalty rate cut for small developers, while in Panel B, the shock corresponds to Google's announcement of the same. The vertical bars represent 95% confidence intervals, and standard errors are clustered at the hunter level.

Table A1: Monthly Number of App Launches

	N. Launches iOS/Android	N. Lower-Quality Launches			N. Higher-Quality Launches		
PANEL A: Product Hunt Developer-type-platform		Low Qrt. Upvotes	Low Qrt. Rating	Self-Hunted	High Qrt. Upvotes	High Qrt. Rating	Externally Certified
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post × Small Developer	0.351***	0.639***	0.534***	0.413***	0.144***	-0.201**	-0.0540
	(0.0430)	(0.0824)	(0.0832)	(0.0441)	(0.0523)	(0.100)	(0.0846)
Small Dev. x Platform FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Platform x Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	100	100	100	100	100	100	100

	N. Launches iOS/Android	N. Lower-Quality Launches			N. Higher-Quality Launches		
PANEL B: Product Hunt Developer-type-app-category-platform		Low Qrt. Upvotes	Low Qrt. Rating	Self-Hunted	High Qrt. Upvotes	High Qrt. Rating	Externally Certified
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post × Small Developer	0.363***	0.535***	0.620***	0.420***	-0.169***	0.174***	-0.0254
	(0.0395)	(0.0959)	(0.113)	(0.0479)	(0.0637)	(0.0465)	(0.0623)
Small Dev. x Platform x Category FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Platform x Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Category x Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	926	922	831	824	758	710	868

PANEL C: AppTweak Developer-type-platform	N. Launches iOS/Android	Zero Downloads	High Qrt. Downloads
	(1)	(2)	(3)
Post × Small Developer	0.0695*	0.314***	-0.0367
	(0.0392)	(0.108)	(0.0637)
Small Dev. x Platform FEs	Yes	Yes	Yes
Platform x Year-month FEs	Yes	Yes	Yes
Observations	100	100	100

PANEL D: AppTweak Developer-type-app-category-platform	N. Launches iOS/Android	Zero Downloads	High Qrt. Downloads
	(1)	(2)	(3)
Post × Small Developer	0.103**	0.416***	0.0196
	(0.0427)	(0.101)	(0.0637)
Small Dev. x Platform x Category FEs	Yes	Yes	Yes
Platform x Year-month FEs	Yes	Yes	Yes
Category x Year-month FEs	Yes	Yes	Yes
Observations	1503	1354	1455

Notes: In Panels A and C, we estimate Poisson quasi-maximum likelihood models for the monthly number of app launches (and distinguishing by app quality) on iOS and Android in a developer-type-platform panel. Developers can be of two types: small and larger. The platforms are iOS and Android. Each developer-type-platform is observed for the 12 months preceding the announcement of the royalty rate cut, the month of the announcement itself, and the 12 months following the announcement (N=2x2x25). In Panel A, we employ Product Hunt data and define *small developers* as *solo makers*, while in Panel C, we employ AppTweak data and identify *small developers* as *individual makers*. In Panels B and D, we estimate Poisson Quasi-Maximum Likelihood models for the monthly number of app launches (and distinguishing by app quality) in a given app-category-platform, again comparing small developers to larger developers. These panels are organized by developer type, app category, and platform, also covering 25 months. In Panel B, we use data from Product Hunt and consider 10 app categories (games & education, health and lifestyle, fintech, productivity, social network, transportation & maps, sales & e-commerce, artificial intelligence & virtual reality, developer tools, and the remainder), leading to a total of 1,000 observations. In Panel B, we use data from AppTweak and consider 16 game app categories (game_action/game_arcade, game_adventure, game_board, game_card, game_casino, game_casual, game_educational, game_music, game_puzzle, game_racing, game_role_playing, game_simulation, game_sports, game_strategy, game_trivia, and game_word), leading to a total of 1,600 observations. The number of observations listed at the bottom of Panels B and D is less than 1,000 and 1,600, respectively, because the Stata command *ppmlhdfe* excludes singleton observations. Robust standard errors in Panels A and C, and clustered by developer-type-app-category-platform in Panels B and D. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A2: App Launches: Distinguishing First from Follow-on Launches

	First Launch		Follow-on Launch	
	(1)	(2)	(3)	(4)
AGGTE	0.00420*	0.00781***	0.00318*	0.00135*
	(0.00215)	(0.00101)	(0.00167)	(0.000741)
Developer-platform FEs	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes
Mean D.V.	0.0177	0.0177	0.009	0.009
Observations	267075	267075	267075	267075

Notes: We estimate variants of Eq. (1) and report the AGGTEs. In columns 1 and 2, the outcome is a (0/1) indicator that takes the value one the month a developer launches a first app in a given platform and zero otherwise; in columns 3 and 4, the outcome is a (0/1) indicator that takes the value one the month a developer launches a follow-on version of an existing app in a given platform and zero otherwise; We observe each developer-platform combination (N=10,683) over a period of 25 months: 12 months before either Apple's or Google's announcement, the month of the announcement, and 12 months after. In columns 1 and 3, the comparison group is represented by the never treated units (larger developers), while in columns 2 and 4, the control group is represented by the not-yet-treated. The AGGTEs are obtained by aggregating the estimated ATEs for each cohort g of small developers in post-announcement year-month t. *Small developers* are measured as *solo developers*. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A3: App Launches - Developer-platform Panel with iOS, Androd, iOS&Android as Platforms

	App Launch on iOS, Androd, iOS&Android	Lower-Quality Launch			Higher-Quality Launch		
		Low Qrt. Upvotes	Low Qrt. Rating	Self-Hunted	High Qrt. Upvotes	High Qrt. Rating	Externally Certified
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PANEL A: Control group: Never treated							
Post $\times$ Small Developer	0.0109***	0.00640***	0.00601***	0.0122***	-0.00139	0.00346	-0.00130
	(0.00334)	(0.00177)	(0.00156)	(0.00292)	(0.00164)	(0.00233)	(0.00163)
PANEL B: Control group: Not-yet treated							
Post $\times$ Small Developer	0.0103***	0.00616***	0.00708***	0.0109***	-0.00148***	0.00155	-0.000519
	(0.00152)	(0.000833)	(0.000812)	(0.00132)	(0.000689)	(0.00102)	(0.000757)
Developer-platform FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean D.V.	0.027	0.009	0.008	0.021	0.005	0.012	0.006
Observations	186325	186325	186325	186325	186325	186325	186325

Notes: We estimate variants of Eq. (1) and report the resulting AGGTEs. In column 1, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app on a given platform; in column 2, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the lowest quartile of the number of upvotes; in column 3, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the lowest quartile of ratings received; in column 4, the outcome is a (0/1) indicator that takes the value one in the month a developer launches a self-hunted app; in column 5, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the upper quartile of the number of upvotes; in column 6, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the upper quartile of ratings received; in column 7, the outcome is a (0/1) indicator that takes the value one in the month a developer launches an externally certified app. We consider 3 platforms: iOS, Android, iOS& Android. For the iOS&Android platform, we identify December 2020 as the beginning of the new royalty rate regime. We observe each developer-platform combination (N=7,453) over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after. In Panel A, the control group is represented by the never treated, namely, the larger developers. In Panel B, the control group is represented by the not-yet treated. The AGGTEs are obtained by aggregating the estimated ATEs for each cohort g and time t. *Small developers* are measured as *solo developers*. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A4: App Launches: Assuming that All Developers are Potential Candidates for Launching an App on either the iOS or Android Platforms

	App Launch on iOS/Android	Lower-Quality Launch			Higher-Quality Launch		
		Low Qrt. Upvotes	Low Qrt. Rating	Self-Hunted	High Qrt. Upvotes	High Qrt. Rating	Externally Certified
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PANEL A: Control group: Never treated							
AGGTE	0.00485**	0.00338***	0.00282***	0.00464***	-0.000279	0.00115	0.000205
	(0.000915)	(0.000491)	(0.000465)	(0.000784)	(0.000428)	(0.000611)	(0.000469)
PANEL B: Control group: Not-yet treated							
AGGTE	0.00606***	0.00412***	0.00453***	0.00676***	-0.00132***	0.000348	-0.000689
	(0.000915)	(0.000491)	(0.000465)	(0.000784)	(0.000428)	(0.000611)	(0.000469)
Developer-platform FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean D.V.	0.020	0.003	0.005	0.015	0.004	0.009	0.005
Observations	366550	366550	366550	366550	366550	366550	366550

Notes: We estimate variants of Eq. (1) and report the AGGTEs. In column 1, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app on a given platform; in column 2, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the lowest quartile of the number of upvotes; in column 3, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the lowest quartile of ratings received; in column 4, the outcome is a (0/1) indicator that takes the value one in the month a developer launches a self-hunted app; in column 5, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the upper quartile of the number of upvotes; in column 6, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the upper quartile of ratings received; in column 7, the outcome is a (0/1) indicator that takes the value one in the month a developer launches an externally certified app. The AGGTEs are obtained by aggregating the estimated ATEs for each cohort g of small developers and post-announcement year-month t. *Small developers* are measured as *solo developers*. **We assume that all 7,331 developers are potential candidates for launching an app on either the iOS or Android platforms. We observe each developer-platform combination (N=14,662) over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after**. In Panel A, the control group is represented by the never treated, namely, the larger developers. In Panel B, the control group is represented by the not-yet treated. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A5: App Launches - Callaway and Sant'Anna's Approach

	App Launch on iOS/Android	Lower-Quality Launch			Higher-Quality Launch		
		Low Qrt. Upvotes	Low Qrt. Rating	Self-Hunted	High Qrt. Upvotes	High Qrt. Rating	Externally Certified
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PANEL A: Control group: Never treated							
AGGTE	0.00712***	0.00497***	0.00415***	0.00693***	-0.000663	0.00185	0.000184
	(0.00272)	(0.00146)	(0.00135)	(0.00238)	(0.00133)	(0.00180)	(0.00133)
PANEL B: Control group: Not-yet treated							
AGGTE	0.00671**	0.00493***	0.00408***	0.00657***	-0.000732	0.00166	0.000142
	(0.00271)	(0.00148)	(0.00137)	(0.00238)	(0.00131)	(0.00178)	(0.00131)
Developer-platform FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean D.V.	0.027	0.008	0.007	0.02	0.006	0.012	0.007
Observations	267075	267075	267075	267075	267075	267075	267075

Notes: We estimate variants of Eq. (1) using Callaway and Sant'Anna's approach (2020) and report the AGGTEs. In column 1, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app on a given platform; in column 2, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the lowest quartile of the number of upvotes; in column 3, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the lowest quartile of ratings received; in column 4, the outcome is a (0/1) indicator that takes the value one in the month a developer launches a self-hunted app; in column 5, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the upper quartile of the number of upvotes; in column 6, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app in the upper quartile of ratings received; in column 7, the outcome is a (0/1) indicator that takes the value one in the month a developer launches an externally certified app. *Small developers* are measured as *solo developers*. We observe each developer-platform combination (N=10,683) over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after. In Panel A, the control group is represented by the never treated, namely, the larger developers. In Panel B, the control group is represented by the not-yet treated. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A6: Hazard of Launching an App: Hazard Ratios Reported

	App Launch on iOS/Android	Lower-Quality Launch			Higher-Quality Launch		
		Low Qrt. Upvotes	Low Qrt. Rating	Self-Hunted	High Qrt. Upvotes	High Qrt. Rating	Externally Certified
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Experienced Announcement	1.680***	1.336***	2.318***	2.380***	1.542***	1.608***	1.372***
	(0.0548)	(0.110)	(0.181)	(0.112)	(0.0892)	(0.0775)	(0.0771)
Small Developer	0.999	2.744***	2.536***	1.253***	0.351***	0.879***	0.553***
	(0.0192)	(0.147)	(0.145)	(0.0295)	(0.0206)	(0.0284)	(0.0255)
Experienced Announcement x Small Developer	1.099***	1.751***	1.508***	1.747***	0.481***	0.753***	0.530***
	(0.0257)	(0.154)	(0.127)	(0.0855)	(0.0452)	(0.0444)	(0.0432)
Start Date x Platform dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
End Date x Platform dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N. Developers	7331	7331	7331	7331	7331	7331	7331
N. Developers-platform	10683	10683	10683	10683	10683	10683	10683

Notes: We estimate multi-failure Cox proportional hazards models and report hazard ratios. Each column corresponds to a specific type of app launch hazard: (1) launching any apps on a platform; (2) launching an app in the lowest quartile for upvotes; (3) launching an app in the lowest quartile for ratings; (4) launching a self-hunted app; (5) launching an app in the upper quartile for upvotes; (6) launching an app in the upper quartile for ratings; (7) launching an externally-certified app. Developers who did not launch any app are assumed to have a start date of January 2019 and an end date 12 months after either Apple's or Google's royalty rate cut announcement. The start date refers to when a developer might have conceived the app. For developers launching a single app, the start date is 12 months before launch. For multiple launches, the start of risk for a new app is the prior app's launch date. *Experienced Announcement* is a binary indicator equal to 1 if a developer experienced either platform's royalty rate cut announcement between app conception and the end of the observation window. *Small developers* are measured as *solo developers*. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A7: Game Apps: Treated Group Built Based on Pre-sample Revenue

	Game Apps Launched on iOS/Android	Lower-Quality Apps: Zero Downloads	Higher-Quality Apps: High Qrt. Downloads	Game Apps Launched on iOS/Android	Lower-Quality Apps: Zero Downloads	Higher-Quality Apps: High Qrt. Downloads
	(1)	(2)	(3)	(4)	(5)	(6)
PANEL A: Control group: Never treated						
AGGTE	0.0109***	0.00566***	-0.00313 **	-0.0155	0.00928 ***	-0.0383 ***
	(0.00253)	(0.000934)	(0.00142)	(0.0218)	(0.00312)	(0.0162)
PANEL B: Control group: Not-yet treated						
AGGTE	0.0145***	0.00565***	-0.00220 ***	-0.00902	0.00314	-0.0109*
	(0.00138)	(0.000493)	(0.000847)	(0.0102)	(0.00300)	(0.00597)
Developer-platform FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes
Mean D.V.	0.0313	0.0069	0.0076	0.0882	0.0077	0.0483
Observations	496400	496400	496400	21293	21293	21293

Notes: We estimate variants of Eq. (1) and report the AGGTEs. In columns 1 and 4, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches a game app on a given platform; in columns 2 and 5, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that has not received any downloads in the first four months after launch; in columns 3 and 6, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that is in the top quartile of downloads. We observe each developer-platform combination over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after. In Panel A, the control group is represented by the never treated. In Panel B, the control group is represented by the not-yet treated. In columns 1 to 3 of both panels, *small developers* are defined as *those who did not generate positive revenue in 2018* (the pre-sample period). In columns 4 to 6, *small developers* are defined as *those who earned less than $1,000,000 in revenue in 2018*. In these columns, we limit the sample to those 861 developers who earned $500,000 or more in the pre-sample period. The AGGTEs are obtained by aggregating the estimated ATEs for each cohort g of small developers and post-announcement year-month t. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A8: Game Apps - Developer-platform Panel with iOS, Androd, iOS&Android as Platforms

	Game Apps on iOS, Android, iOS&Android	Lower-Quality Apps: Zero Downloads	Higher-Quality Apps: High Qrt. Downloads
	(1)	(2)	(3)
PANEL A: Control group: Never treated			
AGGTE	0.00186	0.00420***	-0.00281**
	(0.00237)	(0.000975)	(0.00121)
PANEL B: Control group: Not-yet treated			
AGGTE	0.00360 ***	0.00481 ***	-0.00217 ***
	(0.00131)	(0.000539)	(0.000719)
Developer-platform FEs	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes
Mean D.V.	0.029	0.0068	0.0065
Observations	484425	484425	484425

Notes: We estimate variants of Eq. (1) and report the AGGTEs. In column 1, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches a game app on a given platform; in column 2, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that has not received any downloads in the first four months after launch; in column 3, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that is in the top quartile of downloads. We consider 3 platforms: iOS, Android, iOS& Android. For the iOS&Android platform, we identify December 2020 as the beginning of the new pricing regime. We observe each developer-platform combination (N=19,377) over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after. In Panel A, the control group is represented by the never treated, namely, the larger businesses. In Panel B, the control group is represented by the not-yet treated. The AGGTEs are obtained by aggregating the estimated ATEs for each cohort g of small developers and post-announcement year-month t. *Small developers* are measured as *individual developers* and contrasted with *incorporated businesses*. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A9: Game Apps - Assuming that All Developers are Potential Candidates for Launching an App on either the iOS or Android Platforms

	Game Apps Launched on iOS/Android	Lower-Quality Apps: Zero Downloads	Higher-Quality Apps: High Qrt. Downloads
	(1)	(2)	(3)
PANEL A: Control group: Never treated			
AGGTE	0.000881	0.00259***	-0.00216***
	(0.00139)	(0.000557)	(0.000746)
PANEL B: Control group: Not-yet treated			
AGGTE	0.000217	0.00237***	-0.00187***
	(0.000770)	(0.000300)	(0.000442)
Developer-platform FEs	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes
Mean D.V.	0.0172	0.0038	0.0042
Observations	903050	903050	903050

Notes: We estimate variants of Eq. (1) and report the AGGTEs. In column 1, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches a game app on a given platform; in column 2, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that has not received any downloads in the first four months after launch; in column 3, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that is in the top quartile of downloads. We observe each developer-platform combination over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after. **We assume that all 18,061 developers are potential candidates for launching an app on either the iOS or Android platforms. We observe each developer-platform combination (N=36,122) over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after**. *Small developers* are measured as *individual developers* and contrasted with incorporated businesses. In Panel A, the control group is represented by the never treated, namely, the larger developers. In Panel B, *Small developers* are measured as *individual developers* and contrasted with *incorporated businesses*. control group is represented by the not-yet treated. The AGGTEs are obtained by aggregating the estimated ATEs for each cohort g of small developers and post-announcement year-month t. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A10: Game Apps - Callaway and Sant'Anna's Approach

	Game Apps Launched on iOS/Android	Lower-Quality Apps: Zero Downloads	Higher-Quality Apps: High Qrt. Downloads
	(1)	(2)	(3)
PANEL A: Control group: Never treated			
AGGTE	0.0008965	0.0046032***	-0.004772***
	(0.00257)	(0.0010048)	(0.00136)
PANEL B: Control group: Not-yet treated			
AGGTE	0.0008897	0.0046009***	-0.004769***
	(0.00257)	(0.0010011)	(0.0013434)
Developer-platform FEs	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes
Mean D.V.	0.0313	0.0069	0.0076
Observations	496400	496400	496400

Notes: We estimate variants of Eq. (1) using Callaway and Sant'Anna's approach (2020) and report the AGGTEs. In column 1, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches a game app on a given platform; in column 2, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that has not received any downloads in the first four months after launch; in column 3, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that is in the top quartile of downloads. We observe each developer-platform combination (N=19,856) over a period of 25 months: 12 months before either Apple's or Google's announcement, the month of the announcement, and 12 months after. *Small developers* are measured as *individual developers* and contrasted with *incorporated businesses*. In Panel A, the control group is represented by the never treated, namely, the larger developers. In Panel B, the control group is represented by the not-yet treated. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A11: Game Apps -Alternative Measures of Quality

	Game Apps Launched on iOS/Android	Lower-Quality Apps: Low Qrt. Ratings	Higher-Quality Apps: High Qrt. Ratings
	(1)	(2)	(3)
PANEL A: Control group: Never treated			
AGGTE	0.00102	0.00527***	-0.00449***
	(0.00251)	(0.00126)	(0.00142)
PANEL B: Control group: Not-yet treated			
AGGTE	0.00126	0.00508***	-0.00412***
	(0.00141)	(0.000667)	(0.000818)
Developer-platform FEs	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes
Mean D.V.	0.031	0.009	0.0078
Observations	496400	496400	496400

Notes: We estimate variants of Eq. (1) and report the AGGTEs. In column 1, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches a game app on a given platform; in column 2, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that is in the lowest quartile of ratings received; in column 3, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that is in the top quartile of ratings. We observe each developer-platform combination (N=19,856) over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after. In Panel A, the control group is represented by the never treated, namely, the larger developers. In Panel B, the control group is represented by the not-yet treated. The AGGTEs are obtained by aggregating the estimated ATEs for each cohort g of small developers and post-announcement year-month t. *Small developers* are measured as *individual developers* and contrasted with *incorporated businesses*. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A12: Game Apps - Considering Only The Launches of Apps That Do Not Offer a Subscription Option

	Game Apps Launched on iOS/Android	Lower-Quality Apps: Zero Downloads	Higher-Quality Apps: High Qrt. Downloads
	(1)	(2)	(3)
PANEL A: Control group: Never treated			
AGGTE	0.00105	0.00456***	-0.00375***
	(0.00246)	(0.000990)	(0.00132)
PANEL B: Control group: Not-yet treated			
AGGTE	0.00134	0.00439***	-0.00299 ***
	(0.00135)	(0.000535)	(0.000763)
Developer-platform FEs	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes
Mean D.V.	0.0303	0.0068	0.0072
Observations	496400	496400	496400

Notes: We estimate variants of Eq. (1) and report the AGGTEs. We consider only the launches of apps that do not offer a subscription option. The launches of apps offering a subscription option are set to zero. In column 1, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches a game app on a given platform; in column 2, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that has not received any downloads in the first four months after launch; in column 3, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that is in the top quartile of downloads. We observe each developer-platform combination (N=19,856) over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after. In Panel A, the control group is represented by the never treated, namely, the larger developers. In Panel B, the control group is represented by the not-yet treated. The AGGTEs are obtained by aggregating the estimated ATEs for each cohort g of small developers and post-announcement year-month t. *Small developers* are measured as *individual developers* and contrasted with *incorporated businesses*. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A13: Game Apps - Considering App Launches with In-App Purchase Options Only

	Game Apps Launched on iOS/Android	Lower-Quality Apps: Zero Downloads	Higher-Quality Apps: High Qrt. Downloads
	(1)	(2)	(3)
PANEL A: Control group: Never treated			
AGGTE	0.000690	0.00400***	-0.00393***
	(0.00241)	(0.000930)	(0.00131)
PANEL B: Control group: Not-yet treated			
AGGTE	0.00110	0.00421***	-0.00309 ***
	(0.00132)	(0.000507)	(0.000789)
Developer-platform FEs	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes
Mean D.V.	0.0274	0.006	0.007
Observations	496400	496400	496400

Notes: We estimate variants of Eq. (1) and report the AGGTEs. We consider only the launches of apps that include the in-app purchase option. When information on in-app purchase options is unavailable, we assume the app does not offer that option and set the app launch indicator to zero. In column 1, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches a game app on a given platform; in column 2, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that has not received any downloads in the first four months after launch; in column 3, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches an app that is in the top quartile of downloads. We observe each developer-platform combination (N=19,856) over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after. In Panel A, the control group is represented by the never treated, namely, the larger developers. In Panel B, the control group is represented by the not-yet treated. The AGGTEs are obtained by aggregating the estimated ATEs for each cohort g of small developers and post-announcement year-month t. *Small developers* are measured as *individual developers* and contrasted with *incorporated businesses*. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A14: Hazard of Launching a Game App: Hazard Ratios Reported

	Game Apps Launched on iOS/Android	Lower-Quality Apps: Zero Downloads	Lower-Quality Apps: Low Qrt. Ratings	Higher-Quality Apps: High Qrt. Downloads	Higher-Quality Apps: High Qrt. Ratings
	(1)	(2)	(3)	(4)	(5)
Experienced Announcement	1.635***	1.101	0.916	0.996	1.056
	(0.0695)	(0.0845)	(0.0758)	(0.0723)	(0.0778)
Small Developer	0.867***	1.133	1.297***	0.697***	0.655***
	(0.0293)	(0.0953)	(0.0711)	(0.0515)	(0.0410)
Experienced Announcement x Small Developer	1.033	1.774***	1.454***	0.955	0.945
	(0.0365)	(0.147)	(0.126)	(0.0787)	(0.0768)
Start Date x Platform dummies	Yes	Yes	Yes	Yes	Yes
End Date x Platform dummies	Yes	Yes	Yes	Yes	Yes
N. Developers	18061	18061	18061	18061	18061
N. Developers-platform	19856	19856	19856	19856	19856

Notes: We estimate multi-failure Cox proportional hazards models and report hazard ratios. Each column corresponds to a specific type of app launch hazard: (1) launching any app on a platform; (2) launching an app that has not received any downloads in the first four months after launch; (3) launching an app in the lowest quartile for ratings; (4) launching an app in the upper quartile for downloads; (5) launching an app in the upper quartile for ratings. Developers who did not launch any app are assumed to have a start date of January 2019 and an end date 12 months after either Apple's or Google's royalty rate cut announcement. The start date refers to when a developer might have conceived the app. For developers launching a single app, the start date is 12 months before launch. For multiple launches, the start of risk for a new app is the prior app's launch date. *Experienced Announcement* is a binary indicator equal to 1 if a developer experienced either platform's royalty rate cut announcement between app conception and the end of the observation window. *Small developers* are measured as *individual developers* and contrasted with *incorporated businesses*. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A15: Game Apps: By their Originality

	Original Game Apps	
	Relative to 5 Most Similar Apps	Relative to 10 Most Similar Apps
	(1)	(2)
PANEL A: Control group: Never treated		
AGGTE	-0.00793**	-0.00862**
	(0.00397)	(0.00399)
PANEL B: Control group: Not-yet treated		
AGGTE	-0.00175	-0.00250
	(0.00259)	(0.00270)
Developer-platform FEs	Yes	Yes
Year-month FEs	Yes	Yes
Mean D.V.	0.0103	0.0104
Observations	59975	59975

Notes: We estimate variants of Eq. (1) and report the AGGTEs. In column 1, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches a game app that falls in the lowest quartile of the average similarity score relative to its 5 most similar apps; in column 2, the outcome is a (0/1) indicator that takes the value of one in the month a developer launches a game app that falls in the lowest quartile of the average similarity score relative to its 10 most similar apps. We observe each developer-platform combination (N=2,399) over a period of 25 months: 12 months before either Apple's or Android's announcement, the month of the announcement, and 12 months after. *Small developers* are measured as *individual developers* as opposed to *incorporated businesses*. In Panel A, the control group is represented by the never treated, namely, the larger developers. In Panel B, the control group is represented by the not-yet treated. The AGGTEs are obtained by aggregating the estimated ATEs for each cohort g of small developers and post-announcement year-month t. Standard errors are clustered at the developer-platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A16: Game Apps: The No-passthrough Condition

	App Price ($)	App Price is Lowered (0/1)
	(1)	(2)
Small Developer	-1.5786*	0.0539
	(0.21984)	(0.06434)
Small Developer x Post	0.0293	-0.0754
	(0.65427)	(0.04434)
Platform x Release Date dummies	Yes	Yes
Platform x Change of Price Date dummies		Yes
Observations	1,194	447

Notes: In column 1, we report the results of a cross-sectional analysis, having regressed the original price of a (game) app on an indicator identifying small developers (*Small Developer*) and an interaction between this indicator and a dummy for whether an app was released in the post-announcement periods (*Small Developer x Post*). *Small developers* are measured as *individual developers* as opposed to *incorporated businesses*. In column 2, we report the results of a similar analysis focusing on those 447 game apps released twelve months before, during, and after Apple's and Google's announcements by developers who changed the original price of their app at least once. This time, the dependent variable is a (0/1) indicator for whether developers lowered the original price of an app after it was released. In both columns, the *Post* is absorbed by the time dummies. Standard errors are clustered at the platform level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.

Table A17: Summary Statistics (cross-section): ASO Investments (cumulative numbers)

Variable	Mean	Std. Dev.	Min.	Max.	N
			iOS		
N. Downloads	212062	1109487	0	31376112	5302
N. ASO	13.69	39.056	0	679	5302
N. title (includes subtitle) changes	2.42	9.728	0	210	5302
N. description (includes promotional text) changes	3.864	14.609	0	410	5302
N. screenshot changes	3.454	10.529	0	164	5302
N. icon changes	2.801	11.221	0	224	5302
N. video changes	1.15	4.837	0	114	5302
N. size changes	4.951	16.211	0	228	5302
N. version changes	25.278	66.493	0	930	5302
			Android		
N. Downloads	166877	773439	0	23361316	4198
N. ASO	7.775	21.381	0	821	4198
N. title changes	0.386	1.22	0	19	4198
N. description (short+long) changes	1.813	6.669	0	217	4198
N. screenshot changes	3.51	9.943	0	430	4198
N. icon changes	1.314	8.522	0	286	4198
N. video changes	0.752	6.241	0	349	4198
N. size changes	3.158	5.816	0	59	4198
N. version changes	7.199	12.141	0	84	4198

Table A18: App Store Optimization (ASO): iOS & Android - Monthly Number of Downloads

	Monthly Downloads:	
	(1)	(2)
	iOS	Android
ASO_{t-1} (0/1)	0.01072	0.02022
	(0.01509)	(0.02192)
Post x ASO_{t-1} (0/1)	0.08880***	0.10335***
	(0.02265)	(0.03470)
App FE	Yes	Yes
Year-month FE	Yes	Yes
Observations	90,750	62,208

Notes: We report the results of PQML count models for the monthly number of downloads an app received on iOS (column 1) and Android (column 2) in month t. In column 1, *Post* is an indicator that takes the value one after November 2020, when Apple announced the new royalty rate regime. In column 2, *Post* is an indicator that takes the value one after February 2021, when Google started announcing its new royalty rate regime. *ASO* is an indicator that takes on the value 1 the month in which a developer makes an ASO investment. This variable is lagged one period. Not reported in this table are the coefficients of the (0/1) indicators taking the value 1 the month in which a developer makes a change in an app's version and a change in an app's size (lagged), and interactions between these indicators and *Post*. Standard errors are clustered at the app level. Significance noted as: *p<0.10; **p<0.05; ***p<0.01.