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Data Privacy, Transparency and the Data-Driven Transformation of Games to Services

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***Abstract*— This paper discusses the role of mobile app platforms in the data-driven business models of game app companies, in light of the questions about data privacy and transparency raised in this context. The paper provides a new insight into this question, on the basis of an exploratory study of popular gaming apps and an analysis of the relationship between Apple and Google's mobile ecosystems and mobile apps in terms of the monetization of personal data. Additionally, the study draws upon filings made with the US Securities and Exchange Commission (SEC), which shed light on the crucial role of personal data in the mobile app economy.**

Keywords— mobile platforms, mobile applications, data privacy, business models, transparency

I. INTRODUCTION

Activision Blizzard, Inc., which acquired the developer of Candy Crush Saga for $5.8 billion in 2016, sounded a warning note in its February 2018 filings with the US Securities and Exchange Commission about its dependency on mobile platforms. If these platform providers, such as the App Store and Google Play, would be required to change "how the personal information of consumers is made available to developers, our business could be negatively impacted"[1].

This paper seeks to examine the relationship between mobile app platforms and app business models, building upon earlier research on business models and the regulation of digital platforms[2]. The paper focuses in particular on the way in which the collection and use of personal data has come to support data-driven functionality and monetization strategies. By looking at the role of data in app business models and the role of the platforms in facilitating and shaping these business models, we aim to make a contribution to the discussion about the regulation of (and governance mechanisms providing for) transparency about collection and use of personal data in the smartphone context. The paper also aims to further our understanding of how to adapt privacy governance to the changing nature of how software is being produced and offered as services residing in the cloud[3].

We study the impact of app platforms on app business models by looking at the choices that have been made by platforms in their relationship with apps. As will be discussed in more detail below, there are a lot of similarities here, but we highlight any differences between the platforms in particular. While apps made available through both may appear to behave the same to users, background processes may behave differently as well as their business model characteristics or personal data flows. For example, app developers may use different permissions for free apps and paid apps, with free versions displaying ads and collecting personal data, while paid versions may not display ads and collect no personal data[4].

The paper first provides background on the mobile game app economy from the perspective of platform providers, app developers, app users, focusing on the role of user data in particular. Given recent consolidation and acquisitions in the market, the paper is able to draw upon publicly available financial information from a number of the largest publically-traded corporations operating within the market, to provide insights into revenue, user data, and data-driven business models. Second, the paper describes and discusses the results of a small empirical study, examining a selection of popular gaming apps, across two app stores - Google Play (Netherlands) and App Store (Netherlands). The focus on game apps was motivated by the fact that game apps represent (by far) the largest share in terms of revenues. The study provides a snapshot of the business models that are currently most successful. Third, the paper builds on the preceding to develop a typology of different app types and business models in the two dominant smartphone ecosystems (Android and iOS). This typology builds upon earlier research on business models and the regulation of digital platforms[5], and includes advertising, freemium, in-app purchasing, direct payment, subscription, and data collection as business model characteristics. Finally, the paper discusses the implications of the influence of app platforms on app business models, in particular with regard the apps' transparency about collection and use of personal data.

II. THE APP ECONOMY, GAMES AND THE ROLE OF DATA

A. The app economy

Why examine app business models, why examine game apps in particular, and what is the relevance of personal data and transparency in this? A first reason is the size of the app economy today, the number of users, and the amount and importance of user data in the app economy. This article examines the Apple and the Google ecosystem, and the relevant numbers are quite staggering.

While the App Store was only launched 10 years ago, Apple reported that app developers earned over $20 billion in 2016 alone, which was a 40 percent increase from 2015. Indeed, in one month alone in 2016, users spent $3 billion in purchases from the App Store, and in one day in January 2017, users spent nearly $240 million in purchases on the App Store. Crucially, app profits directly translate to platform profits through revenue sharing. Under the Apple Developer Programme, developers receive 70% of sales revenues, while Apple receives 30%. In Apple's latest financial filing with the U.S. Securities and Exchange Commission (SEC) in September 2017, Apple reported its revenues from the App Store under "Digital Content and

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Services" (which also includes the iTunes Store, TV App Store, iBooks Store, and Apple Music). In 2017, Apple had revenues of $29.9 billion from Digital Content and Services, which was a 23% year-over-year increase in revenues. Apple stated that the increase "was due primarily to increases in App Store and licensing sales"[6]. Google stated in 2015 that nearly $7 billion was paid to developers making apps available on Google Play[7]. Similar to Apple, under the Google Play Console programme, developers receive 70% of sales revenue, while Google receives 30%. Google's parent company Alphabet Inc.'s latest annual SEC filing reports revenues from Google Play under "other revenues," which was $10 billion in 2016[8]. Alphabet stated that "other revenues" increases "were primarily due to the growth in revenues from Google Play, primarily through in-app purchases (revenues which we recognize net of payout to developers), hardware sales, and Google Cloud offerings"[9].

These figures are built upon equally notable numbers in terms of users and app downloads. Apple users download more than 800 apps per second, at a rate of over two billion apps per month on the App Store, while in 2017, the App Store had over 500 million unique visits every week. The App Store had 2.2 million apps available in 2016, which was an increase of 20 percent from 2015. In 2016, Google stated that 82 billion apps were downloaded from Google Play, and there were more than 8 billion new installs per month globally. According to Google, the "number of developers with more than 1 million monthly installs grew by 35% year on year," and the "number of buyers on Google Play grew by almost 30% in the last year"[10].

B. The game app economy

Game apps are notable in that they represent a large proportion of the app economy, are the highest grossing and most popular. Of the 2.2 million apps available on the App Store, half a million are game apps. While the App Store has 25 app categories, according to Apple, the "gaming and entertainment are the top-grossing categories"[11], with the top grossing apps include the game apps Fortnight, Monster Strike, Fantasy Westward, Clash Royale and Pokémon Go (the most downloaded app in 2016 on the App Store).

David B. Nieborg has noted that the "economics of game app development" can be "opaque for financial analysts, journalists, and scholars as the great majority of app developers are private companies", and "are reluctant to open their books"[12]. However, in the last two years, there have been a number of major acquisitions of game app developer companies by publicly-traded companies. These companies' public financial filings provide new insights into game app revenues. For example, Blizzard acquired the developer of Candy Crush Saga (King Digital Entertainment) for $5.8 billion, and in its annual report reported revenues of $1.6 billion in 2016 for mobile games[13].

Similarly, in 2016, Tencent Holdings Ltd., acquired a majority stake in the developer of Clash of Clans and Clash Royale (Supercell) for $10.2 billion. Supercell reported revenues of €2.1 billion in 2016, and Tencent reported revenues from smartphone games grew by 54% to $2.2 billion in 2017, and "exceeded PC client games revenue for the first time"[14]. NetEase, a Chinese publicly-traded company, reported revenues of $2.4 billion from mobile games in 2016, while "mobile game revenues are primarily derived from sales of in-game virtual items"[15]. Electronic Arts Inc. reported digital net revenues of $2.8 billion in 2017, which was an increase of 19 per cent, and mobile apps represented $626 million in revenue.

The number of users combined with the growing importance of user data in the game app economy, has opened the pathway for a focus on data-driven user engagement and monetisation, facilitated by the mobile platforms as well as third-party analytics. The size of the Apple and Google ecosystems has meant that game apps can potentially reach an enormous number of users.

C. Uncovering the role of data from financial filings

In order to better understand the role of user data, and data-driven analytics in game apps, we examined the financial filings of these publicly-traded companies (in contrast to privacy policies), with some interesting results. For example, Rovio states that it has a "sophisticated, data-driven process for paid user acquisition with the clear return on investment targets aimed at delivering calculated results within a moderate risk level"[16]. In addition, Rovio aims to "improve monetization through data-driven feature development," and has "been able to increasingly convert users into paying users as well as to increase the spend per active user"[17]. Rovio reports that it has increased the number of paying users by 83% between 2015 and 2017. Further, it "collects and stores user behavior data and uses from these both quantitative and qualitative data in all stages of game development and in live operations"[18]. It has an "analytics platform, which processes billions of analytics events every day, and dashboard-operated data-driven features for games monetization and cross-promotion"[19]. User analytics "also serve marketing efforts in the form of ad-generated interaction and in-app virtual goods sales"[20].

Tencent notes about its strategy for mobile games that through "data mining, we improved performance of our existing titles and gained deeper insights into player behaviours". It's "strategy is to engage a large pool of casual gamers and gradually advance them to mid-core and hard-core categories"[21].

Finally, King Entertainment emphasizes that its "data-driven marketing processes," and "massive player network are key competitive advantages"[22]. This allows "large investments in paid player acquisition" and "run acquisition campaigns in a highly granular and data-driven way"[23]. In particular, "to drive retention and cross-promotion, we use a data-centric, rules-based approach aimed at maximizing aggregate"[24]. Moreover, "we rely on the unique cross-platform data set generated by our player network to direct our decisions"[25] and "have built extensive analytics capabilities and proprietary technology infrastructure to support the growth and retention of our audience through data-driven marketing and management of our games"[26].

D. Uncovering the role of platforms from financial filings

We also found evidence that game app providers are acutely aware of their dependency on the conditions under which they get access to user data. As mentioned above, Activision Blizzard recently reported that if the Apple App Store or the Google Play are required to "change how the personal information of consumers is made available to developers, our business could be negatively impacted"[27]. It also states that they "collect and store information about

our consumers of [mobile device] games—both personally identifying and non-personally identifying information"[28]. Similarly, Rovio stated in its 2017 IPO filings that its business could be "negatively affected" if the Apple App Store or Google Play "change how the personal information of users is made available to developers"[29]. Moreover, Zynga Inc. (FarmVille 2, Zynga Poker), stated in its 2017 annual filings that if Goole or Apple would make "changes to how the personal information of its users is made available to application developers on the platform or restrict how players can share information with friends on its platform or across platforms," this "could adversely affect our business, financial condition or results of operations"[30]. Relatedly, EA also notes in its latest filings with the SEC Apple and Goole "set the rates that we must pay to provide our games and services through their online channels, and retain flexibility to change their fee structures or adopt different fee structures for their online channels, which could adversely impact our costs, profitability and margins"[31]. Clearly, for game apps, the platforms' policies with respect to the collection and use of personal data are a significant factor in their operations, to the extent that these platforms act as *de facto* regulatory gatekeepers.

E. The gaming industry generally

The increasing importance of in-app purchase optimization in the business model of apps is changing the nature of the gaming industry as well as the gaming experience. As discussed in the next section, the shift to in-app purchases optimization illustrates the transformation of games from software to services. In-app purchases may change the nature of videogames, by rewarding willingness and ability to make in-game purchases, rather than rewarding skill and gameplay.

III. Study on Game Apps

We conducted a small exploratory study in October 2017, in order to gain insight into the business models that are adopted by a selection of popular game apps available in the Google Play (Netherlands) app store, and Apple's App Store (Netherlands). The study was meant to provide insights in view of future investigations, specifically into the role of smartphone ecosystems in shaping privacy-relevant app behavior, considering their gatekeeping role in setting the conditions for collection and use of user data.

TABLE I. Study Questions 1 - 12

1. App category 2. Version 3. Year when app first offered in app store 4. App developer 5. Developer's country 6. Ownership (private, public) 7. Is there a recent change in ownership? a. if yes, date of acquisition	8. Privacy policy link 9. Is privacy policy available in app store 10. Is privacy policy available in app store 11. Acknowledgement of whether EU data protection law applies 12. Choice of law included in app's terms and conditions

A. Study Design

First, a set of questions were developed to investigate the business model characteristics of selected apps, with a first set of questions (1-7) relating to general business characteristics and a second set (8-12) relating to the privacy policy and applicable law. The remaining questions (13-21) focus more specifically on the app's business model, including on fees to download, in-app purchases, in-app advertising, account creation requirements, payment, subscriptions, and revenues.

TABLE II. Study Questions 13 - 21

13. Is there a fee to download the app? a. if yes, what is the fee? 14. Does the app offer in-app purchases? a. If yes, is it possible to make in-app purchase for additional functionality? b. What is the price range of the in-app purchases? 15. Are there in-app purchases for real money or in-app currency (or both)? a. If yes, does the app rely on the relevant app store to handle payments or does it handle payments itself? 16. Does the app have in-app advertising? a. If yes, does the app offer an in-app purchase for no advertising?	17. Do you need to sign up for the app? a. If yes, do you create an account with the app or does the app rely on third party authentication? 18. Does the app offer the possibility to create a subscription? a. If yes, does the subscription remove the advertising? b. If yes, does the subscription version offer additional functionality? 19. Does the app connect service/content providers to app users? 20. Is the app revenue-generating, or apparently trying to be revenue-generating? 21. What are the revenues (if reported)?

We used the following selection mechanism to select 20 popular gaming apps for the study of business model characteristics. First, we required that selected apps should be available in both Netherlands app stores: Apple's App Store and Google Play. This also helped to ensure we did not have too many outliers. To guarantee inclusion of apps with different business models, we used publicly available lists of top "paid", "free" and "grossing" apps in the respective app stores. We required popularity in one of the two app stores. Second, two charts containing three lists each (paid, free, and grossing) were collected on 23 October 2017. The first app from the first of these two charts of apps would be selected. A check was made that the app is at least available in the other app store. Then the first app was selected from the second chart, etc., until a selection of 20 was reached. Applying our app selection methodology resulted in the selection presented in Table III.

The answering of the questionnaire took place on 26 and 27 October 2017. An Android smartphone (Samsung), running the latest version of Android (Android 8.0), was

used to download the apps, using the researcher's own Google account. The Google Play store was accessed through the Play Store app. Similarly, an iOS smartphone (iPhone 6), running the latest version of iOS (iOS 11.0.3), was used to download the apps, using the researcher's own Apple account. The App Store was accessed through the App Store app. A PDF copy of each app's privacy policy page was also stored for later analysis.

TABLE III. SELECTED APPS FOR STUDY

App	*App Store*	*Google Play*
Color Ballz	Free	Free
Word Snack	Free	Free
F1 2016	€2.29	€2.29
Minecraft	€7.99	€6.99
Pokemon Go	Free	Free
Candy Crush Saga	Free	Free
Pocket Pool	Free	Free
Fut 18 Draft	Free	Free
Push	€1.09	€0.99
Construction Simulator	€0.99	€0.10
Clash Royale	Free	Free
Homescapes	Free	Free
Jachtseizoen	Free	Free
Rider	Free	Free
Plague Inc.	€0.99	Free
Monument Valley	€4.49	€2.29
Castle Clash	Free	Free
Candy Crush Soda Saga	Free	Free
Bike Race Pro	€0.49	€1.09
Wordfeud	Free	Free

B. Study Results

The first result relates to questions 7, 8, and 9, on privacy policies, and whether the app makes a privacy policy available in the app store, and if the privacy policy is available in the app itself (or linked in the app). There was some difference between Google Play and the App Store in terms of the privacy policies being made available on an app's store page. In Google Play, 16 of the 20 apps had a privacy policy link in the app store (with two links being broken), and four apps with no privacy policy link. In contrast, in the App Store, only 12 of the 20 apps had privacy policy links in the app store, and 8 apps had no privacy policy link in the app store. Notably, 4 apps were found to have privacy policy links in Google Play which do not have a similar privacy policy link in the App Store (Fut 18 Draft, PUSH, Construction Simulator, Jachtseizoen).

However, when examining whether an app's privacy policy is available in-app (whether through a link, or displayed in-app), a majority (15) of the apps available in Google Play had no privacy policy available in-app. Thus, there seems to be a disconnect between privacy policy availability in Google Play (16), and within the apps themselves (5). A majority (12) of the apps available in the App Store had no privacy policy available in-app. This is similar to the 12 apps which had no privacy policy link in the App Store. Thus, only five apps from Google Play had privacy policies available in-app, and only six apps from the App Store had privacy policies available in-app. Notably, a number of the app privacy policies (4) consisted of a parent company's privacy policy. Three apps from Ketchapp (Color Ballz, Pocket Pool, Rider) link to Ubisoft's general privacy policy, and an app from Mojang (Minecraft) links to Microsoft's general privacy policy.

A second result concerns question 10, and whether there is an acknowledgement in an app's privacy policy that EU data protection law applies. A majority (11) of the apps' privacy policies make no mention of EU data protection law, or what data privacy framework is applicable. Eight apps mention that an EU member state's law is the applicable data protection framework, or where a user is resident (Bike Race Pro). Only one app (Minecraft) mentions the US-EU Privacy Shield, in its parent company's (Microsoft) privacy policy.

A third result concerns questions 11 and 11a on whether there is a choice-of-law provision in an app's terms of use, and which jurisdiction applies. A majority (15) of apps included a choice of law provision in the terms of use, with 11 apps including an EU member state's laws (seven of these apps mentioned laws of England, or the UK), and four apps included a non-EU jurisdiction (Russia, Singapore, California, Michigan).

When we look at the results for questions about the business model characteristics, we found that 13 apps are free to download on Google Play, and 13 of the apps are free to download on the App Store. One app was free in one store (Plague Inc. in Google Play), and pay to download in the other store (Plague Inc. in the App Store). The cheapest pay-to-download app was €0.49 (Bike Race Pro in the App Store), while the most expensive was €7.99 (Minecraft in the App Store).

We found that 16 of the 20 apps have in-app purchases, with two of the apps without in-app purchases being pay to download apps (F1 2016 and PUSH). Delving a little deeper into the types of in-app purchases, five apps provide an in-app purchase to remove advertising (Color Ballz, Word Snack, Pocket Pool, Rider, and Wordfeud), while 13 apps provide in-app purchases for in-game coins, gems, levels, lives and vehicles/buildings. The price of in-app purchases ranges from €0.49 to €109.99. Of note, while both app stores provide a range of in-app purchase prices in an app's listing, there are examples of differences between the range reported in the app store, and the actual in-app price range (Clash Royale and Homescapes). In terms of payment handling, 15 of the 16 apps with in-app purchases available on Google Play use Google Play In-App Billing (Minecraft uses Microsoft's Xbox Live account), while all 16 apps with in-app purchases in the App Store use Apple in-app billing.

Question 15 and 15a concerned in-app advertising, and whether there is an option to pay for its removal. A majority (11) of the apps available in Google Play have no in-app advertising, while three additional apps (Candy Crush Saga, Candy Crush Soda Saga, and Homescapes) only have advertisements for other apps by the same app publisher. Of the 11 apps that have in-app advertising, only one of these apps (Fut 18 Draft) does not have the option to purchase removal. Thus, it seems that apps that have in-app

advertising generally offer the option to purchase removing advertising. Notably, no difference was found between apps available on Google Play and the App Store in terms of in-app advertising.

The issue of signing-in to use an app was explored in questions 16 and 16a, and whether an app uses third-party authentication. Of the 20 apps, both for Google Play and the App Store, only three apps requirec signing-in to use the app (Pokemon Go, Clash Royale, and Wordfeud). All three apps provided a choice as to sign-in, including using email, Google, Apple, or Facebook accounts. Concerning subscriptions, only one of the 20 apps offered a subscription (Bike Race Pro), which was also a pay to download app. The subscription offered additional functionality. Finally, only one of the 20 apps was found to lack clear revenue generation (Jachtseizoen), as it was free to download, did not have in-app advertising, and did not have in-app purchases or subscriptions. The app is connected to a Dutch TV show.

From the above results, a majority of apps (13) were free to download, a majority of apps (11) have no in-app advertising, and a majority (16) of the apps have in-app purchases. Thus, it would seem that from the sample examined in the study, that the dominant business model seems to be free-to-download, with no in-app advertising, and availability of in-app purchases. Thus, the study results align with Rovio's reported view that the freemium model has become "the dominant revenue model in the market, significantly increasing the revenue potential of mobile games as games have evolved into services"[32].

IV. Business model typology

Having discussed the study results, we now move on to building an app business model typology. Notably, both Apple and Google give advice about possible business models for app developers, as part of their respective app developer platforms (Apple Developer Program and Google Play Console). Apple suggests five business models app developers could consider in order to monetise an app:[33]

1. free model: users do not pay to download, or use the apps. However, some apps "earn revenue by displaying ads within the app," And Apple suggests that developers seeking to "attract a large user base may choose to offer their apps for free."
2. freemium model: users do not pay to download the app, but may make in-app purchases for premium features, additional content, subscriptions, or digital goods. Apple has guidelines for developers on using the freemium model, and that the "path to monetization is through engagement, and when users are given time to enjoy an app, they may be more inclined to invest in paid features."[34]
3. subscription model: users can buy in-app purchases to access content, services, and experiences for renewable or non-renewing durations.
4. paid model: users pay once to download an app, and use all of its functionality, with no additional charges.
5. paymium model: users pay to download an app and have the option to buy additional features, content, or services through in-app purchases.

Google also suggests five business models app developers may consider in order to maximise revenue:[35]

1. in-app purchases: users make in-app purchases for items and additional features, or to remove ads.
2. subscriptions: offer users ongoing access to content or services for a recurring fee.
3. advertising: developers are paid to show relevant ads from over a million advertisers with Google's AdMob platform. Google suggests that "well-placed, well-targeted ads in apps, particularly free apps, can achieve good click-through rates while preserving the app's user experience."[36]
4. paid apps: users pay a price for an app before they can download and install it.
5. e-commerce: use Android Pay to sell physical goods and services from your app.

Looking at these suggested business models, the following stands out. First, Apple mentions that developers may want to display ads within the free model, but does not suggest a stand-alone advertising model. In contrast, Google does not suggest a free model, but instead includes an advertising model. Second, Apple does not seem to suggest the e-commerce model, while Google suggests such a model, and promotes its Android Pay platform in this regard. Third, Google does not seem to suggest a free model as a business model, where there is no in-app advertising and no in-app purchases. In this regard, while Apple does mention that the free model may include in-app advertising, it would seem more appropriate to draw a clear distinction between the free model without advertising, and the free model with advertising, as some of the most successful apps (e.g. WhatsApp, Instagram, Snapchat), adopted the free model with no in-app advertising to build a large user base, before then moving to a free model with in-app advertising (e.g., Instagram and Snapchat), or aiming for an acquisition (e.g., WhatsApp and Instagram).

An important consideration for app developers is the revenue split between an app developer and the app platform. While Apple and Google do not charge hosting fees for apps made available on the App Store and Google Play, it should be noted that under the Apple Developer Programme, developers receive 70% of sales revenues, while Apple receives 30%. Similarly, under the Google Play Console programme, developers receive 70% of sales revenue, while Google receives 30%. Notably, in 2016, Apple introduced a new revenue structure for developers making their apps available through subscriptions. For the first year of the subscription, the developer receives the same 70%, but if it retains a user for more than one year, the share increases to 85%. Similarly, in 2017, Google announced that from January 2018, developers will receive 85% of revenue from subscriptions retained after 12 paid months.

Thus, taking account of Apple's and Google's suggested business models, and the points made above, a preliminary typology of business models is as follows:

1. free model: users do not pay to download app, with no in-app purchases, and no advertising.
2. advertising model: users do not pay to download app, with no in-app purchases, but with in-app advertising.

3. freemium model: users do not pay to download app, but with in-app purchases for additional content or features, and may include in-app advertising (and an in-app purchase to remove advertising).
4. subscription model: users do not pay to download app, but with in-app subscription for ongoing access to content or services for a recurring fee, and no advertising.
5. pay model: users pay a fee to download app, with no in-app purchases, and no advertising.
6. paymium model: users pay a fee to download app, with in-app purchases for additional content or features, and no advertising.

A. *In-app purchases*

Given the prominence of in-app purchases in the game app economy, it should be noted that both Apple and Google exercise a considerable degree of control over this. First, within the Apple ecosystem, developers may use Apple's StoreKit framework to offer app in-app purchases. Developers that use the In-App Purchase API for "fee-based content," are subject to additional terms under the Apple Developer Program License Agreement, and in-app products are reviewed as part of the app review process, submitted through an iTunes Connect account. Apple allows in-app purchases to sell content (such as additional characters and levels in a game), functionality (such as a free game that offers multiplayer mode as an in-app purchase), or services (users pay for one-time services or ongoing services), but they can't be used for "Real-world goods and services "[37].

Within the Google ecosystem, developers must use Google's In-App Billing API for in-app purchases offered within an app made available on Google Play. Similar to Apple, in-app purchases can only be used for "digital products" within an app, and cannot be used "sell physical products, personal services, or anything that requires physical delivery"[38]. Finally, Google requires that developers "charging for apps and downloads from Google Play must use Google Play's payment system," and developers "offering products within a game downloaded on Google Play or providing access to game content must use Google Play In-app Billing as the method of payment"[39]. The Google Play In-app Billing API is free to download[40].

Importantly, Apple and Google are in a position to alter the mechanisms of in-app purchases to respond to regulatory concerns, which was evident in the controversy surrounding in-app purchases by children. In 2014, Apple settled with the Federal Trade Commission (FTC), agreeing to change its billing practices to ensure express, informed consent from consumers before charging them for in-app purchases[41]. Apple also agreed to issue refunds of over $32.5 million to consumers who were billed for in-app purchases by children and were either accidental or not authorized by the consumer. Similarly, in 2014, Google settled with the FTC, agreeing to modify its billing practices to ensure express, informed consent from consumers before charging them for items sold in mobile apps[42].

V. THE RELATIONSHIP BETWEEN USER DATA, BUSINESS MODELS AND APP MONETISATION

This section connects the preceding discussion of the data-driven nature of app business models and discusses the role of mobile app platforms in shaping this monetisation. Thus, the paper delves a little deeper into Google and Apple's ecosystems, moving beyond the suggested business models described above to the tools that are made available to developers for data-driven monetisation. Google's developer platform (Google Play Console) and Apple's developer platform (Apple Developer Program) were examined in more depth. It should be noted that Alphabet made a number of acquisitions recently in the area of app developer analytics, including acquiring the Fabric developer platform from Twitter in January 2017, after acquiring the Firebase platform in 2014. Notably, many other companies provide app analytics software, including Facebook Inc., which offers a number of tools to app developers in order to monetise apps, including in-app advertising (Facebook Audience Network) and user analytics (Facebook Analytics). Facebook's analytics platform for developers is Facebook Analytics, for use in both the Apple and Google ecosystems.

A. *Google's developer ecosystem and monetising user data collection*

Within Google Play Console, a number of software tools are offered to developers in order to "increase your paying users" with "insights into user behaviour by data on up to 500 in-app events"[43].

First, within the Google Play Console, developers may use Firebase, which is a Google platform with tools to "grow your user base, and earn more money"[44]. Google also makes the Firebase software development kit (SDK) available for free for iOS developers, and use with Apple's Xcode and Swift platforms (discussed below)[45]. This Firebase SDK includes Google Analytics for Firebase (collects usage and behaviour data), Firebase Predictions (predict app user behaviour), and AdMob (in-app targeted advertising). The Google Analytics for Firebase SDK allows a developer to collect data on over 500 "events" within an app and an app's "user properties"[46]. Firebase automatically collects (more precisely, facilitates collection of) data on a number of events, including when a user launches an app, completes an in-app purchase, when the user's device is updated, and when an app is uninstalled on a user's device[47]. A developer can initiate collection of data on other events, such as when a user logs in, when a user searches within an app, when a user has shared content, which methods a user uses to sign in ("which methods of sign-up (e.g., Google account, email address, etc.) are most popular.") and when a user spends virtual currency[48]. Notably, Firebase also automatically collects certain "user properties" from an app, including a user's age, country, gender, interests, device model name, and device language[49]. On Android devices, Firebase collects demographics and interests data from the Android Advertising ID, and "Analytics generates an identifier based on the ID that includes demographic and interest information associated with users' app activity"[50]. Firebase notes that on iOS devices, the app must collect Apple's Advertising Identifier (IDFA), which is an "alphanumeric string unique to each device, used only for serving advertisements"[51].

Second, Firebase Predictions allows developers to create user groups that can be used for targeting with notifications from the Firebase console[52]. This helps developers "engage users before they churn, and reward users who are likely to make in-app purchases"[53]. For example, developers can send a notification message advertising certain in-game goods to users who are predicted to spend based on recent events. Moreover, Firebase Predictions allows developers to "provide an ad-free experience to users who are likely to make in-app purchases in the future, and show ads to everyone else"[54]. Finally, Firebase Predictions can be used to (a) optimise monetisation strategies, (b) optimise in-app promotions: promote more expensive premium bundles to users likely to spend, and promote less expensive basic bundles to other users,[55] and (c) prevent churn: identify users who are likely to disengage from an app, and apply a user retention strategy to those users.[56]

Firebase, Google Analytics for Firebase, and Firebases Predictions may be used by most app developers, although Firebase does include a focus on games)[57]. The Google Play Console platform does provide specific tools for game apps. Google states that "gathering analytics is a key component of offering a game as a service and is also an increasingly important part of running a successful mobile games business"[58]. Two notable tools are available for game app developers within Google Play Console, namely Player Analytics and the Player Stats API. Player Analytics helps apps with gathering analytics, which are considered to be a key component of offering a game as a service and an increasingly important part of running a successful mobile games business more generally. Google encourages developers "to help get more players using game services, make Google Account sign-in more visible in your game"[59]. For users signed in with their Google Account player engagement statistics are collected on the basis of players' activity.

Developers can use the Player Stats APIs to retrieve data about a player's in-game activity, including:

1. Spend percentile: the approximate spend percentile of the player, given as a decimal value between 0 and 1. This value indicates how much a player has spent in comparison to the rest of the game's player base.
2. Spend probability: the approximate probability of the player choosing to spend in a game, given as a value between 0 and 1.
3. Total spend next 28 days: The approximate total amount a player is expected to spend over the next 28 days in a game.
4. High spender probability: The approximate probability that over the next 28 days a player will spend an amount that is in the 95th percentile or higher of a game's player base.

Finally, the Google Play Games Services SDK allows developers to "collect cumulative data generated by your players during gameplay and store them in Google's servers for game analytics" and use analytics to understand how players are "progressing, spending, and churning"[60].

In 2016, Google integrated its AdMob mobile advertising platform with Firebase, to make it "simpler to use AdMob along with other Firebase services such as Analytics"[61]. AdMob uses Google Mobile Ads SDK, which allows developers to show ads from millions of Google advertisers, or use AdMob Mediation, to earn "from over 40 premium networks"[62]. AdMob allows a developer to provide "targeting information to an ad request," including a user's gender ("If your app already knows user's gender, it can be supplied in the ad request for targeting purposes. This information is also forwarded to ad network mediation adapters."), and a user's date of birth ("If your app already knows user's birthday, it can be supplied in the ad request for targeting purposes. This information is also forwarded to ad network mediation adapters.")[63]. AdMob analytics helps "make smarter data-driven decisions to improve your monetization strategy with AdMob's robust app analytics across ad networks"[64].

B. Apple's developer ecosystem and monetising user data collection

Apple also makes tools available to developers within the Apple Developer Programme to "measure user engagement, marketing campaigns, and monetization"[65]. One of these tools is App Analytics on iTunes Connect, which is included with the Apple Developer Programme membership, and requires no technical implementation. The App Analytics tool includes a number of data sources, including impressions, sales, and installations, user retention for an app over time, filter metrics by purchase date, territory, source, and track and measure the performance of marketing campaigns. App analytics includes the following features:

1. Paying users: a user count metric based on Apple ID instead of device type, which provides a precise look at paying user data.
2. User engagement: App Analytics provides user engagement metrics, including number of sessions, active devices, and retention. With these metrics, developers can evaluate the impact of product changes.
3. User acquisition marketing: this metric helps developers understand which sources of marketing drive product page views, downloads, engagement, and monetization.

Apple suggests to developers that the "path to monetization is through engagement, and when users are given time to enjoy an app, they may be more inclined to invest in paid features"[66]. Apple emphasises the importance of data analytics, stating that "Successful freemium apps have analytics built into the experience so that developers can understand user preferences and continually improve the apps"[67]. Apple states in its App Analytics Guides that "All data is aggregated, and no personally identifiable information for any customer is shown. Apple does not share or publish your data with other developers"[68].

The dependency on user data analytics creates a certain weariness in the app industry about increased end-user control over behavioural advertising and related tracking. Notably, Zynga Inc. stated that mobile devices "increasingly contain features that allow device users to disable functionality that allows for the delivery of advertising on their devices." Thus, "when Apple announced that UDID, a standard device identifier used in some applications, was

being superseded and would no longer be supported, application developers were required to update their apps to utilize alternative device identifiers such as universally unique identifier, or, more recently, identifier-for-advertising, which simplify the process for Apple users to opt out of behavioral targeting. If users elect to utilize the opt-out mechanisms in greater numbers, our ability to deliver effective advertising campaigns on behalf of our advertisers would suffer, which could cause our business, financial condition, or results of operations to suffer"[69].

VI. Furthering Transparency About the Collection and Use of Data

Transparency about the collection and use of personal data is at the core of data privacy frameworks in Europe and the US. In this final section we will discuss the state of transparency with respect to the collection and use of data within the mobile game app economy, examining the mechanisms and requirements, if any, that Apple and Google provide to developers seeking to collect and use data.

A. Transparency requirements imposed by app platforms

As recognised by companies such as Rovio, EA, and Activision Blizzard, the App Store and Google Play have "significant influence"[70] over the distribution of apps, including through their policies and guidelines that control the features and functionalities of apps. In this regard, both Apple and Google can influence transparency about the collection and use of user data. There are a number of layers in this potential role of the ecosystem providers in governing transparency by apps, including accessing the developer platform, app design within the developer platform, uploading the app for distribution within an app store, and the app store review process.

The first layer are the agreements developers must agree to in order to gain access to the developer platforms, namely the Google Play Console and the Apple Developer Program. In order to distribute an app on the Apple App Store, a developer must enrol in the Apple Developer Program and agree to the Apple Developer Program License Agreement. This agreement has a clause concerning transparency about the collection and use of personal data, stating that developers "must provide clear and complete information to users regarding Your collection, use and disclosure of user or device data, e.g., a link to Your privacy policy on the App Store"[71]. Moreover, "Applications that offer location-based services or functionality must notify and obtain consent from an individual before his or her location data is collected, transmitted or otherwise used by the Application"[72].

The second layer within the Apple ecosystem is that before an app can be uploaded for distribution in the App Store, a developer must upload a record of the app to iTunes Connect, which is an online tool within the Apple Developer Program to manage "My Apps," App Analytics," "Sales and Trends," "Payments and Financial Reports," and "Agreements, Tax and Banking." Notably, Apple requires certain information about an app to be provided when it is uploaded to iTunes Connect, and other optional information, which is displayed in the Apple App Store. Within iTunes Connect, it is "optional" to include a "Privacy Policy URL". However, "Privacy policy URLs are required for all apps that offer auto-renewable subscriptions, apps that are set to Made for Kids, and apps that contain Research Kit"[73].

The third layer concerns in-app purchases. Apple requires a developer to agree to a further agreement (Paid Applications Agreement) within iTunes Connect concerning paid applications. This agreement has a specific clause on transparency where subscriptions use the In-App Purchase API. A developer must "clearly and conspicuously disclose" to users regarding the auto-renewing subscription "Links to Your Privacy Policy and Terms of Use"[74]. There is no such requirement with non-subscription in-app purchases.

The fourth layer is submission of apps for App Review through iTunes Connect. The app must comply with the Advertising Identifier (IDFA) usage, where the developer must indicate whether the app uses the IDFA. The IDFA is a unique ID for each device and is the only permitted way to offer targeted ads. Apple imposes responsibility of the app for third-party code behaviour, including compliance with the usage limitations of the Advertising Identifier and the Limit Ad Tracking setting[75]. The Apple Developer Licence Agreement bans the use of the Advertising Identifier for any other purpose than serving advertising[76]. Moreover, it requires apps to respect a reset of the identifier, banning apps to infer the old number[77]. Finally, it bans the use of analytics software to collect and send device data to third parties and bans the use of any "permanent, device-based identifier, or any data derived therefrom, for purposes of uniquely identifying a device"[78].

Finally, apps are subject to the App Store Review Guidelines, which include a section on privacy. This section contains a number of transparency requirements, including (a) "apps that collect user or usage data must have a privacy policy and secure user consent for the collection," (b) "your app description should let people know what types of access (e.g. location, contacts, calendar, etc.) are requested by your app, and what aspects of the app won't work if the user doesn't grant permission," (c) "apps may not require users to enter personal information to function, except when directly relevant to the core functionality of the app or required by law," (d) "You may not use or transmit someone's personal data without first obtaining their permission and providing access to information about how and where the data will be used," and (e) "Data collected from apps may not be used or shared with third parties for purposes unrelated to improving the user experience or software/hardware performance connected to the app's functionality, or to serve advertising in compliance with the Apple Developer Program License Agreement"[79].

Thus, during the development of an app, Apple encourages developers to be transparent about the collection and use of personal data by providing a privacy policy link in the App Store. However, this not a strict requirement within iTunes Connect, although where an app offers subscriptions, a privacy policy must be included. Notably, the Apple Developer Program License Agreement does include a clause that "You may not use analytics software in Your Application to collect and send device data to a third party" but there is not a similar clause concerning user data[80]. Of course, a reasonable question can be raised over whether privacy policies are an adequate means of ensuring transparency for users.

In the Google ecosystem, the first layer in order to distribute an app in Google Play is for a developer to create a Google Play Developer account and accept the Google Play Developer Distribution Agreement. This includes a clause that if an app "accesses or uses, user names, passwords or any other login information or personal information," then the developer "must make the users aware that the information will be available to your Product and you must provide a legally adequate privacy notice and protection for those users"[81].

The second layer is uploading an app within Google's developer platform, the Google Play Console. This requires that a developer "provide a privacy policy URL for this application," or tick a box "Not submitting a privacy policy URL at this time." It also includes a link to "please check out our User Data policy to avoid common violations." This User Data policy begins by stating "You must be transparent in how you handle user data (e.g., information provided by a user, collected about a user, and collected about a user's use of the app or device), including by disclosing the collection, use, and sharing of the data, and you must limit use of the data to the description in the disclosure"[82].

Notably, if an app "handles personal or sensitive user data (including personally identifiable information, financial and payment information, authentication information, phonebook or contact data, microphone and camera sensor data, and sensitive device data) then your app must: Post a privacy policy in both the designated field in the Play Console and from within the Play distributed app itself"[83]. "Make sure your privacy policy is available on an active URL, applies to your app, and specifically covers user privacy"[84]. Further, there are additional transparency requirements, in the form of a "Prominent Disclosure Requirement," where an app "collects and transmits personal or sensitive user data unrelated to functionality described prominently in the app's listing on Google Play or in the app interface"[85].

VII. Conclusion and Discussion

Our study illustrates that the increasingly dominant business model within the game app economy is free-to-download apps, with data mining, analytics and targeting being used to encourage users to make in-app purchases. This was evident from the financial filings of major global companies that are dominant in the game app economy currently, and from the pilot study undertaken examining a selection of popular game apps. Due to the increased importance of personal data for the digital economy, we find that financial filings of companies are increasingly useful as a resource for privacy research. In looking at the way in which financial statements discussed the importance of data and relationship with the app platforms, we only scratched the surface of what we believe is possible looking at this source of information on relevant business practices.

Furthermore, the paper demonstrates evidence of consolidation in the game app market, and the influence both Apple and Google wield within this market on multiple levels. It seems that both the Apple and Google ecosystem, in particular through their developer platforms, facilitate, encourage and shape the use of user data analytics to optimize in-app purchase revenues. This was seen through examination of the tools and information made available to developers in particular. Considering the profitability of the freemium business model, combined with revenue sharing conditions, the platforms have significant incentives to help games optimize such revenues. More generally, we believe that the platforms can be expected to set the conditions under which data and data analytics become available to developers for game apps and other apps, in view of the potential impact on these game app revenues.

Both Apple and Google include clauses within license agreements with developers, such as "data collected from apps may not be used or shared with third parties for purposes unrelated to improving the user experience or software/hardware performance connected to the app's functionality." The question is about how adequate data protection can be ensured once user data is transferred to developers and third-party data analytics and advertising networks. A related point was similarly made by Sandy Parakilas, a former operations manager on Facebook's developer platform, which hosted games such as Farmville (developed by Zynga Inc.) and Candy Crush (King), stating that "there were no protections around the data they were passed through Facebook to outside developers"[86]. Indeed, "once data passed from the platform to a developer, Facebook had no view of the data or control over it"[87].

In the game app context, it is clear that in-app purchase optimization practices run the risk of harming vulnerable users. Generally, the economics of the industry are similarly troubling, in certain respects, as in the case of gambling, because of the inherent incentives to exploit the weaknesses of players to spend much more on the game than any other player. In what situation does behavioural discrimination turn into a form of undue exploitation that requires regulatory intervention because of social welfare and public interest perspectives? Currently the platforms appear to have weak incentives to impose restrictions in view of vulnerable users, in view of their 30% share of collected revenues.

Given the amount of user data collected and the detailed monitoring of in-app activity, the question must be raised whether provisions in developer privacy policies are sufficient to adequately inform users about the extent of data collection and use in the case of data-driven monetization. In particular, the question arises as to how game app developers can adequately satisfy the transparency requirement in EU data protection law. Should game apps be required to be more up front about their attempts to make users spend as much money on the game as possible? Perhaps users would be able to make better judgments if they were informed how much they spend on the game in relation to other users? While adding further specificity to privacy policies may have some value, we consider it worth exploring whether more targeted mechanisms, such as those developed for the collection and use of location data, could be more effective in informing users. Such research could be combined with a more in-depth exploration of users' game experience, including the ways in which different users are confronted with different in-app purchasing offers.

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