App Store Competition*

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Abstract

We study within-device competition between integrated and third-party app stores. We find that if the integrated store enjoys a default advantage and app developers earn complementary revenues from advertising or data linked to their subscriber base, the market tends toward a natural monopoly. Thus, head-to-head competition is unlikely to reduce commission fees. The reason is that developers incentives to obtain complementary revenues leads to a negative pass-through of commission fees to app prices, which in turn creates incentives for developers to adopt price parity across stores, thereby weakening consumers' incentives to install third-party alternatives. We then study how competition is affected by the presence of superstar apps, the provision of exclusive content or functionality by third-party stores, and the introduction of choice screens that eliminate default advantages. We find that the first two policies are likely to allow for effective competition, but may not decrease commission fees (and in some cases may increase them), while elimination of the default advantage has ambiguous effects. Moreover, we show that side-loading is more likely to be effective that app store competition in reducing commission fees.

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1 Introduction

App stores have been heavily scrutinized, gathering complaints by app developers over allegedly excessive commission fees. Apple's App Store and Google Play are the main platforms for the Apple and Android ecosystems, and have traditionally charged a 30% commission for in-app purchases and subscriptions.[1] Some large app developers have tried to circumvent default stores by side-loading apps and launching third-party stores. Epic Games sued Apple and Google in 2020, and Samsung in 2024, for blocking or hindering the possibility of launching or installing third-party stores.[2] In 2025, the UK CMA started a market investigation on Apple which has gained strong market power due to a combination of exclusivity clauses, limited competition with Android devices and high consumers' switching costs.[3]

In 2023, the European Commission designated Apple's App Store and Google Play Store as *Core Platform Services* under the *Digital Markets Act* (DMA). Article 6 of the DMA stipulates that gatekeepers must allow third-party stores to be installed and function seamlessly within their operating systems and that app developers should be able to communicate directly to consumers their alternative cheap offers. Conventional wisdom suggests that introducing competition would reduce commission fees and benefit developers.[4]

In this paper, we study the effects of within-device app store competition on commission fees, developer profits, and consumer surplus. We identify intended and unintended outcomes that may arise in a context in which a pre-installed *integrated* app store (e.g., the App Store on iPhones and iPads, Google Play on Android devices, and AppGallery on Huawei devices) competes with a *third-party* store.[5]

We present a general and tractable model of a two-sided market where developers provide apps and sell them to consumers through competing app stores. Consumers have already purchased a device (e.g., an iPhone) and decide how many apps to subscribe after observing their prices and given their heterogeneous valuations for the apps.[6] App developers choose subscription prices and earn additional revenues in a complementary market (e.g., ads). Consistent with current practices, app stores set *ad valorem fees* on subscription prices but not on complementary revenues.

[1]Beginning in January 2021, businesses with earnings below $1 million became eligible for a reduced 15% commission rate on the App Store. A similar reduction was introduced by Google in July 2021.

[2]See https://www.theverge.com/23959932/epic-v-google-trial-antitrust-play-store-fortnite-recap and https://www.theverge.com/policy/2024/9/30/24256395/epic-sues-google-samsung-antitrust-auto-blocker.

[3]See https://assets.publishing.service.gov.uk/media/67911972e2b9324a911e26db/Apple_investigation_notice.pdf.

[4]For example, the UK Competition and Market Authority (CMA) states that "[i]f other distribution channels were effective constraints on the App Store and Play Store, we would expect to see lower commission rates or increased quality" (CMA, 2022, p.82).

[5]While Apple Store is integrated with iOS, Google had agreements with manufacturers that ensure the Play Store is pre-installed and prominently displayed on the home screen of most Android devices.

[6]As noted by the CMA, "[u]sers rarely switch between iOS and Android devices—with material perceived barriers to switching, such as losing the ability to connect to other personal smart devices. These concerns are higher among Apple users" (CMA, 2022, p.28).

In our baseline model, the two stores provide the same value to consumers. The integrated store has a *default* advantage because it is pre-installed on devices whereas the third-party store must be installed by consumers. Beside this difference, the app stores have no quality differences, and once developers create an app for a device, they can make it available on both stores at no additional cost.[7] Consumers have heterogeneous adoption costs, so they may single-home on the integrated store or multi-home by installing the third-party store. Multi-homing consumers purchase apps from the store where prices are lower.

We find that as the ad valorem fee rises, developers' marginal revenue from subscriptions decreases, so they have incentives to lower prices to increase revenues from complementary markets. This result is known as the Edgeworth Paradox. Thus, if the third-party store chooses a *smaller fee* than the integrated store, developers would want to set a *higher price* for their apps in that store. However, in this case, all consumers would buy their apps from the integrated store, which is suboptimal for developers because they prefer to sell as much as possible in the store with the lowest fee. As a result, developers find it optimal to choose the same prices across stores. This self-imposed *price parity* implies that consumers do not have any incentive to install the third-party store, because doing so is costly and provides no additional value.

As a consequence of this result, *undercutting* the ad valorem fee set by the integrated store is ineffective for inducing customers to install the third-party store.[8] In equilibrium, the integrated store monopolizes the market, and since it anticipates that it will serve all the market regardless of the fee set by the third-party store, it chooses the fee in the same way it would choose it if it did not face competition. These results remain robust when the integrated store sets an ad valorem fee while the third-party store imposes a per-unit fee (e.g., a fee for each app downloaded through its store). In this scenario, the Edgeworth Paradox does not arise, and the per-unit fee introduces a double marginalization problem, which leads to a higher price on the integrated store. The third-party store, too, finds it optimal to self-impose price parity. However, since both stores are symmetric from the consumer's perspective and adopting the third-party store incurs additional costs, no consumers choose it in equilibrium.

We then examine how competition between the two app stores can effectively materialize. Specifically we focus on the case in which a certain mass of consumers has installed the alternative store. This can be microfounded in different ways, such as the alternative store offering higher quality or securing access to exclusive apps. To avoid unreasonable mixed-strategy equilibria, we assume that the stores set fees sequentially, with the integrated store acting as the first mover.[9] We find that the average commission fee remains unchanged but

[7]The reason is that apps run on the same operating system, regardless of the distribution channel from which they are downloaded. For example, Apple developers must have an Apple account whenever they want to develop an app for third-party marketplaces operating on Apple iOS. This approach contrasts with situations where developers need to create apps for two different ecosystems (Apple and Google), which can involve costly porting.

[8]Raising the fee over the integrated store's fee would also not work for the third-party store, because then developers would prefer not to sell through this store.

[9]This can be reconciled with the incumbency advantage that a manufacturer has over third-party rivals, or with transparency obligations imposed by regulation on gatekeeping platforms (see, e.g., the DMA).

consumer surplus is now increases.

Secondly, we consider the possibility of sideloading, that is, the possibility of a developer to bypass the compulsory fee by diverting consumers to another page where they can purchase the game at a lower price. This practice was central to the lawsuits Epic Games v. Google and Epic Games v. Apple. In April 2025, a Supreme Court judge ruled that Apple had "willfully" failed to comply with anti-steering provisions and and now prevents Apple from collecting any fees from third-party storefronts and from imposing restrictions on app interfaces or blocking external links. In the same month, the European Commission found Apple not compliant with the anti-steering obligations under the DMA. To gain insights, we extend our baseline model to the case in which app developers can generate out-of-store untaxed transactions. We find that this alternative is more likely to be effective that app store competition in reducing commission fees and always benefits both developers and consumers, exerting a pressure on the integrated store.

Finally, we provide multiple extensions of our analysis. We consider the case in which app developers incur a marginal cost for serving each consumer. While digitization has brought marginal costs close to zero, it is increasingly common for consumption to be costly for app developers due to computing and storage expenses (see, e.g., AI-based apps). We find that in this case the endogenous price parity breaks up and there is a (positive) pass-through of the commission fee on prices when the marginal cost is higher than the complementary revenues. Moreover, we examine a potential remedy: a regulatory choice of eliminating a default advantage. This regulatory intervention reflects recent interventions such as those under the DMA, which aim to counteract default advantages by encouraging upfront user choice in the search engine and browser market. Upon first use, consumers choose between two app stores (the integrated store and a third-party option) at no cost, removing default advantages and allowing single-homing on the third-party store.Counterintuitively, this results in a "race to the top," with rising commission fees that drive app prices toward zero and shift developers' revenue models to complementary sources. Developers and the integrated store are worse off relative to the baseline model, and consumers may be better or worse off. However, there are also two other equilibria, on in which developers single-home on the store with the lowest fee or the one with the highest fee and in such a case no consumer would multi-home.

Related Literature. To the best of our knowledge, ours is the first paper studying within-platform app store competition.

The closest paper to ours is Jeon and Rey (2024), who study how the competition between integrated device manufacturers affects device prices, ad valorem fees, and app development. They find that competition between platforms leads to higher fees than what would maximize consumer surplus and social welfare. In their framework, raising the commission on one platform reduces the number of apps available on the rival platform, particularly when developers can easily port their apps between platforms (economies of scope). This effect discourages app development. While Jeon and Rey (2024) suggest that improving competition within a platform might better support app development and consumer welfare, we find that in the context of an integrated store benefiting from its default status, within-device app store competition may fail to materialize. Importantly, under some conditions, if competition occurs between a *superstar developer*, launching its own app store together with its superior app and offering free access to developers (sponsored app store), the fee of the integrated store might even raise.

Our paper also relates to Teh and Wright (2024), who develop a general framework to analyze how platforms' design of multiple instruments—such as commission fees, market entry, self-preferencing, and price parity clauses—affects sellers and overall welfare in two-sided markets. In competitive bottleneck settings, even when platforms compete for buyers, they act as gatekeepers for sellers, often leading to distorted outcomes that harm sellers. They find that when competition between platforms generates spillovers (e.g., when fees set for sellers impact users' utility on another platform), distortions are more likely to be amplified. These negative externalities cause platforms to compete less vigorously for sellers, leading to higher fees and more restrictive policies. Teh and Wright (2024) conclude that addressing these distortions may require policy interventions, such as preventing platforms from banning third-party stores.

Etro (2023) examines platform competition where platforms compete for single-homing buyers through device pricing while charging sellers (i.e., developers) ad-valorem fees. He finds that competition between platforms via device pricing leads to the redistribution of commission revenues to buyers.

Our paper also relates to recent works on the transaction fees set by an online monopolist. Anderson and Bedre-Defolie (2024) also consider a market in which a platform sells devices and makes revenues from apps fee. They analyze a platform serving consumers with varying preferences for app quality, which limits the platform's ability to fully exploit the benefits of higher-quality apps. Their findings suggest that the platform overcharges on both sides of the market, resulting in suboptimal app quality and reduced consumer participation. Additionally, while limiting app commissions could expand the app base, it would also lead to higher consumer prices, ultimately lowering consumer welfare. We focus instead on within-platform competition for a given decision of consumers on their device.

Relatedly, D'Annunzio and Russo (2024*b*) examine the distortions that arise when ad valorem transaction fees are applied to revenues from app developers using freemium pricing strategies, where developers endogenously determine the quality of both free and premium versions of their products. The authors show that such fees reduce the developers' incentive to distort the quality of the lower-tier product, potentially improving consumer surplus and total welfare. However, the fee also distorts the quality of the premium version. Thus, the platform may set fees that exceed the socially optimal level. Furthermore, they demonstrate that when platforms earn revenue from complementary sources, such as device sales or ads, they tend to set even higher fees, as access and transaction charges act as complements rather than substitutes. This mechanism is different from the one inducing a positive relation between ad valorem fees and app prices in our paper (the Edgeworth Paradox).

Gans (2024) studies how app store's fees affect consumer and developer welfare. He shows that the unregulated commission fee chosen by a monopolist device maker maximizes consumer surplus.[10] App developers would prefer a lower commission rate, but reducing the commission further would shift the burden to consumers through higher device prices. He also finds that eliminating app commissions leads to higher device prices, both in absolute terms and when adjusted for quality.

The above papers do not focus on how transaction fees and pricing strategies are affected by the introduction of a competing app store. Some other recent papers have focused on the regulation of commission fees and whether they are excessive relative to the level that maximizes social welfare, developer welfare, or consumer surplus. Wang and Wright (2025) focus on the platform's decision to set fees platform's fee and their regulation in a context in which consumers have the possibility to engage in disintermediation and buy from the direct channel of sellers, which is not present in our case. Bisceglia and Tirole (2023) focus on regulation of access fee on a competitive bottleneck platform. The paper highlights the importance of "zero lower bound" constraints on both core services (e.g., app stores or search engines) and digital goods (e.g., apps).

Heresi and Lefouili (2024) study instead how the decision of an app store about the fee affects the business model chosen by the apps, which is the key feature in their model. This constrains the ability of an app store to see a higher fee since app developers might have incentives to become ad-based. This aspect is also present in our model since a higher fee reduces the app price and, when it becomes too high, induces developers to monetize only via complementary revenues. Carroni, Madio and Shekhar (2024) examine how the presence of superstars in platform markets and their incentives for exclusivity influence platform competition. In our context, a superstar app can help the an alternative store to emerge and compete with the default platform.

This paper also relates to a recent stream of literature on self-preferencing and steering such as De Corniere and Taylor (2019) and Heidhues, Kösters and Kîoszegi (2024), among others. We do not focus on steering and self-preferencing, rather we emphasize the role of integrated stores in shaping developers' incentives to develop new apps via fees.

Finally, our paper contributes to the literature on the Edgeworth Paradox, which shows that, when subject to ad valorem taxation on a subset of its products, a multi-product monopolist has an incentive to lower the price of the taxed good and shift marginal gains to untaxed products. Recent contributions to this literature include Armstrong and Vickers (2023) and D'Annunzio and Russo (2024*a*). We demonstrate that this effect applies in the context of app stores, where stores tax apps on in-app purchases and subscriptions but not on complementary revenue sources such as ads. A related paper is Miao (2022), though it does not endogenize store fees or focus on competition between app stores.

[10] Jeon and Rey (2024) find a similar result for a duopoly platform.

Structure. The structure of the paper is as follows. In Section 2 we present the model setup. In Section 3 we solve the baseline model of app store competition. In Section 4 we present our main results in the context in which the third-party store provide standalone functionalities. In Section 5 we consider how competition changes in the presence of a superstar app. In Section 6 we consider the economic effects of side-loading practices by the app developers. In Section 8 we provide a conclusive remarks. Proofs for the main results of the paper are in Appendix A.

2 Model Setup

Two app stores, $i = A, B$, mediate transactions between app developers and consumers. Each consumer owns a device (e.g., a phone or tablet), and wants to install apps on it. Developers can develop apps and distribute them through one or both stores. In addition to earning revenue from selling apps (subscriptions) to consumers, developers obtain complementary revenues from a separate market. For example, a developer may sell subscriptions to a music app and obtain complementary revenues by monetizing ads or consumer data.

Store A is an *integrated store*—owned by the device manufacturer—and is pre-installed on consumer devices. Store B is a *third-party store* and must be installed by consumers before they can use it to purchase apps. Stores compete to attract consumers and developers, and profit by charging ad valorem fees on the prices charged by developers for their apps.[11]

Users. There is a continuum of consumers of mass 1. Each consumer has an idiosyncratic valuation $v_i \geq 0$ for each app i, drawn independently from a distribution with a twice-differentiable cumulative distribution function (CDF) F over $\mathbb{R}_+$, where $F'(0) > 0$. Following Jeon and Rey (2024), we assume that valuations are independent across consumers and apps. A consumer's valuation for a given app is the same across stores. Thus, the integrated store has no advantage in terms of app integration or performance. For simplicity, we assume that if a consumer is indifferent between purchasing an app from either store, she chooses B.

Whenever a consumer installs store B, she incurs an adoption or installation cost $\sigma > 0$, drawn independently from a distribution with twice-differentiable CDF $G(\sigma)$ over $\mathbb{R}_+$, where $G'(0) > 0$. This cost implies that the integrated store has a *default advantage*. In Section 4 we consider a case in which store B provides a standalone benefit to consumers, which may partially offset A's default advantage.

In what follows, let m represent the measure of consumers who install B (and therefore multi-home across stores). Consumers who do not install B can only make purchases through A. Thus, $1 - m$ represents the measure of single-homing consumers.

[11]In our setting, fees encompass multiple store activities, including permission to sell the app, certification, and payment processing.

App Developers. There is a continuum of developers of mass 1. Each developer has a fixed development cost $k_i \geq 0$, drawn independently from a distribution with CDF H over $\mathbb{R}_+$. Since we are dealing with digital goods, marginal costs are equal to zero.[12]

We assume that porting an app to either store is costless. That is, after developing an app, a developer does not pay additional costs for joining one or both app stores.[13]

Each developer i sets a price p_{ij} for its app on store $j = \{A, B\}$ and earns complementary revenues $\lambda \geq 0$ from each subscriber. To prevent a situation in which developers set prices equal to zero, we assume that

$$\lambda < \bar{\lambda} \equiv \frac{1 - F(0)}{F'(0)}, \tag{1}$$

which guarantees that developers charge positive prices in equilibrium. If (1) does not hold, equilibrium prices (and stores' profits) are zero, which implies that ad valorem fees have no effect on consumers and developers.

Let a and b be the ad valorem commission fees charged by A and B. If developer i develops its app and sells q_{iA} subscriptions in A and q_{iB} in B, its profit is

$$q_{iA}\left[(1-a)p_{ia} + \lambda\right] + q_{iB}\left[(1-b)p_{ib} + \lambda\right] - k_i.$$

In what follows, let n be the number of developers developing an app.

App Stores. Consistent with current practices, we assume that fees are levied on monetary transactions and not on the revenues that developers earn in complementary markets. Given app prices p_{ij} and subscriptions q_{ij}, the profits of stores A and B are

$$\Pi_A = \int_0^n a\, p_{iA}\, q_{iA}\, di, \qquad \Pi_B = \int_0^n b\, p_{iB}\, q_{iB}\, di.$$

Timing. The timing of the game is as follows. In the first stage of the game, each app store chooses its commission fee. In the second stage, each developer decides whether to develop an app, and through which store(s) to sell it. Then, in the third stage, each consumer decides whether to install store B. In Stage 4, each developer chooses the price for its app on each store in which it is present. Finally, in the last stage of the game, each consumer decides which apps to consume, and from which store to buy each of them. The equilibrium concept is subgame perfect Nash equilibrium.

[12] Our main results are robust to the introduction of a marginal cost of production, as long as this cost is smaller than the complementary benefit λ discussed below. In Section 7, we study the case in which marginal costs are larger than complementary benefits.

[13] This assumption allows us to focus on the most favorable scenario for entry. Our results become stronger when a positive porting cost is introduced. To focus on market outcomes under effective competition, we assume the third-party store pays no fee to operate. This conservative assumption—given that, in practice, platforms like Apple charge a Core Technology Fee (CTF) to large developers—ensures a level playing field, allowing us to isolate conditions under which app store competition might arise in equilibrium.

3 Baseline Analysis

We solve the model by backward induction. For ease of notation, we omit functional arguments whenever it does not lead to ambiguity.

Stage 5. Consumers purchase apps. Consider a consumer's decision to buy app i. If the consumer has installed B and the app is available in both stores, the consumer will either consume the app from the store with the lowest price, or not consume the app. If the consumer has not installed B, she will either consume the app from A or not consume it.

Let p be the lowest price of a given app available to a consumer. The consumer's demand for this app (i.e., the probability she purchases the app) is

$$d(p) = 1 - F(p), \tag{2}$$

and its expected surplus is

$$s(p) = \int_p^\infty (v - p) dF(v). \tag{3}$$

Stage 4. Developers set prices. Suppose that m consumers have installed B, which implies that $1 - m$ consumers can only access apps through A.

Consider a developer that has decided to multi-home. If $p_{iB} \leq p_{iA}$, a measure m of consumers consider purchasing the app on store B and $1 - m$ consider purchasing it on A. Developer i's demands are

$$q_{iA} = (1 - m)\ d(p_{iA}), \qquad q_{iB} = m\ d(p_{iB}),$$

and its profit is

$$m\left[(1 - b)p_{iB} + \lambda\right] d(p_{iB}) + (1 - m)\left[(1 - a)p_{iA} + \lambda\right] d(p_{iA}). \tag{4}$$

If $p_{iB} > p_{iA}$, all consumers buy from A, i's demands are

$$q_{iA} = d(p_{iA}), \qquad q_{iB} = 0,$$

and its profit is

$$\left[(1 - a)p_{iA} + \lambda\right] d(p_{iA}).$$

Our assumptions imply that developers' profits are twice-differentiable and globally quasi-concave.

Let $p^*_{iA}(a, b, m)$ and $p^*_{iB}(a, b, m)$ be developer i's optimal prices as a function of a and b. When setting prices, each developer is at competition with itself. Setting a higher price on one of the stores implies that m additional consumers buy the app on the other store. Optimal prices depend on the relationship between a and b, as the following lemma shows.

Lemma 1 (Intra-app competition). *If $b < a$, then $p^*_{iB} \le p^*_{iA}$. If $b = a$, then $p^*_{iB} \ge p^*_{iA}$. If $b > a$, then $p^*_{iB} > p^*_{iA}$.*

If $b > a$, developers prefer to sell through A, and choose $p^*_{iB} > p^*_{iA}$ so no consumer buys through B. If $b = a$, developers are indifferent between the two stores and set $p^*_{iB} \ge p^*_{iA}$.[14]

Suppose until further notice that $b < a$. Lemma 1 implies that $p^*_{iB} \le p^*_{iA}$, and thus profits are given by (4). Let $\hat{p}_{iA}$ and $\hat{p}_{iB}$ be the unrestricted optimum prices (that is, ignoring the restriction that $p^*_{iB} \le p^*_{iA}$). These prices solve

$$(1-a)d(p_{iA}) + [(1-a)p_{iA} + \lambda]\, d'(p_{iA}) = 0, \tag{5}$$
$$(1-b)d(p_{iB}) + [(1-b)p_{iB} + \lambda]\, d'(p_{iB}) = 0. \tag{6}$$

The implicit function theorem implies that

$$\frac{\partial \hat{p}_{iA}}{\partial a} = \frac{d(p_{iA}) + p_{iA}d'(p_{iA})}{(1-a)\,(2d'(p_{iA}) + p_{iA}d''(p_{iA}))} < 0 \tag{7}$$

as the denominator of (7) is negative by the second-order condition and the numerator is positive because the first-order condition (5) implies

$$d(p_{iA}) + p_{iA}d'(p_{iA}) = \frac{-\lambda\, d'(p_{iA})}{(1-a)} > 0. \tag{8}$$

Therefore, $\partial \hat{p}_{iA}/\partial a < 0$. This result implies that the optimal price *decreases* with the ad valorem fee. This result is known as the *Edgeworth paradox*, and holds when an ad valorem fee affects only one product of a multiproduct monopolist.[15] When choosing its price, the multiproduct monopolist considers its profits on the taxed market (in our case, the market for apps) and the untaxed market (in our case, the complementary market). As the ad valorem fee increases, the marginal benefit in the taxed market decreases, which induces the monopolist to lower its price to increase revenues in the untaxed market.

The above result implies that if $b < a$, then $\hat{p}_{iA} < \hat{p}_{iB}$, and therefore the unrestricted optimal prices given above cannot be optimal. Proposition 1 follows.

Proposition 1 (Price parity). *If $b < a$ then $p^*_{iA} = p^*_{iB}$.*

Proposition 1 shows that if $b < a$ optimal prices must be the same across stores. This result is caused by three factors: the integrated store's default status, intra-app competition, and the Edgeworth Paradox. The absence of either of these features, which are present in app store markets, suffices to preclude this result.[16]

[14] If $b = a$, there exists a continuum of equilibria for this subgame. In particular, if p_{iA} is set at the profit maximizing level p^*_{iA}, any $p^*_{iB} \ge p^*_{iA}$ yields the same profits for the developer, and is thus optimal. In this case we will select the equilibrium such that $p^*_{iB} = p^*_{iA}$ because this imposes the greatest competitive constraint on A.

[15] See Armstrong and Vickers (2023) and D'Annunzio and Russo (2024*a*) for recent studies.

[16] For instance, if stores were to set per-unit fees instead of ad valorem fees, the Edgeworth Paradox would no longer hold, and the optimal price would be strictly lower at the store with the smallest fee.

Moreover, it is important to remark that the mechanism through which price parity is generated is unrelated to Bertrand competition. In our setting, developers face no external competition (each is a monopolist in its own app market). Developers optimally adopt price parity, although this restriction is not set by the store or induced by external competition.[17]

Given the result on price symmetry, the developer chooses $p_i^* = p_{iA}^* = p_{iB}^*$ to maximize

$$\left\{ [1 - (1-m)a - mb]\, p_i + \lambda \right\} d(p_i). \tag{9}$$

Thus, when choosing its optimal price, the developer considers an *average ad valorem* fee, defined as

$$t(a, b) \equiv (1 - m)a + mb.$$

The first-order condition for maximizing (9) is

$$(1 - t)d(p_i) + [(1 - t)p_i + \lambda]\, d'(p_i) \quad = \quad 0. \tag{10}$$

Conditional on entry, developers' problems are symmetric. Given t, the optimal price, gross profit, and subscription revenue of any developer are

$$p(t) \equiv \underset{p}{\text{argmax}}\ [(1 - t)\, p + \lambda]\ d(p), \tag{11}$$

$$\pi(t) \equiv \max_p\ [(1 - t)\, p + \lambda]\ d(p), \tag{12}$$

$$R(t) \equiv p(t)\ d(p(t)). \tag{13}$$

From the previous discussion on the Edgeworth Paradox, it follows that $p'(t) < 0$. The envelope theorem implies that $\pi'(t) = -R(t) < 0$. Finally, differentiating $R(t)$ we obtain

$$R'(t) = (d + p\ d')\ p' = \frac{-\lambda\ d'(p_{iA})}{(1 - t)}\ p'(t) < 0,$$

since $p'(t) < 0$ and $d'(p_{iA}) < 0$. Thus, an increase in t leads to a reduction in profit and subscription revenues for developers.

The above results hold if $b < a$ (as we have been considering until now). If $b \geq a$, then the optimal price is $p(a)$, where $p(\cdot)$ is the same function given above (evaluated at a different argument). Finally, if the developer single-homes on A or B, its optimal price is $p(a)$ or $p(b)$, respectively.

Stage 3. Consumers decide whether to install B. A consumer will install B if and only if the benefit it obtains is larger than her installation cost σ.

Suppose a consumer does not install B. Then, she anticipates that she will consume from A all those apps for which $v_i > p_i = p(t)$. If n apps are available, the consumer expects a total

[17] For recent studies on platform-imposed price parity see, e.g., Johnson (2017); Calzada, Manna and Mantovani (2022); Peitz and Sobolev (2024) and Gomes and Mantovani (2025).

surplus of $n\, s(p(t))$.

Suppose now a consumer installs B. If $b > a$, the consumer anticipates that apps will be more expensive in B, and thus she has no incentives to install it. If $b \leq a$, then prices will be identical across stores, and the consumer will obtain the same surplus $n\, s(p(t))$ regardless of the store on which she purchases.

Comparing the surplus from installing and not installing B, it follows that a consumer type-σ will choose to install store the third-party store if

$$n\, s(p(t)) - \sigma \geq n\, s(p(t)),$$

which never holds for $\sigma > 0$. Therefore, for both $b > a$ and $b \leq a$, $m^* = G(0) = 0$ and no consumer adopts the third-party store. We summarize this result in the following proposition.

Proposition 2 (Natural monopoly). *For any pair of ad valorem fees a and b, no consumer installs the third-party store B in equilibrium.*

Proposition 2 shows that a third-party store will find it difficult to attract consumers. The result arises because developers have incentives to adopt price parity across stores. Thus, undercutting the integrated store's ad valorem fee is not effective to attract consumers.

It is important to note that the lack of effective competition is not due to an explicit anti-competitive practice by the incumbent app store. The outcome is a byproduct of integrated store's default status and developers' incentives to adopt price parity.

It is also important to remark that the natural-monopoly result arises for a different reasons than those previously studied, such as scale economies (Baumol, 1977), network effects (Katz and Shapiro, 1985), or endogenous sunk costs (Shaked and Sutton, 1983). In our case, the result is due to the interaction between default advantages, intra-app competition, and the Edgeworth paradox.

Before moving to the analysis of stage 2, note that the above result is robust to changes in the costs of installing B: it holds even if all consumers have an infinitesimal cost ε of installing B. The result continues to hold for some equilibria if some or all consumers have zero installation costs, although in this case there may exist other equilibria with effective competition.

Stage 2. App development decisions. Developers anticipate that no consumer will install B. Since it is costless to make an app available on the third-party store, developers are indifferent between single-homing on A or multi-homing. In their decision to develop the app, the developers only take into account the fee a. The profit of a developer with cost k_i is

$$\pi(a) - k_i.$$

Thus, the measure of developers developing an app given an ad valorem fee a is

$$n(a) = H\big(\pi(a)\big).$$

Stage 1. Fee setting. Given that developers' and consumers' decisions are unaffected by b, A acts as a monopolist. Let

$$Q(a) \equiv n(a)\, R(a)$$

be the revenue base when n developers enter and each obtains a subscription revenue of R. Store A's profit is

$$\Pi_A(a) = a\, n(a)\, R(a) = a\, Q(a).$$

We assume stores' profit functions are twice-differentiable and globally quasi-concave. The optimal ad valorem fee a^M solves

$$Q(a^M) + a^M\, Q'(a^M) = 0. \tag{14}$$

Let $\Pi^M := \Pi_A(a^M)$ be the monopoly profit. In Appendix A.7 we show that (1) guarantees that equilibrium app prices and the integrated store's monopoly profit are positive in equilibrium.

4 Exclusive content or standalone functionality

In this section, we study whether the provision of exclusive content or standalone functionality by the third-party store can lead to effective competition. Suppose the standalone functionality yields a consumer utility of $\delta > 0$ upon installation. This content is offered at no cost for consumers, and is small relative to the utility obtained from apps, so that $G(\delta) \leq 1/2$.[18] All other aspects of the game remain as described in Section 2.

The solutions to stages 4 and 5 are analogous to those of Section 3, since in that section consumers' and developers' decisions are calculated for given m. In particular, Proposition 1 continues to hold, so developers adopt price parity if $b < a$.

In stage 3, if $b > a$, the surplus a consumer obtains from app consumption is $n\, s(p(a))$ regardless of whether she installs B. Likewise, if $b \leq a$, the surplus a consumer obtains from app consumption is $n\, s(p(t))$ regardless of whether she installs B (because price parity continues to hold). In either case, the measure of consumers installing B is

$$\tilde{m} = G(\delta).$$

In stage 2, if $b > a$ the measure of developers that enters the market is $n(a) = H(\pi(a))$. If $b \leq a$, the measure of developers is $n(t) = H(\pi(t))$, where $t = (1-\tilde{m})\, a + \tilde{m}\, b$ is the average fee. Note that the function n is the same in both cases, but it is evaluated at different arguments.

We now turn to stage 1. In the proof of Lemma 2 we show there is no equilibrium in pure strategies. The result follows from an "elevator logic": B wants to match A's fee, as this is the largest fee that allows it to remain in the market, but then A wants to slightly undercut B to

[18] Note that this $\delta > 0$ can also capture the (homogeneous) aversion of consumers to the integrated store.

capture the full market. This leads to a race to the bottom until fees are so low that A prefers to raise its fee and focus on its captive consumers. In response, store B also raises its fee, and the cycle begins again. Thus, no pair of fees is chosen with probability 1 in equilibrium.

Lemma 2 shows there exists a unique equilibrium, which is in mixed strategies, and characterizes some of its properties for a particular example.

Lemma 2 (Exclusive content or functionality)**.** *If the third-party store provides a standalone value $\delta > 0$ to consumers, there exists a unique equilibrium, which is in mixed strategies. There exist $\underline{a} \in (0, a^M)$ and $\overline{a} \in (\underline{a}, 1)$ such that in equilibrium: (i) A chooses a fee according to a distribution F_A in the support $(\underline{a}, \overline{a}]$, (ii) B chooses a fee according to a distribution F_B in the support $(\underline{a}, \overline{a})$, (iii) A's expected profit is strictly larger than $(1 - \tilde{m})\, \Pi_a^M$, and (iv) B's expected profit is positive and strictly smaller than $\tilde{m}\, \Pi_a^M$. If Q is log-concave, then $\overline{a} > a^M$.*

Proposition 2 shows two important results, namely, that fees may increase or decrease after B's entry, and that both A and B can have positive profits when B provides a standalone benefit. While these results are interesting, the above equilibrium implies that fees are unstable, which we believe is not an accurate description of real-world app markets.

One reason fees may be more stable than predicted by the model is that the integrated store may be act as a price leader.[19] We examine this alternative assumption below. We also analyze a scenario in which the third-party store sets fees equal to zero.[20] Altogether, these alternative scenarios show that average fees are unlikely to decrease—and may even increase—after the successful entry of a third-party app store.

Suppose first that the third-party store sets a fee equal to zero, which may be the case if it is open source or if its owner has an alternative revenue model (relying on ads or donation, as in the case of F-Droid, an Android-based app store).[21] We have the following result

Proposition 3 (Free or open source store)**.** *If B sets a fee equal to zero, A's optimal fee $\hat{a}$ is such that $\hat{a} > a^M = \hat{t}$, where $\hat{t} = (1-\tilde{m})\hat{a}$ is the average fee. Thus, the average fee, the integrated-store's profit, developer profits, and app prices remain unchanged with respect to the benchmark model, while consumer surplus increases by $\delta - \sigma$ for consumers with $\sigma \leq \delta$.*

Suppose now that the integrated store is a price leader, so that B selects its fee after observing A's fee. Given that platforms compete in prices (fees), this assumption implies the integrated store has a first-mover disadvantage. We have the following result. also pay core technology fees to the platform owner, are thus aware of these fees.

[19]In Europe, platforms such as Apple are likely to commit to their fee structures in advance to comply with the Digital Markets Act (DMA). The DMA requires platforms to set fees ex ante and ensure app safety and portability, which contributes to fee stability.

[20]In Section 7.3, we further explore a case in which the entrant commits to a fee to guarantee its successful entry.

[21]Note that this is also consistent with the case of app stores that, in a dynamic setting, try to establish a critical mass of developers and consumers. For example, Huawei kept its commission fees on HarmonyOS at zero for a long time before considering raising them. However, as of May 2025, no fees have been introduced yet.
https://www.ndtvprofit.com/technology/huawei-considers-app-store-fees-as-it-surpasses-iphone-in-china

Proposition 4 (Price leadership)**.** *If A is a price leader, the equilibrium fees are $\hat{a} = \hat{b} = a^M$. The average fee, developer profits, and app prices remain unchanged with respect to the benchmark model, while consumer surplus increases by $\delta - \sigma$ for consumers with $\sigma \leq \delta$. The integrated store's profit is $(1 - \tilde{m})\, \Pi_a^M$ and the third-party store's profit is $\tilde{m}\, \Pi_a^M$.*

Proposition 4 shows that if A is a price leader, in equilibrium it chooses the monopoly fee and B chooses to match it. The reason is that B always has incentives to match A's fee, and—unlike in the model with simultaneous fee setting—A cannot undercut B after it equates its fee.

It is interesting to note that store's equilibrium payoffs with simultaneous fee setting are between the equilibrium payoffs of the open source and price leadership cases. In particular, A's payoffs are smaller when it is a price leader.

5 Superstar Apps

In progress.

6 Side-loading

We now analyze the option available to developers to bypass the integrated store by offering side-loading methods (that is, alternative methods for downloading apps, registering subscriptions, or completing payments), without paying store commission fees.

To focus on the most relevant aspects of the analysis, we assume that there is only one store (the integrated store), and that each consumer values each app at a fixed level v.

Consumers may download an app through store A, as in previous sections, but may also side-load it, by downloading it with the alternative method offered by the developer. Downloading an app at store A does not imply any installation costs for consumers or developers.[22] On the other hand, side-loading entails an idiosyncratic cost s, drawn independently from a distribution with CDF Z. This cost may reflect the fact that consumers often need to change device settings (e.g., enabling "Allow unknown sources"), which can be intimidating or confusing, the lack of perfect integration with the operating system (e.g., notifications, battery optimization), as well as the absence of centralized or automatic updates, unlike in official app stores.[23]

Developers may charge different prices in the store or with side-loading. Let p_{iA} be the price charged by developer i in store A, and p_{iS} the price charged with side-loading.

[22] Thus, we assume that the integrated store cannot charge developers to enable side-loading. In Europe, Apple has tried to introduce such payments, but they have been considered a violation to the DMA by the EC.

[23] In other words, s can be considered as an inconvenience cost from purchasing from the direct channel of the app. This is analogous to the convenience benefit that Hagiu, Teh and Wright (2022) consider in the case of a consumer that can purchase from a seller on a marketplace platform relative to buying from the direct channel of the seller.

We consider the following timing. First, each app store chooses its commission fee. Second, each developer decides whether to develop an app, whether to make it available at store A and whether to enable side-loading. Third, each developer chooses the price for its app on each available download method. Fourth, each consumer decides which apps to consume, and how to download each of them. The equilibrium concept is subgame perfect Nash equilibrium.

In stage 4, a consumer buys app i from store A if and only if $v - p_{iA} \geq \max\{0, v - p_{iS} - s\}$, and buys by side-loading if $v - p_{iS} - s > \max\{0, v - p_{iA}\}$. If $p_{iS} \leq p_{iA} \leq v$, the measure of consumers that buys app i on the integrated store is $1 - Z(p_{iA} - p_{iS})$.

In stage 3, seller i is going to set $p_{IA} = v$ and with any price $p_{IS} < v$ is going to attract consumers that would side-load the app store. Therefore for any $p_{IS} < v$, the gross profit of a developer is given by:

$$\pi_i = Z(v - p_{iS})[p_{iS} + \lambda] + (1 - Z(v - p_{iS}))[v(1 - a) + \lambda]$$

Differentiating it with respect to p_{iS} yields

$$-Z'(\dot{})[p_{iS} + \lambda] + Z(\cdot) + Z'(\cdot)[v(1 - a) + \lambda] = 0$$

The implicit function theorem implies that an increase in a would lead to a reduction in price under side-loading since

$$\frac{\partial^2 \pi_i}{\partial a \partial p_{iS}} = -Z'(\cdot)v < 0$$

Lemma 3 (Side-loading effects on prices)**.** *Suppose side-loading is allowed. An increase in the commission fee by the integrated store leads to a lower price by sellers on their direct-channel.*

The intuition behind the above result is simple. When facing an increase in the commission fee, which reduces sellers' margins, it becomes optimal for them to shift demand toward the direct channel by inducing (costly) side-loading. This leads to a reduction in the price charged in the direct channel, where the entire margin is retained.

Moving now to the decision of the platform in the first instance. Since we have modified the baseline setting, we first define the benchmark decision of the integrated platform when it acts as a monopolist and no side-loading is possible. Then, the profit of the platform is given by

$$\Pi_A = a\, v\, n(a)$$

where $n(a) = H(\pi(a))$. We then have that a^M

$$v[n + a\, n'] = 0 \implies v[H(\cdot) + a\, H'(\cdot)(-v)] = 0$$

Note that in such a setting sellers extract all surplus from consumers, thus consumers obtain an ex-post utility equal to zero and seller retains $v(1 - a^M)$.

Consider now the case in which side-loading occurs. Now the platform obtains

$$\Pi_A = a\, v\, Z(\cdot)[v(1-a)+\lambda]$$

Differentiating it with respect to a yields

$$\frac{\partial \Pi_A}{\partial a} = 0\, \underbrace{Z'(\cdot)\frac{dp_{iS}}{da}\, a\, v\, n(a)}_{(-)} + \underbrace{(1 - Z(\cdot)\, v[n + a\, n']}_{(+)} = 0$$

Note that evaluating it at a^M where $v[n + a\, n'] = 0$ we then observe

$$\left.\frac{\partial \Pi_A}{\partial a}\right|_{a=a^M} = Z'(\cdot)\frac{dp_{iS}}{da}\, a\, v\, n(a) < 0$$

Therefore, denoting the equilibrium fee under side-loading, we observe that $a^S < a^M$ since the FOC is negative at $a = a^M$.

We conclude the following

Proposition 5. *Side-loading leads to a reduction in the equilibrium fee a, which raises both consumer and developer surplus.*

The intuition behind the above proposition is also straightforward. The integrated store anticipates that raising the commission fee will lead app developers to steer demand toward the direct channel by lowering their price on that channel. As a result, the store is constrained in how high a commission fee it can set.

Ultimately, this benefits developers in two ways. First, for a given commission fee, some consumers purchase through the direct channel, where developers earn a higher margin (i.e., they receive $p_{iS} > (1-a)v$). Second, for a given level of consumer demand, the commission fee is lower in equilibrium. Overall, developers are better off.

Note that not all consumers would sideload, due to the idiosyncratic cost σ. As for consumers, they are also better off. Without sideloading, all surplus is extracted by developers; with sideloading, some surplus is retained by consumers since $p_{iS} < v$. Thus, sideloading benefits both consumers and developers.

7 Extensions

7.1 Apps with positive marginal costs

We now assume that app developers face a strictly positive marginal cost of producing an app. While digitization has historically driven marginal costs to near zero (i.e., negligible), AI-oriented apps may involve strictly positive marginal costs $c > 0$, for instance, due to expenses related to AI tokens or cloud infrastructure. In this extension, we allow for such a possibility.

Let a and b be the ad valorem commission fees charged by A and B. If developer i develops its app and sells q_{iA} subscriptions in A and q_{iB} in B, its profit is

$$q_{iA}\left[(1-a)p_{ia}+\lambda-c\right]+q_{iB}\left[(1-b)p_{ib}+\lambda-c\right]-k_i.$$

It is immediate that for any $c<\lambda$, the main results from our baseline model continue to hold. In particular, there cannot exist an equilibrium in which the alternative store attracts consumers. However, if $c>\lambda$, then complementary revenues effectively become negative. We now examine how the app developers' pricing strategies respond in this scenario.

As in the baseline model, if $b\geq a$, it is never (strictly) more profitable for the developers to have sales in store B, which they can avoid by just setting $p^*_{iB}>p^*_{iA}$. If $b<a$ then the developers' first-order conditions are such that

$$\begin{aligned}(1-a)d(p_{iA})+\left[(1-a)p_{iA}+\lambda-c\right]d'(p_{iA}) &= 0, &(15)\\ (1-b)d(p_{iB})+\left[(1-b)p_{iB}+\lambda-c\right]d'(p_{iB}) &= 0. &(16)\end{aligned}$$

Let $\hat{p}_{iA}$ and $\hat{p}_{iB}$ be the unrestricted optimum prices, then implicit function theorem implies a positive pass-through

$$\frac{\partial\hat{p}_{iA}}{\partial a}=\frac{d(p_{iA})+p_{iA}d'(p_{iA})}{(1-a)\left[2d'(p_{iA})+p_{iA}d''(p_{iA})\right]} \tag{17}$$

which has the opposite sign of $d(p_{iA})+p_{iA}d'(p_{iA})$. Unlike the baseline model, for any $c>\lambda$ we have that

$$d(p_{iA})+p_{iA}d'(p_{iA})=\frac{-(\lambda-c)d'(p_{iA})}{1-\alpha}<0.$$

Therefore, unlike the baseline model, we have that

$$\frac{\partial\hat{p}_{iA}}{\partial a}>0 \qquad \frac{\partial\hat{p}_{iB}}{\partial b}>0$$

This implies if $b<a$ then $p^*_{iB}<p^*_{iA}$ since now the Edgeworth Paradox no longer applies. As a result, *price parity* is broken and the developers will set the unconstrained optimal prices. Therefore, if $b<a$ then $p^*_{iB}<p^*_{iA}$. We conclude the following.

Lemma 4 (No Price Parity)**.** *Suppose $c\geq\lambda$. If $b<a$, then $p^*_{iB}<p^*_{iA}$*

An immediate consequence of this result is that prices on each store will only depend on the fee set by that store, i.e., $p^*_{iB}(b)$ and $p^*_{iA}(a)$.

In stage 3 consumers decide whether to install store B. Note that consumers have heterogeneous installation cost for B.

If $b>a$, the consumer anticipates that apps will be more expensive in B, and thus has no incentives to install it. If $b\leq a$, let us first suppose that developers multi-home. Then, the decision of each consumer is between finding cheaper apps on the alternative store and incurring installation cost.

Throughout the remaining part of the section, we assume that $n = 1$ and we treat the mass of developers fixed. This allows us to simplify the analysis and enhance tractability while maintaining the scope of studying whether effective competition can materialize in equilibrium.

Let $s(p^*_{iA}(a))$ the consumer surplus at store A and $s(p^*_{iB}(b))$ the consumer surplus at store B. a consumer type-σ will choose to install store B if and only if $s(p^*_{iB}(b)) - \sigma \geq s(p^*_{iA}(a))$. Thus, a mass $m^* = G(n(s(p^*_{iB}(b) - s(p^*_{iA}(a)))$ joins the alternative store (and is a multi-homer) and the complementary mass of consumers single-home on the integrated store.

In stage 2, developers make their decision about developing an app. Suppose $b \geq a$, then they are just indifferent between single-homing on the integrated store or multi-homing. This is because if $b = a$, they make the same revenues regardless of the store, whereas if $b > a$ they only sell via the integrated store.

If $b < a$, the analysis is more interesting and we show in the Appendix that in equilibrium all developers multi-home (since deviaitons by an atomistic developer would not be profitable when all others multi-home).

Since we keep the mass of developers fixed to $n = 1$ and all developers in equilibrium multi-home, we can now move to stage 1 where the two platforms can compete in the fees.

We must rely on numerical simulation due to tractability issues. We consider two main cases: the benchmark model in Section 3, where $\lambda > c = 0$, and the current setting, where $c > \lambda$. Let $\eta := c - \lambda$ denote the effective marginal cost.

If $\eta < 0$, then the Edgeworth paradox arises, price parity holds, and the baseline analysis applies—resulting in a natural monopoly. On the other hand, if $\eta > 0$, price parity is broken and competition emerges. We assume η is small and examine two scenarios: $\eta = -0.1$ and $\eta = 0.1$.

In the first case, due to price parity, there is a natural monopoly with $a^M \approx 0.74$. In the second case, let a^C and b^C denote the equilibrium values of a and b that simultaneously solve the maximization problems of platforms A and B, respectively. The only equilibrium is one in which $b < a$, and we find that $a^C \approx 0.73$ and $b^C \approx 0.46$.

The average commission fee relevant for developers is

$$t(a^C, b^C) = m^\star b^C + (1 - m^\star) a^C \approx 0.72 < a^M.$$

Therefore, in this case, competition is effective and leads to a reduction in equilibrium fees.

7.2 Eliminating defaults through choice screens

In digital markets, recent regulations have tried to eliminate default advantages by requiring the use of choice screens. For example, the DMA applies this solution to several core platform services, such as search engines and browsers.[24]

To this end, we assume that no store has a default advantage. Instead, the first time a consumer uses her device, she is confronted with a choice screen that asks her whether to install A or B. This first installation is costless. Consumers may install a second store at cost σ, distributed according to G.[25] Apart from the removal of default advantages, the model and solution concept are identical to those in Section 2.

As we will show, the model has multiple equilibria. To select among them, we assume that the integrated store has a *focal point advantage*: if the subgame starting in stage 2 has multiple equilibria, we select the one that maximizes its market share. This assumption is motivated by the fact that the integrated store is likely to have an installed base of apps and consumers, which coordinates expectations in its favor.

Proposition 6 (Choice screen). *In the model without a default advantage:*

- *There exist multiple equilibria in which developers and consumers single-home on one store. Any fee can be sustained in an equilibrium of this type.*
- *There exist multiple equilibria in which developers multi-home. In these equilibria, consumers single home, both stores set the maximum fee, and app prices are equal to zero.*
- *If the integrated firm has a focal point advantage, there is a unique equilibrium in which the integrated store is a natural monopoly. The equilibrium fee, app prices, and consumer surplus are the same as in the equilibrium of Section 3.*

7.3 Penetration pricing

Suppose that the third-party app store chooses a fee $\tilde{b}$ to avoid being excluded from the market. This fee is such that A prefers to charge a fee $\tilde{a}$ (and have a market share of $1 - \tilde{m}$) rather than charging a fee $\tilde{b} - \varepsilon$ (and capture all the market). Thus,

$$\tilde{b}\; Q(\tilde{b}) = \max_{a \geq \tilde{b}}\; (1 - \tilde{m})\; a\; Q\left((1 - \tilde{m})a + \tilde{m}\tilde{b}\right).$$

$\tilde{a}$ is given by the first-order condition:

$$(1 - \tilde{m})\; [Q + a\; (1 - \tilde{m})\; Q] = 0.$$

We have the following lemma.

[24] See e.g., Decarolis and Li 2023; Decarolis, Li and Paternollo 2024.

[25] We are implicitly assuming the device can function without the integrated store. This assumption may not hold in the real world because the integrated store may share basic functionalities with the operating system that make it essential. Once again, our intention is to consider a worst-case scenario for the integrated store.

Lemma 5 (Penetration pricing). *If B chooses a fee so that A does not have incentives to exclude it from the market, equilibrium fees are such that* $\tilde{b} < a^M < t(\tilde{a}, \tilde{b}) < \tilde{a}$. *Thus, the average fee increases, fewer apps are developed in equilibrium, app prices decrease, and consumers may be better or worse off.*

8 Conclusions

This paper investigates the competitive dynamics between integrated (default) and third-party app stores in the context of multi-sided markets, focusing on consumer behavior, developer incentives, and regulatory interventions. Our analysis demonstrates that default advantages and ad valorem fee structures are pivotal in shaping app store competition, often leading to outcomes where integrated app stores maintain dominance.

Specifically, we find that even when third-party app stores are allowed on devices, the default status of integrated app stores gives them a significant edge. Consumers face switching costs and behavioral inertia, while developers have an incentive to maintain price parity across stores to avoid arbitrage. These factors reinforce a natural monopoly for integrated stores, despite the presence of competing alternatives. A direct implication of our analysis is that the above results would also hold in a pre-DMA environment in which the integrated store is the sole app store available to consumers. The equilibrium in which no consumer installs the app is welfare and profit equivalent to the equilibrium that results when the device owner does not permit the installation of a third-party app.

In this context, the ability to side-load apps directly (direct channel) is more likely to exert competitive pressure on integrated stores. Specifically, allowing side-loading would limit the integrated platform's ability to extract rents via commission fees. Our findings suggest that, in contrast to app store competition, enabling side-loading places more credible constraints on incumbent stores, leading to lower commission fees and unambiguously benefiting both developers and consumers .This is consistent with the outcome of the *Epic Games v. Apple* case in April 2025, where the court *de facto* recognized side-loading as an important mechanism for disciplining Apple power on its store and promoting more competition.

Our model also suggests that regulatory interventions, such as mandating choice screens or prohibiting defaults, can have mixed effects. For instance, removing the default status of integrated app stores introduces multiple potential equilibria. In one scenario, competition drives fees to zero, benefiting consumers but potentially harming app quality due to reduced developer revenues. In another scenario, instead, fees may remain excessively high, exacerbating market concentration.

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A Proofs not in text

A.1 Proof of Lemma 1

To prove the first part of Lemma 1, suppose that $b < a$ and $p^*_{iB} > p^*_{iA}$. Then, all consumers buy the app from A, and profits are $\left[(1-a)p^*_{iA} + \lambda\right] d(p^*_{iA})$. But then, developer i can set the price in B equal to $p'_{iB} = p^*_{iA}$, by which profit becomes

$$m\left[(1-b)p^*_{iA}+\lambda\right]d(p^*_{iA}) + (1-m)\left[(1-b)p^*_{iA}+\lambda\right]d(p^*_{iA})$$
$$= \left[(1-a)p^*_{iA}+\lambda\right]d(p^*_{iA}) + m\,(a-b)\,p^*_{iA}\,d(p^*_{iA}).$$

which is a profitable deviation given that $b < a$.

To prove the second part of Lemma 1, suppose $b = a$ and $p^*_{iB} < p^*_{iA}$. Then, m consumers buy in B and $1-m$ in A. But given that prices are different it must either hold that

$$\left[(1-b)p^*_{iA}+\lambda\right]d(p^*_{iA}) > \left[(1-b)p^*_{iB}+\lambda\right]d(p^*_{iB}),$$

or

$$\left[(1-b)p^*_{iA}+\lambda\right]d(p^*_{iA}) < \left[(1-b)p^*_{iB}+\lambda\right]d(p^*_{iB}).$$

In the first case, it is optimal to increase p^*_{iB}. In the second case, it is optimal to decrease p^*_{iA}, and thus these cannot be the optimal prices.

Finally, to prove the third part of Lemma 1, suppose $b > a$ and $p^*_{iB} \leq p^*_{iA}$. Profits are as in (4):

$$m\left[(1-b)p^*_{iB}+\lambda\right]d(p^*_{iB}) + (1-m)\left[(1-a)p^*_{iA}+\lambda\right]d(p^*_{iA}). \tag{18}$$

Because $a < b$ it must hold that

$$\left[(1-b)p^*_{iB}+\lambda\right]d(p^*_{iB}) < \left[(1-a)p^*_{iB}+\lambda\right]d(p^*_{iB}),$$

but revealed preference implies that

$$\left[(1-a)p^*_{iB}+\lambda\right]d(p^*_{iB}) \leq \left[(1-a)p^*_{iA}+\lambda\right]d(p^*_{iA}).$$

If developer i deviates and chooses $p'_{iB} > p^*_{iA}$ for B, profits become

$$\left[(1-a)p^*_{iA}+\lambda\right]d(p^*_{iA}),$$

which is a profitable deviation by the above arguments.

A.2 Proof of Proposition 1

Suppose $b < a$. From Lemma 1 we know that $p_{iB} \leq p_{iA}$. We want to show that $p^*_{iB} < p^*_{iA}$ is not possible, so that $p^*_{iB} = p^*_{iA}$ in equilibrium.

Suppose by way of contradiction that $p^*_{iB} < p^*_{iA}$. Let $\pi_A(p_{iA}) = [(1-a)p_{iA}+\lambda]d(p_{iA})$ and $\pi_B(p_{iB}) = [(1-b)p_{iB}+\lambda]d(p_{iB})$. If $p^*_{iB} < p^*_{iA}$, it must be the case that $d\pi(p^*_{iA})/dp_{iA} \geq 0$ and $d\pi(p_{iB})^*/dp_{iB} \leq 0$. Otherwise, it would be optimal to either decrease p_{iA} or increase p_{iB}. Since from the analysis in the main text we know that both prices cannot be set at the level which maximizes independent profits, both conditions cannot hold with equality at the same time. Thus, it must be the case that $\partial \pi_A(p^*_{iA})/\partial p_{iA} > \partial \pi_B(p^*_{iB})/\partial p_{iB}$. But differentiating the first-order condition $\partial \pi_A/\partial p_{iA}$ yields:

$$\frac{\partial^2 \pi_A}{\partial p_{iA} \partial a} = -\left[d(p_{iA}) + p_{iA} d'(p_{iA})\right] < 0$$

because of (8). This result implies that the slope of the profit function with respect to price decreases with the ad valorem fee, and thus it must hold that $\partial \pi_A(p^*_{iB})/\partial p_{iA} < \partial \pi_B(p^*_{iB})/\partial p_{iB}$, which is a contradiction. Therefore, in equilibrium it must hold that $p^*_{iB} = p^*_{iA}$.

A.3 Proof of Proposition 4

In stage 1b, given a, B will never choose $b > a$ because then developers would set $p_{iB} > p_{iA}$ and no consumer would download apps through B. Suppose then that $b \leq a$, and let $t \equiv mb + (1-m)a$ be the average fee, where $\partial t/\partial b = \tilde{m} > 0$.

Recall $\tilde{m} = G(\delta)$. B chooses a fee to maximize

$$\Pi_B(b, a) = \tilde{m}\; b\; Q((1-\tilde{m})\; a + \tilde{m}\; b).$$

Our previous assumptions imply that B's profit function has a unique maximizer.

The first-order condition is

$$\frac{\partial \Pi_B}{\partial b} = \tilde{m}\left(Q + b\; Q'\; \frac{\partial t}{\partial b}\right) = 0 \tag{19}$$

if $b \leq a$, and

$$\frac{\partial \Pi_B}{\partial b} \geq 0$$

if $b = a$.

If the first-order condition has an interior solution, the optimal fee $b(a)$ solves

$$Q + b(a)\; \tilde{m}\; Q' = 0, \tag{20}$$

and its sign is given by the sign of

$$\frac{\partial^2 \Pi_B}{\partial b \partial a} = \tilde{m}(1-\tilde{m})\; (Q' + b\; \tilde{m} Q'')$$

The second-order condition ($\partial^2 \Pi_B/\partial b^2 \leq 0$) does not restrict the sign of $\frac{\partial^2 \Pi_B}{\partial b \partial a}$, which can be positive or negative. Thus, fees may be strategic complements or substitutes.

If the first-order condition has a corner solution, then $b(a) = a$ and $b'(a) = 1$, so the fees are strategic complements.

In stage 1a, A chooses a fee to maximize

$$\Pi_A = (1-\tilde{m})\; a\; Q(t(a)),$$

where $t(a) \equiv (1-\tilde{m})\; a + \tilde{m}\; b(a)$. The first-order condition is

$$\frac{\partial \Pi_A}{\partial a} = (1-\tilde{m}) \left(Q + a\, Q' \,\frac{\partial t(a)}{\partial a} \right) = 0,$$

which implies

$$Q + a\, Q' \,(1-\tilde{m} + \tilde{m}\; b'(a)) = 0. \tag{21}$$

A's first-order condition has an interior solution. The reason is that A's profits are zero if $a = 0$ or at the level which implies zero app prices.

B's optimal fee is a corner solution. To see this result, note that if (21) holds with equality, then

$$\left.\frac{\partial \Pi_B}{\partial b}\right|_{b=a^M} = \tilde{m}\,(Q + a\,\tilde{m}\,Q') > 0.$$

We now show that Π_A has a local maximum at a^M. If $a = a^M$, then B's first-order condition has a corner solution. To see this result, note that

$$\left.\frac{\partial \Pi_B}{\partial b}\right|_{b=a^M} = \tilde{m} \left(Q(a^M) + a^M \tilde{m}\; Q'(a^M) \right) > 0.$$

This expression is positive because it matches (14) except that the second term is multiplied by a factor strictly smaller than 1. Thus, if A sets $a = a^M$, B chooses $b = a^M$.

Going back to A's first-order condition, we have that if $b(a)$ is at a corner solution, then since $b'(a) = 1$. Then, at $a = a^M$ (21) becomes

$$Q(a^M) + a^M\; Q'(a^M) = 0,$$

which is exactly the same condition determining a^M in the baseline model. This shows that $a = a^M$ is indeed a local maximum. At this maximum, A's profits are $(1-\delta)\;\Pi^M$.

In addition to $a = a^M$, A's optimization problem may have another local maximum . In particular, A could have incentives to set a larger fee, if this induces B to lower its fee. In this equilibrium the first-order conditions of both firms would hold with equality and $b < a$.

We now show that in this solution: (1) it must hold that $b' < 0$, and (ii) the average fee is larger than the monopoly fee.

Suppose first that $b' > 0$ at the equilibrium. From (20) and (21) it must be the case that

$$a\;(1-\tilde{m} + \tilde{m}\; b'(a)) = b\;\tilde{m}.$$

Given that in this solution $b < a$, this equation implies that $\tilde{m} > 1/2$.

Suppose now that $b' < 0$. Then the first-order conditions imply

$$Q + ((1-\tilde{m})a + \tilde{m}b)\, Q' = -Q - a\tilde{m}\, b'(a)Q',$$

that is,

$$Q(t) + t\, Q'(t) = -Q - a\tilde{m}\, b'(a)Q' < 0,$$

which implies that the equilibrium average fee t is larger than a^M.

A.4 Proof of Lemma 2

Non-existence of equilibrium in pure strategies. We begin by showing that there is no equilibrium in pure strategies. Suppose, by contradiction, that each firm chooses some fee with probability 1. B will never choose $b > a$ because, in this case, developers will set $p_{iB} > p_{iA}$ and no consumer will download apps through its store. Thus, $b \leq a$ and app stores' profits are

$$\Pi_A(a,b) = (1-\tilde{m})\, a\, Q(t), \qquad \Pi_B(a,b) = \tilde{m}\, b\, Q(t).$$

Suppose that first-order conditions hold with equality. The first-order condition for A is

$$\frac{\partial \Pi_A}{\partial a} = (1-\tilde{m})\left(Q + a\, Q' \frac{\partial t}{\partial a}\right) = 0 \quad \Leftrightarrow \quad Q + a\,(1-\tilde{m})\, Q' = 0,$$

and the first-order condition for B is

$$\frac{\partial \Pi_B}{\partial b} = \tilde{m}\left(Q + b\, Q' \frac{\partial t}{\partial b}\right) = 0 \quad \Leftrightarrow \quad Q + b\, \tilde{m}\, Q' = 0.$$

From these conditions, we obtain that at an interior equilibrium fees must verify

$$\frac{a^{**}}{b^{**}} = \frac{\tilde{m}}{1-\tilde{m}}.$$

If $G(\delta) < 1/2$, this condition implies that $b^{**} > a^{**}$ but this violates the assumption that $b \leq a$. Thus, B's optimal fee given A's is $b^{**} = a^{**}$. But at this fee, A has incentives to charge $a^{**} - \varepsilon < b^{**}$, capturing all the market. A similar argument holds if $G(\delta) = 1/2$. Thus, there is no equilibrium in pure strategies.

Existence. To prove an equilibrium exists, we next show that:

(i) The choice sets of both firms are intervals of the real line, non-empty and compact.

(ii) The function $\Pi(a,b) \equiv \Pi_A(a,b) + \Pi_B(a,b)$ is upper semi-continuous in a and b.

(iii) The functions $\Pi_A(a,b)$ and $\Pi_B(a,b)$ are weakly lower semi-continuous according to Definition 6 of Dasgupta and Maskin (1986).

Under these conditions, an equilibrium in mixed strategies exists by Theorem 5 of Dasgupta and Maskin (1986).

Result (i) follows from the fact that fees lie in the unit interval, which is a subset of the real line, non-empty and compact.

Result (ii) follows because Π is continuous in a and b (which is stronger but not necessary). To see this, note that Π is continuous for $a \leq b$ and for $a > b$, and that $\lim_{b \to a^-}(a, b) = \Pi(a, a) = \Pi_A^M(a)$.

We now prove result (iii). Let

$$S = [0, f^{\max}]$$

be the set of strategies for both stores. This is the set of strategies because any fee higher than $f^{\max}$ for any store is weakly dominated. Let

$$S^{**}(i) = S^{**} \equiv \{(a, b) \in S^2 \mid a = b\}$$

be the set of discontinuities of Π_A and Π_B. Let

$$S_A^{**} \equiv \{a \in S \mid \exists (a, b) \in S^{**}\} = (0, f^{\max})$$

be the set of fees for A for which there is a discontinuity. Let

$$S_B^{**} \equiv \{b \in S \mid \exists (a, b) \in S^{**}\} = (0, f^{\max})$$

be the set of fees for B for which there is a discontinuity. Let

$$S_{-A}^{**}(a) \equiv \{b \in S \mid (a, b) \in S^{**}\} = \{a\}$$

be the set of fees for B for which there is a discontinuity when A chooses a fee a. In our model this is simply one point: $b = a$.

The following is a restatement of Definition 6 of Dasgupta and Maskin (1986).

Definition 1 (Weak lower semi-continuity). *$\Pi_A(a, b)$ is weakly lower semi-continuous in a if $\forall \bar{a} \in S_A^{**}, \exists \lambda \in [0, 1]$ such that $\forall b \in S_{-A}^{**}(\bar{a}), \lambda \liminf_{a \to \bar{a}^-} \Pi_A(a, b) + (1 - \lambda) \liminf_{a \to \bar{a}^+} \Pi_A(a, b) \geq \Pi_A(\bar{a}, b)$. The property is defined analogously for Π_B.*

Fix $\bar{a} \in S_A^{**} = (0, f^{\max})$. Fix any $\lambda \in (0, 1)$. There exists a unique $b \in S_{-A}^{**}(\bar{a})$, which is $b = \bar{a}$. For this $\bar{a}$, λ and $b = \bar{a}$, it holds that

$$\lambda \liminf_{a \to \bar{a}^-} \Pi_A(a, \bar{a}) + (1 - \lambda) \liminf_{a \to \bar{a}^+} \Pi_A(a, \bar{a}) = \lambda\, \bar{a}\, Q(\bar{a}) + (1 - \lambda)\, \bar{a}\, (1 - G(\delta))\, Q(\bar{a})$$

$$\geq \Pi_A(\bar{a}, \bar{a}) = \bar{a}\, (1 - G(\delta))\, Q(\bar{a}).$$

Thus, Π_A is weakly lower semi-continuous in a.

Fix $\bar{b} \in S_B^{**} = (0, f^{\max})$. Fix $\lambda = 1$. There exists a unique $a \in S_{-B}^{**}(\bar{b})$, which is $a = \bar{b}$. For this $\bar{b}$, $\lambda = 1$ and $a = \bar{b}$, it holds that

$$\lambda \lim_{b \to \bar{b}^-} \inf \Pi_B(\bar{b}, b) + (1-\lambda) \lim_{b \to \bar{b}^+} \inf \Pi_B(\bar{b}, b) = \bar{b}\, G(\delta)\, Q(\bar{b}) = \Pi_B(\bar{b}, \bar{b}).$$

Thus, Π_B is weakly lower semi-continuous in b.

Equilibrium characterization. If $\delta = 0$, the model is that of Section 2, and the market is a natural monopoly. The optimal fee solves the first-order condition

$$Q(a^M) - a\, Q'(a^M) = 0. \tag{22}$$

Let a^M denote this fee and let

$$\Pi^M = a^M\, Q(a^M) \tag{23}$$

denote the monopoly profits.

Suppose that A and B randomize in the supports S_A and S_B. From Narasimhan (1988), we know that (1) the supports are convex (i.e., they do not have holes), (2) the supports are the same, (3) no firm has a mass point inside the supports, and (4) at most one firm has a mass point in the boundaries of the support. In the analysis below, we show that A places positive mass in the upper bound, and that no store places positive mass in the lower bound.

Let the supports be $S_A = [\underline{a}, \overline{a}]$ and $S_B = [\underline{b}, \overline{b}]$. Let $\tilde{\Pi}_A(a) = E_b(\Pi_A(a, b))$. In a mixed strategy equilibrium, $\tilde{\Pi}_A(a)$ is constant for all $a \in [\underline{a}, \overline{a}]$. Let $\tilde{\Pi}_A$ denote this constant equilibrium profit. In a similar way, let $\tilde{\Pi}_B(b) = E_a(\Pi_B(b, a))$. In a mixed strategy equilibrium, $\tilde{\Pi}_B(a)$ is constant for all $b \in [\underline{b}, \overline{b}]$. Let $\tilde{\Pi}_B$ denote this constant equilibrium profit.

Claim 1. $\tilde{\Pi}_A \geq (1-\delta)\, \Pi^M$.

Proof. We first obtain A's maxmin profit. Given a, A's profit is minimized when $b = a$. To see this, note that if $b > a$, then A obtains all the market. Thus, its profit is smaller if $b \leq a$. And given $b \leq a$, A's profit declines as b increases because this decreases the measure of developers entering the market and the subscription revenues each obtains. Therefore, A's maxmin is

$$\begin{aligned} M_A &= \max_a \min_b \Pi_A(a, b) && (24) \\ &= \max_a \min_{b \leq a} (1-\delta)\, a\, Q((1-\delta)a + \delta b) && (25) \\ &= \max_a (1-\delta)\, a\, Q(a) && (26) \end{aligned}$$

Maximizing this expression is equivalent to maximizing profits in the baseline model. Thus, the maxmin is

$$(1-\delta)\, a^M\, Q(a^M) = (1-\delta)\, \Pi^M.$$

The result follows because in equilibrium A has to make more than its maxmin value. Otherwise, it would choose its maxmin strategy (which in this case is a^M) and increase its profit. □

Claim 2. $\underline{a} > 0$.

Proof. $\tilde{\Pi}_A(0) = 0 < (1-\delta)\,\Pi^M$, which contradicts Claim 1. Thus, $a = 0$ cannot be in S_A. □

Claim 3. $\underline{b} = \underline{a}$ *and* $\tilde{\Pi}_B > 0$.

Proof. Suppose $\underline{b} < \underline{a}$. For any $b < \underline{a}$, B captures the δ market with probability 1. Then, there is some $b \in [\underline{b}, \underline{a})$ which leads to maximum profits for B in that segment. This violates the assumption that $\tilde{\Pi}_B$ is constant.

Suppose now $\underline{b} > \underline{a}$. For any $a < \underline{b}$, A captures the δ market with probability 1. Then, there is some $a \in [\underline{a}, \underline{b})$ which leads to maximum profits for A in that segment. This violates the assumption that $\tilde{\Pi}_A$ is constant.

If $b = \underline{b} = \underline{a}$, B captures the δ market with probability 1. Given that $\underline{a} > 0$ by Claim 2, this implies that $\tilde{\Pi}_B(\underline{b}) > 0$. Thus, $\tilde{\Pi}_B > 0$. □

Claim 4. $\overline{b} = \overline{a}$.

Proof. Suppose $\overline{b} > \overline{a}$. For any $b > \overline{a}$, the probability that B captures the δ market is zero, which implies that it has zero profits. But this violates the result in Claim 3.

Suppose $\overline{b} < \overline{a}$. For any $a > \overline{b}$, the probability that A captures the δ market is zero. Then, there is some $a \in (\underline{b}, \underline{a}]$ which leads to maximum profits for A in that segment. This violates the assumption that $\tilde{\Pi}_A$ is constant. Therefore, $\overline{b} = \overline{a}$. □

Claim 5. *The distribution of a has a mass point at $\overline{a}$.*

Proof. If the distribution of a does not have a mass point at $\overline{a}$, then choosing $b = \overline{a}$, which is equal to $\overline{b}$ by Claim 4, would imply a zero probability that B captures the δ market, and thus, to zero profits for B. This contradicts Claim 3 that $\Pi(\overline{b}) > 0$. □

Claim 6. *The distribution of b cannot have a mass point at $\overline{b}$.*

Proof. If the distribution of b has a mass point at $\overline{b}$, then it would be optimal for A to shift probability from $\overline{a} = \overline{b}$ to $\overline{a} - \varepsilon$. □

Claim 7. *The distribution of b cannot have a mass point at $\underline{b}$.*

Proof. If the distribution of b has a mass point at $\underline{b}$, then it would be optimal for A to shift probability from $\underline{a} = \underline{b}$ to $\underline{a} - \varepsilon$, for a small enough $\varepsilon > 0$. □

Claim 8. $\underline{a} < a^M$.

Proof. Suppose that $\underline{a} \geq a^M$. Then, A can chose $a = a^M - \varepsilon$ with probability 1 for some small ε and obtain profits arbitrarily close to the monopoly profits. Thus, in equilibrium it must hold that $\underline{a} < a^M$. □

Claim 9. *If Q is log-concave, then $\overline{a} > a^M$.*

Proof. A's profit is

$$\begin{aligned}
\tilde{\Pi}_A(a) &= \Pr(a < b)\ a\ Q(a) + \Pr(a \geq b)\ (1-\delta)\ a\ E_b(Q((1-\delta)a + \delta b) \mid a \geq b), \\
&= (1 - F_B(a))\ a\ Q(a) + F_B(a)\ (1-\delta)\ a\ E_b(Q((1-\delta)a + \delta b) \mid a \geq b).
\end{aligned}$$

The expectation is given by:

$$E_b(Q((1-\delta)a + \delta b) \mid a \geq b) = \int_{\underline{b}}^{a} Q((1-\delta)a + \delta b)\ \frac{f_B(b)}{F_B(a)} db.$$

We can also write:

$$F_B(a)\ E_b(Q((1-\delta)a + \delta b) \mid a \geq b) = \int_{\underline{b}}^{a} Q((1-\delta)a + \delta b)\ f_B(b) db.$$

The derivative of this expression with respect to a is

$$\begin{aligned}
\frac{F_B(a)\ E_b(Q((1-\delta)a + \delta b) \mid a \geq b)}{\partial a} &= Q(a)\ f_B(a) \\
&\quad + (1-\delta) \int_{\underline{b}}^{a} Q'((1-\delta)a + \delta b)\ f_B(b) db, \\
&= Q(a)\ f_B(a) \\
&\quad + (1-\delta)\ F_B(a)\ E_b(Q'((1-\delta)a + \delta b) \mid b \leq a).
\end{aligned}$$

The derivative of profit with respect to a is

$$\begin{aligned}
\Pi_A'(a) &= -f_B(a)\ a\ Q(a) + (1 - F_B(a))\ Q(a) + (1 - F_B(a))\ a\ Q'(a) \\
&\quad + a\ (1-\delta)\ Q(a) f_B(a) \\
&\quad + a\ (1-\delta)^2\ F_B(a)\ E_b(Q'((1-\delta)a + \delta b) \mid b \leq a) \\
&\quad + F_B(a)\ (1-\delta)\ E_b(Q((1-\delta)a + \delta b) \mid a \geq b).
\end{aligned}$$

We have the following limits:

$$\begin{aligned}
\lim_{a \to \overline{a}^-} \Pi_A'(a) &= -\delta\ f_B(\overline{a})\ \overline{a}\ Q(\overline{a}) + (1-\delta)\ E_b(Q((1-\delta)\overline{a} + \delta b)) \\
&\quad + \overline{a}\ (1-\delta)^2\ E_b(Q'((1-\delta)\overline{a} + \delta b)) \\
\lim_{a \to \overline{a}^+} \Pi_A'(a) &= (1-\delta)\ E_b(Q((1-\delta)\overline{a} + \delta b)) \\
&\quad + \overline{a}\ (1-\delta)^2\ E_b(Q'((1-\delta)\overline{a} + \delta b))
\end{aligned}$$

In equilibrium, it must hold that

$$\begin{aligned}\lim_{a \to \bar{a}^-} \Pi'_A(a) &= 0,\\ \lim_{a \to \bar{a}^+} \Pi'_A(a) &\leq 0.\end{aligned}$$

The only way to satisfy these conditions is that $f_B(\bar{a}) = 0$ and

$$E_b(Q((1-\delta)\bar{a} + \delta b)) + \bar{a}\,(1-\delta)\,E_b(Q'((1-\delta)\bar{a} + \delta b)) = 0. \tag{27}$$

(If $f_B(\bar{a}) > 0$, then $E_b(Q((1-\delta)\bar{a} + \delta b)) + \bar{a}\,(1-\delta)\,E_b(Q'((1-\delta)\bar{a} + \delta b)) > 0$ to satisfy the first condition, but this violates the second).

If Q is log-concave, (27) implies $\bar{a} > a^M$. To see this result, define $r = Q'/Q$. If Q is log-concave, then $r' < 0$. Let

$$\phi(\bar{a}) \equiv E_b(Q((1-\delta)\bar{a} + \delta b)) + \bar{a}\,(1-\delta)\,E_b(Q'((1-\delta)\bar{a} + \delta b)).$$

Working with this expression, we obtain

$$\begin{aligned}\phi(\bar{a}) &= E_b\left\{Q((1-\delta)\bar{a} + \delta b))\left[1 + \bar{a}\,(1-\delta)\,r(Q'((1-\delta)\bar{a} + \delta b))\right]\right\},\\ &> E_b\left\{Q((1-\delta)\bar{a} + \delta b))\left[1 + \bar{a}\,(1-\delta)\,r(Q'(\bar{a}))\right]\right\},\\ &= E_b[Q((1-\delta)\bar{a} + \delta b))]\left[1 + \bar{a}\,(1-\delta)\,r(Q'(\bar{a}))\right],\\ &> E_b[Q((1-\delta)\bar{a} + \delta b))]\left[1 + \bar{a}\,r(Q'(\bar{a}))\right].\end{aligned}$$

The second line follows because r' so substituting $b \leq \bar{a}$ for $\bar{a}$ decreases the right hand side. The third line follows because the term in square brackets does not depend on b. The fourth line follows because $r < 0$, so removing the factor $(1-\delta)$ decreases the right hand side.

If $\bar{a} \leq a^M$, then $1 + \bar{a}\,r(Q'(\bar{a})) \geq 0$, which by the previous inequalities implies $\phi(\bar{a}) > 0$. But this contradicts the condition that $\phi(\bar{a}) = 0$. Thus, it must hold that $\bar{a} > a^M$. □

Claim 10. *$\tilde{\Pi}_A > (1-\delta)\Pi^M$ and $\tilde{\Pi}_B < \delta\Pi^M$.*

Proof. We first show $\tilde{\Pi}_A > (1-\delta)\Pi^M$. We must consider two cases: $\bar{a} \geq a^M$ and $\bar{a} < a^M$.

Suppose first that $\bar{a} \geq a^M$ and consider A's profit at $a = a^M$:

$$\begin{aligned}\tilde{\Pi}_A(a^M) &= \Pr(b > a^M)\,a^M\,Q(a^M) + \Pr(b \leq a^M)\,(1-\delta)\,a^M\,E_b(Q((1-\delta)a^M + \delta b) \mid b \leq a^M),\\ &> \Pr(b > a^M)\,(1-\delta)\,a^M\,Q(a^M) + \Pr(b \leq a^M)\,(1-\delta)\,a^M\,Q(a^M),\\ &= (1-\delta)\,a^M\,Q(a^M) = (1-\delta)\,\Pi^M,\end{aligned}$$

where the second line follows from $(1-\delta) < 1$ and

$$E_b(Q((1-\delta)a^M + \delta b) \mid a^M \geq b) < Q(a^M).$$

Suppose now that $\overline{a} < a^M$. By the definition of mixed-strategy equilibrium, if must be that $\tilde{\Pi}_A \geq \tilde{\Pi}_A(a^M)$, where

$$\begin{aligned}\tilde{\Pi}_A(a^M) &= (1-\delta)\, a^M\, E_b(Q((1-\delta)a^M + \delta b)), \\ &> (1-\delta)\, a^M\, Q(a^M) = (1-\delta)\, \Pi^M,\end{aligned}$$

where the second line follows because Q decreases in b. These arguments prove the first statement.

We next show $\tilde{\Pi}_B < \delta\Pi^M$. Consider B's profit at $b = \overline{a}$:

$$\begin{aligned}\tilde{\Pi}_B(\overline{a}) &= \Pr(a = \overline{a})\, \delta\, \overline{a}\, H(1-\overline{a}) \\ &< \Pr(a = \overline{a})\, \delta\, \Pi^M, \\ &< \delta\, \Pi^M,\end{aligned}$$

where the second line follows from the optimality of a^M in the monopoly case. □

A.5 Proof of Proposition 6

Equilibrium with developer multi-homing. We begin by showing there exists an equilibrium in which developers multi-home and consumers single-home. We first assume they do, and then show that no agent has incentives to deviate.

Let m represent the measure of consumers single-homing on B (thus, $1-m$ single-home on A). In stage 5, each consumer can only buy from one store. Given a price p_{ij} for app i on store j, a consumer's demand is $d(p_{ij})$ and her surplus is $s(p_{ij})$, as given in (2) and (3).

Since all consumers single-home, a developer's price in one store is not constrained by the price set in the other store. As a consequence, Lemma 1 and Proposition 1 no longer hold. Developer i chooses p_{iA} and p_{iB} to maximize

$$m\,[(1-b)p_{iB} + \lambda]\, d(p_{iB}) + (1-m)\,[(1-a)p_{iA} + \lambda]\, d(p_{iA}).$$

The optimal prices $\hat{p}_{iA}$ and $\hat{p}_{iB}$ solve (5) and (6). From previous results, the price is higher in the store with the lowest fee. If fees are the same, prices are equal across stores.

The largest fee compatible with positive prices is

$$f^{\max} \equiv 1 - \lambda \frac{F'(0)}{1-F(0)} > 0.$$

If $a \geq f^{\max}$ prices in A are equal to zero, and if $b \geq f^{\max}$ prices in B are equal to zero.

In stage 3, the value for consumers of installing A is $n\, s(\hat{p}_A)$ and the value of installing B is $n\, s(\hat{p}_B)$. If $\hat{p}_{iA} < \hat{p}_{iB}$ (which occurs if $a > b$ and $b < f^{\max}$), all consumers install A; if $\hat{p}_{iA} > \hat{p}_{iB}$ (which occurs if $b > a$ and $a < f^{\max}$), all consumers install B. If $\hat{p}_{iA} = \hat{p}_{iB}$ (which occurs if

$a = b$ or $\min\{a, b\} \geq f^{\max}$), consumers may coordinate in different ways between the two stores. For simplicity, we assume that they split evenly between the two stores.

Consider consumers' decision to multi-home. If prices differ across stores, a consumer does not gain from joining a second store (after it joins the store with lowest prices). The same is true if stores have the same prices (because all apps are available in both stores). Thus, in equilibrium, it is optimal for all consumers not to multi-home.

In stage 2, if $a > b$ and $b < f^{\max}$, developer profit is $\pi(a)$ and the measure of apps is $H(\pi(a))$. If $b > a$ and $a < f^{\max}$, developer profit is $\pi(b)$ and the measure of apps is $H(\pi(b))$. If $a = b < f^{\max}$, developer profit is $\pi(a) = \pi(b)$ and the measure of apps is $H(\pi(a)) = H(\pi(b))$. If $\min\{a, b\} > f^{\max}$, developer profit is $\pi(f^{\max})$ and the measure of apps is $H(\pi(f^{\max}))$.

Consider developers' decision to multi-home. If one store (say, A) charges a lower fee, consumers single-home on B. If a developer switches to single-homing on A, it loses all demand, and if it switches to single-homing on B, it obtains the same payoff as with multi-homing. Thus, there are no incentives to deviate. If $a = b$ or $\min a, b > f^{\max}$, consumers split evenly across stores. If a developer switches to single-homing, it loses half its demand. Thus, there are no incentives to deviate.

In stage 1, given that the store with the largest fee captures the entire market, stores "race to the top," increasing fees until prices are equal to zero. Any set of fees larger than $f^{\max}$ is thus an equilibrium.

Equilibrium with developer single-homing. We next prove there exist equilibria with single-homing by developers and consumers. We first assume they do, and then show they have no incentives to deviate. For concreteness, suppose all agents single-home on A. The proof is equivalent if they single-home on B instead.

In stage 5, demand and surplus are $d(p_{iA})$ and $s(p_{iA})$. In stage 4, developers set $p^*_{iA} = p(a)$, as given in (11). In stage 3, given that developers single-home on A, it is optimal for consumers to single-home on A. In stage 2, given that a deviation by a single developer does not influence consumers' decision to single-home on A, no developer can gain by deviating to single-homing on B or multi-homing.

Finally, to prove that any fee can be sustained as an equilibrium. Suppose that the equilibrium fee is $\tilde{a}$. For this fee, developers believe that other developers single-home on A, and thus, it is optimal for each of them to single-home on A. Given that developers beliefs are not constrained off the equilibrium path, we may assume that if they observe a different fee, they believe that other developers single-home on B, and thus, it is optimal for each of them to single-home on B. This implies that A does not have incentives to deviate from $\tilde{a}$.

Equilibrium refinement. For any fee a, there exists an equilibrium of the continuation game in which developers single-home on A. Given store A's focal point advantage, this equilibrium is selected if there exists another equilibrium. In stage 1, store A chooses a fee anticipating that, regardless of what fee it chooses, it will capture the entire market. Thus, it will choose the monopoly fee.

A.6 Proof of section 7

Consider the case in which $c > \lambda$. If all developers multi-home, they obtain

$$G((s(p^*_{iB}(b) - s(p^*_{iA}(a)))dp^*_{iB}[(1-b)p^*_{iB} + \lambda - c]$$
$$+(1 - G((s(p^*_{iB}(b) - s(p^*_{iA}(a))))d(p^*_{iA})[(1-a)p^*_{iA} + \lambda - c] - k$$

whereas if they all single-home on the integrated store, they obtain

$$1 \times d(p^*_{iA})[(1-a)p^*_{iA} + \lambda - c] - k \tag{28}$$

whereas if they all single-home on the alternative store, they obtain

$$G(s(p^*_{iB}(b))d(p^*_{iB})[(1-b)p^*_{iB} + \lambda - c] - k \tag{29}$$

We note that, as in the baseline model in Section 3, there is an equilibrium with natural monopoly where all developers single-home and obtain profits as in (28). To see why, note that if all developers but one single-home on the integrated store, the profit obtained by the developer that single-homes on the alternative store is 0 since no consumer joins the platform when only one (infinitesimally small) is available on the alternative store, i.e., $m^\star = G(0) = 0$ whenever only one developer is available on B. For the same rationale, it is never optimal for a developer to multi-home when all others single-home on the integrated store. There is, however, another equilibrium in which all developers multi-home. To see why, recall that porting one app from the integrated store to the alternative store is costless, therefore if a mass $m^\star = G(s(p^*_{iB}(b) - s(p^*_{iA}(a))$ is available on the alternative store, it is always profitable for a developer to multi-home (else, the will be a reduction in sales and, as a result, profits).

A.7 Proof that app prices are positive in equilibrium

The condition for the equilibrium price to be positive is

$$\left.\frac{\partial \pi_i}{\partial p_{iA}}\right|_{p_{iA}=0} = (1-a^M)\, d(0) + \lambda\, d'(0) = (1-a^M)[1-F(0)] - \lambda\, F'(0) > 0,$$

which is equivalent to

$$a^M < f^{\max} \equiv 1 - \lambda\, \frac{F'(0)}{1-F(0)}. \tag{30}$$

If $a^M < f^{\max}$ store A's profits are equal to zero, and thus the store has incentives to choose a smaller fee (i.e., the proposed fee cannot be an equilibrium). As long as

$$\lambda < \frac{1 - F(0)}{F'(0)},$$

there exists a positive fee that the store can choose that leads to positive app prices and positive store profits. If this condition does not hold, there is no such positive fee and the store cannot prevent app prices from becoming zero. The above inequality is precisely condition (1).