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ABSTRACT

Mobile app commissions paid by app developers to a monopolist device maker/app store operator are examined. Three results are demonstrated. First, unregulated app commissions are set at a level that maximises consumer surplus. Second, eliminating app commissions will lead to higher device prices. Third, requiring a menu of options for consumers as to how device makers receive subsidies from app developers constrains app commissions in a way that provides a more equal balance between consumer versus app developer interests.

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1 Introduction

Since mobile app stores were created by Apple in 2008, followed by others (notably Google Play), app store owners have charged a commission on paid app purchases. Recently, the controversy over Apple and Google's app store commissions has become a focal point of debate within the tech industry and beyond. Critics, including high-profile companies like Spotify and Epic Games, argue that the commissions — up to 30% on transactions made through their app stores — are excessively high and constitute an abuse of market power, stifling competition and innovation. They contend that this practice is particularly detrimental to smaller developers who struggle to sustain their businesses under such financial pressures. On the other hand, Apple and Google defend their commission rates by highlighting the value they provide in terms of a secure, reliable platform for developers and consumers alike, including tools, support, and a global marketplace for apps.

Regulators around the world have taken a keen interest in this issue, with varying perspectives. In the United States, lawmakers and the Department of Justice have scrutinized these practices, considering antitrust legislation and bringing legal action to address potential monopolistic behaviour. Similarly, the European Union has advanced its Digital Markets Act, aiming to curtail the power of major tech platforms and ensure fair competition.

Given this, it is timely to actually consider the role of commissions in the app ecosystem and whether they will be set in the interests of consumers or app developers. There is limited past research on such topics. Hermalin and Katz (2007) examine how product variety in what we would term today as 'apps' interacts with platform policies and prices. Gans (2012) identified commitment issues that impacted app store pricing and led to equilibria with higher app pricing and lower device pricing. Tirole and Bisceglia (2023) have examined fair access provisions and the impact of this on alternative app store policies. Etro (2021) examines competition between platforms operating by a device-maker and an advertising-funded operating system (akin to Apple's iOS versus Google's Android) and how their app store policies, including commissions, impact welfare outcomes. Finally, in a paper that the present paper builds upon, Jeon and Rey (2022) examines commissions in the context of platform competition. The distinctive contribution of this paper is to focus solely on the case of a monopoly device-maker, providing a context for examining app store commissions that are not set with a view to competitive interactions, which has been the focus of past work.

This paper presents three results using a simple monopoly model of a device market interacting with an ecosystem of app developers. First, the unregulated app commission rate paid by app developers to the device maker and set by the device maker is the rate that maximises consumer surplus. It does not maximise total welfare, as app developers would prefer a lower app commission (Section 3). Second, eliminating app commissions leads to higher device prices – both absolute and quality-adjusted – even taking into account the potential increase in the equilibrium number of apps available (Section 4). Third, a mechanism whereby the device maker is required to offer a menu between paying a baseline device price and posted app prices versus paying a premium above the baseline device price and app prices discounted by the app commission rate leads to equilibrium commission rates that are lower and potentially improve total welfare (Section 5). This is achieved without requiring a regulated commission rate and using consumer choice as a means that impacts the monopolist's choices.

2 A Simple Monopoly Model

The baseline model here adopts the environment, and the notation of Jeon and Rey (2022). The difference is that while their examination is of platform competition – for instance, the broad competition between mobile operating systems (iOS versus Android) or mobile devices (Apple versus Samsung and others) – here it is assumed that there is a single monopoly device market (or mobile operating system). That is clearly not an assumption based on reality, but instead, it is to examine welfare and other outcomes as if the device maker had monopoly power. In that respect, it provides a counterpoint to examinations that assume a more competitive environment.[1]

2.1 Model Set-up

The elements of the model are as follows:

- **Consumer Behaviour**: Suppose that an individual consumer values a specific app at v which is distributed independently and identically across consumers according to $G(.) \in \mathbb{R}^+$. Thus, an individual consumer's expected demand for an individual app is $d(p) \equiv 1 - G(p)$ where p is the price of an app. The expected surplus for that consumer is $s(p) = \int_p^\infty d(i)di$. Consumers derive intrinsic utility from a device of $u > 0$ and thus, if they purchase a device at a price of P, their total utility is:

$$U \equiv u + s(p)y - P$$

[1]For that reason, this paper sets aside issues of app developer multi-homing that is the focus of Jeon and Rey (2022).

where y represents the number of apps they purchase. It is assumed that u is distributed such that the aggregate demand for a device is $D(P - s(p)y)$; that $P - s(p)y$ is, in effect, a quality-adjusted price. Consumer type, u, is private to each consumer and unknown to others.

- **App Developers**: Given p an app developer's profit per consumer is $\pi(p) \equiv pd(p)$. Thus, apps do not involve ongoing costs but involve a development cost of k. k is identically and independently distributed according to $F(k)$ amongst app developers.

- **Device Maker**: Devices cost c per unit to make. The device-maker charges consumers a price of P and developers a commission, a, which is a share of the app developer's total revenues, $\pi(p)D(P)$ where $D(P)$ is the total device demand at a price of P. Thus, the device-makers profit is:

$$\Pi(P, a) = (P + a\pi(p)y - c)D(P)$$

It is important to point out that the apps being considered here are paid apps. A large class of apps is free apps that are funded by advertising. App stores typically do not charge a commission for those apps. Hence, the value of those apps would be part of the intrinsic utility consumers may draw from their devices. However, this abstraction does set aside an important choice for app developers as to their monetisation strategies that may, in reality, be influenced by commissions.

The timeline for the model is as follows:

1. (*Commission Choice*) The device maker sets its commission, a.

2. (*App Developer Choices*) App developers realise their entry costs, k, make their entry decisions and choose their app price, p.

3. (*Device Pricing Choice*) The device maker sets its price, P.

4. (*Consumer Choices*) Consumers choose whether to purchase a device and pay P and, if so, whether to purchase apps and pay p for each app.

5. (*Payoffs*) Profits and payoffs are realised.

The first two stages could be collapsed into a simultaneous choice without changing the conclusions that follow. It is convenient to separate out the stages for analytical purposes but also because, at the very least, the commission rate is set prior to other choices in reality.

2.2 App Developer's Pricing and Entry Condition

It is expositionally useful to consider the app developer's choices first even though those choices are made based on their expectations of the device-maker's price, P. Note that, as there is a continuum of app developers, no single developer anticipates influencing that pricing choice.

Should they enter, what price will app developers set? Their profits are $(1-a)pd(p)$ per consumer, and thus, their price will be $p_m \equiv \arg\max_p pd(p)$ because the commission rate does not matter for optimal pricing post-entry.[2]

Given this, the entry condition for an app developer with cost, k, is $(1-a)\pi(p_m) - k$. For notational convenience in what follows, $\pi_m \equiv \pi(p_m)$. Thus, the total number of apps in equilibrium, $y_m(a)$, will be determined by:

$$y_m(a) = F((1-a)\pi_m D(P - s_m y_m(a)))$$

Thus, the surplus going to a consumer per app is:

$$s_m \equiv s(p) = \int_p^\infty d(\hat{p})d\hat{p}$$

Therefore, each consumer expects to earn $s_m y_m(a)$ in surplus from apps if they own a device.

2.3 Device Maker's Pricing and Commission Choices

Working backwards, given app entry and pricing, the device maker chooses price P to maximise:

$$(P + a\pi_m y_m(a) - c)D(P - s_m y_m(a))$$

For a convenient change of variables, following Jeon and Rey (2022), I analyse the device maker's choice of the quality-adjusted price, $\tilde{P} \equiv P - s_m y_m(a)$. It chooses $\tilde{P}$ to maximise:

$$(\tilde{P} + \sigma(a) - c)D(\tilde{P})$$

where $\sigma(a) \equiv (s_m + a\pi_m)y_m(a)$. σ is a measure of what Jeon and Rey (2022) term the 'subsidy' to the device maker from the app ecosystem. Using this, the first-order condition for $\tilde{P}$ is:

$$D(\tilde{P}) + (\tilde{P} + \sigma(a) - c)D'(\tilde{P}) = 0$$

[2] This presumes that there are no unit costs. If there are unit app costs, this condition will not hold.

This is similar to a standard monopoly pricing outcome except that the device maker anticipates earning commissions of $a\pi_m y$ per unit of device demand. As we will see, this factor tends to put downward pressure on the equilibrium device price.

Turning now to the choice of commission, the device maker chooses a to maximise profits. Using the envelope theorem, the first-order condition is:

$$D(\tilde{P})\sigma'(a) = 0$$

where $\sigma'(a) = (s_m + a\pi_m)y_m'(a) + \pi_m y_m(a)$. Therefore, the device-maker sets the commission rate to maximise $\sigma(a)$. Given this, if it is an interior solution, the optimal commission rate, a_m satisfies:

$$\frac{s_m}{\pi_m} = -\frac{y_m(a_m) + a_m y_m'(a_m)}{y_m'(a_m)} \tag{1}$$

The equilibrium, a_m, is characterised by this condition. Note also that, for an interior solution $y_m'(a_m) < 0$, implying that a higher commission rate reduces the equilibrium number of apps available.

Note that the equilibrium commission rate, a_m, could be 0. This occurs if:

$$\sigma'(0) = s_m y_m'(0) + \pi_m y_m(0) < 0 \implies \frac{s_m}{\pi_m} > -\frac{y_m(0)}{y_m'(0)}$$

This requires the ratio of consumer app surplus to app profits to be sufficiently large.

Example: *In order to examine these conditions more closely, it is useful to pick a specific assumption for $F(.)$ and $G(.)$. Here, it is assumed that (i) $u \sim U[0,1]$; (ii) $k \sim U[0,1]$; and (iii) $\pi_m(0) < 1$; the latter condition ensuring an interior solution to app developer entry. With this assumption, $\tilde{P}(a) = \frac{1}{2}(1 - \sigma(a) + c)$ and $y_m(a) = (1-a)\pi_m(1 - \tilde{P}(a))$. Together, these imply that:*

$$y_m(a) = \frac{(1-a)}{2 - (1-a)\pi_m(s_m + a\pi_m)}(1-c)$$

Using this and substituting into (1) *gives the equilibrium commission rate:*

$$a_m = \max\{\frac{\pi_m - s_m}{2\pi_m}, 0\}$$

Thus, the optimal $a_m = 0$ if $\pi_m \leq s_m$. When $\pi_m > s_m$, the equilibrium $a_m > 0$ and this results in $y_m(a_m) = \frac{2(s_m+\pi_m)}{\pi_m(8-(s_m+\pi_m)^2)}(1-c)$.

3 Equilibrium Commission is Optimal for Consumers

The first main result here concerns the welfare properties of the commission rate. Given that regulatory concerns motivated the present paper, it is instructive to compare the commission rate, a_m, that is chosen by the device maker with the rate that maximises social welfare. First, note that consumer surplus for a given commission, a, is:

$$S(\tilde{P}(a)) \equiv \int_{\tilde{P}(a)}^{\infty} D(P)dP$$

Note that minimising the quality-adjusted price, $\tilde{P}$, will maximise consumer surplus. This is achieved by maximising $\sigma(a)$ (see Jeon and Rey (2022)). Given this, the following proposition can be demonstrated:

Proposition 1 *The commission rate that maximises consumer surplus is the same as the commission chosen by the device maker.*

The proof follows from the earlier observation that both consumers and the device maker choose the commission rate to maximise $\sigma(a)$. A similar result has been noted previously in the literature. Etro (2021) demonstrate this result for a device-funded platform in competition with an ad-funded platform, while Jeon and Rey (2022) demonstrates this result when there is competition amongst device makers (platforms). Here, the result is shown to be more fundamental; arising in the monopoly platform case.

This welfare implication covers two of the three classes of agents with regard to welfare but does not consider the impact on app developers. For a given developer, a marginal increase in the commission has a direct effect on app profits. Aggregate developer profits is:

$$\Pi_A(a) \equiv \int_0^{(1-a)\pi_m D(\tilde{P}(a))} ((1-a)\pi_m D(\tilde{P}(a)) - k)dF(k)$$

The first derivative of $\Pi_A(a)$ with respect to a is:

$$\int_0^{(1-a)\pi_m D(\tilde{P}(a))} \Big((1-a)\pi_m D'(\tilde{P}(a))\sigma'(a) - \pi_m D(\tilde{P}(a))\Big) dF(k)$$

Note that at $a = a_m$, this derivative is negative and, therefore, even taking into account the fact that a reduced commission might increase device demand, developers would prefer a lower app price than the device maker or consumers. Note, however, that the developer-optimal commission may be greater than zero if:

$$D'(\tilde{P}(0))\sigma'(0) > D(\tilde{P}(0))$$

which may or may not hold depending on parameters.

Example (Continued): *What is the total welfare maximising commission level? That is, what commission level maximises:*

$$\Pi(a) + S(a) + \Pi_A(a)$$

Note that:

$$\Pi(a) = \tfrac{1}{4}(1 - c + \sigma(a))^2$$

$$S(a) = \tfrac{1}{8}(1 - c + \sigma(a))^2$$

$$\Pi_A(a) = \tfrac{1}{8}(1 - a)^2 \pi_m^2 (1 - c + \sigma(a))^2$$

This demonstrates clearly the difference in incentives between the device maker/consumers and the app developer. Note that the a that maximises app developer profits is characterised by:

$$\sigma'(a) \leq (1 - c + \sigma(a))$$

This involves a positive commission if

$$\sigma'(0) > (1 - c + \sigma(0)) \implies \pi_m > \frac{2(1 - 2s_m c)}{2 + s_m(1 - c) + s_m^2}$$

which holds for s_m/π_m low enough.

Taking the derivative of total welfare with respect to a gives:

$$\tfrac{1}{4}(3 + (1 - a)^2 \pi_m^2)\sigma'(a)(1 - c + \sigma(a)) - \tfrac{1}{4}(1 - a)\pi_m^2 (1 - c + \sigma(a))^2$$

This implies a first-order condition of:

$$\sigma'(a) = \frac{(1 - a)\pi_m^2}{3 + (1 - a)^2 \pi_m^2}(1 - c + \sigma(a))$$

Thus, the total welfare commission exceeds a_m, which involves the left-hand side of this inequality being zero.

As noted in the Introduction, Etro (2021) provides a model where a mobile operating system and app store are funded using advertisements rather than revenue from selling devices themselves. It is useful to note here, as does Etro (2021), that this change in the platform model fundamentally changes the welfare properties of the app store commission. To see this, suppose that $D(.)$ is independent of price or, more critically, depends on other factors, such as expected advertising revenue per consumer. Let R be revenue per consumer. Given this, platform profits become:

$$\Pi_{ad} = (R + a\pi_m y_m(a))D(P(a) - s_m y_m(a))$$

where, here, $P(a)$ is set by another party (device-maker). The first-order condition for the platform owner is:

$$\pi_m(y_m(a) + ay'_m(a))D(.) + (R + a\pi_m y_m(a))D'(.)(P'(a) - s_m y'_m(a)) = 0$$

By contrast, maximising consumer surplus involved maximising $(s_m + a\pi_m)y(a)$ or

$$(\pi_m y(a) + (s_m + a\pi_m)y'_m(a))D(.) + (s_m + a\pi_m)y(a)D'(.)(P'(a) - s_m y'_m(a)) = 0$$

Note that the returns to setting a higher a are greater for an ad-funded platform than the value to consumers if the right-hand side of the first order condition for a is higher than the right-hand side for the consumer welfare condition:

$$(R - s_m y_m(a))D'(.)(P'(a) - s_m y'_m(a)) \geq s_m y'_m(a)D(.)$$

$$\Leftrightarrow \frac{R - s_m y'_m(a)}{s_m y'_m(a)} \geq \frac{D(.)}{D'(.)(P'(a) - s_m y'_m(a))}$$

This demonstrates, first, that the result that app commissions are consumer-optimal does not extend to the case where app commissions are set by a platform motivated by advertising revenue from devices. Second, it shows that the commission set could be higher than the consumer-optimal commission if the level of advertising revenue per consumer exceeds the consumer's value of apps and the price elasticity of device demand is relatively high. Etro (2021) demonstrates that when the two types of platforms compete, the ad-funded platform has an incentive to set higher app commission rates than the consumer-optimal commission level that is set by the device-funded platform.

4 A Zero Commission Increases Device Prices

As discussed in the Introduction, some of the discussion regarding app store commissions reflects a desire that these should not exist. As already noted, the device makers and consumers would not hold this position. However, what is of interest here is whether app developers would prefer $a = 0$ to $a = a_m$. On the one hand, a lower commission means that app developers appropriate a greater amount of the revenue they generate. On the other hand, that lower commission may cause the device maker to choose a higher device price that reduces overall demand in the ecosystem and, in the process, reduces app developer profits.

Suppose that $a = 0$ and any higher commission is prohibited. An app developer will choose its price to maximise:

$$\pi(p) = pd(p)$$

which gives rise to an optimal price of p_m; that is, the level of a does not impact optimal pricing. Thus, expected consumer surplus from each app is unchanged at s_m.

However, app developer profits will change. These are now $\pi_0(p_m) \equiv p_m d(p_m)$. Therefore, $y_m(0) \equiv \hat{y}(0, p_m) = F(\pi_0(p_m)) > y_m(a_m)$. Thus, moving from the equilibrium commission to a zero commission increases the number of available apps.

An increase in y has a direct impact on the quality-adjusted device price, $\tilde{P}$. Device maker profits are now:

$$\Pi(0) = (\tilde{P} + \sigma(0) - c)D(\tilde{P})$$

where $\sigma(0) = s_m y_m(0)$. The optimal price, $\tilde{P}(0)$ satisfies:

$$D(\tilde{P}(0)) + (\tilde{P}(0) + \sigma(0) - c)D'(\tilde{P}(0)) = 0$$

Note that $\tilde{P}(0) > \tilde{P}(a_m)$ if, for all a,

$$\sigma'(a) > 0 \Leftrightarrow \epsilon_{y,a} \equiv -\frac{ay'(a)}{y(a)} < 1$$

That is, if the reduction in y from an increase in a is proportionately less than the increase in a; i.e., the elasticity of app supply with respect to the commission is less than unity. Note that at the optimal, a_m, if $a_m > 0$, from (1), this must hold if $\pi_m > s_m$. Thus, it has been shown that:

Proposition 2 *Compared with the unregulated equilibrium outcome, if $\pi_m > s_m$, eliminating app store commissions leads to a higher quality-adjusted device price.*

Example (Continued): *Returning to the running example, when $a = 0$:*

$$\tilde{P}(0) = 1 - \frac{1 - c}{2 - s_m \pi_m}$$

Note that,

$$\sigma(a_m) > \sigma(0) \Leftrightarrow s_m < (1 - a_m)\pi_m$$

or $a_m < \frac{\pi_m - s_m}{\pi_m}$*. This always holds if* $\pi_m > s_m$*. Therefore, in the zero commission model,* $\tilde{P}$ *rises if* $a_m > 0$*. What about the non-quality adjusted device price,* P*? Note that:*

$$
\begin{aligned}
& P(0) > P(a) \\
& \implies \tfrac{1-c}{2-s_m\pi_m} + c > \tfrac{4+2c(2-s_m(s_m+\pi_m))+s_m^2-\pi_m^2}{8-(s_m+\pi_m)^2} \implies \tfrac{(1-c)(\pi_m-s_m)(s_m(3-\pi_m(s_m+\pi_m))+\pi_m)}{(2-s_m\pi_m)(8-(s_m+\pi_m)^2)} > 0
\end{aligned}
$$

which holds if $\pi_m > s_m$*. Therefore, in a zero-commission model, device prices would rise.*

Finally, it is useful to note that app developer profits will increase proportionately more than a_m *if a zero-commission is imposed. When* $a = a_m = \frac{\pi_m - s_m}{2\pi_m}$*, app developer profits are:*

$$
\pi(a_m)y_m(a_m)D(P(a_m)) = (1-a_m)p_m d(p_m)y_m D(P(a)) = \frac{64(1-c)^2(s_m+\pi_m)^2}{(127-8s_m(1+2s_m))(8-(s_m+\pi_m)^2)}
$$

When $a = 0$*, these become:*

$$
\pi(0)y_m(0)D(P(0)) = p_m d(p_m)y_m D(P(a)) = \frac{(1-c)^2\pi_m^2}{(2-s_m\pi_m)^2}
$$

It can be readily shown that, for $\pi_m \geq s_m$*,*

$$
\frac{\pi(0)y_m(0)D(P(0)) - \pi(a_m)y_m(a_m)D(P(a_m))}{\pi(a_m)y_m(a_m)D(P(a_m))} \geq \frac{\pi_m - s_m}{2\pi_m}
$$

5 A Required Menu Constrains Commission Rates

As just established, while the elimination of app commissions would result in an app-developer optimal outcome and a greater number of apps in equilibrium, it comes at the expense of the device maker and consumer welfare. This suggests that if regulators could set an app commission rate, they might be able to more appropriately balance the outcomes for different groups in the mobile app ecosystem. One option would be to identify that rate and impose it. However, as has already been noted, precisely what the optimal rate ought to be may be difficult to establish.

Is there a mode of regulation that could increase app developer profits while key decisions are still made based on parameters in the ecosystem that regulators may not easily observe? While in the baseline model (and reality), app store commissions are chosen by the device maker, the mechanism proposed here would give consumers a choice as to how devices are subsidised. The present unregulated system has app developers subsidise the device maker directly. The zero commission outcome has no explicit subsidy. What if consumers had a choice as to whether app developers subsidised the device maker or, instead, consumers did so themselves through a higher device price? The idea is that a consumer could either pay the device price and app prices as stated *or* pay a premium for the device and receive a discount on app prices set by the commission the device maker would otherwise charge. How would this influence the various prices in the ecosystem, including the device price, app prices and app commission?

Specifically, under this mechanism, the device maker is required to offer consumers a menu $(P+\Delta(a),(1-a)p)$ where, depending on a, the consumer has a different set of device and app prices. Specifically, when $a=a_m$, the consumer is offered (P,p) while if they elect for $a=0$ on apps they purchase, the consumer is offered $(P+\Delta,(1-a)p)$. The device maker and app developers are constrained to choose P and p, respectively, across both menu items. The idea is that the consumer chooses whether they or the app developer pays device costs.

Let $s_c(p)$ give a consumer's surplus when they pay p for an app. A consumer will choose (P,p) rather than $(P+\Delta,(1-a)p)$ if:

$$u+s_c(p)y_c-P>u+s_c((1-a)p)y_c-(P+\Delta) \implies \Delta>(s((1-a)p)-s(p))y_c$$

where y_c is the number of apps available. Note that this condition is independent of the base device price, P. To examine this condition, suppose that all consumers choose (P,p). We want to derive the conditions under which this will be an equilibrium. As this is the same contract as in the baseline model, we know that $p=p_m$ and $\pi_c=(1-a)\pi_m$. Therefore, this will be a pure strategy equilibrium if:

$$\Delta \geq \underline{\Delta} \equiv (s((1-a)p_m)-s(p_m))y_m(a)$$

By contrast, suppose that all consumers choose $(P+\Delta,(1-a)p)$. In this case, an app developer will choose its price to maximise:

$$\pi_c(p)=(1-a)pd((1-a)p)$$

It is easy to see that the optimal price is $p_c=p_m/(1-a)$. Thus, expected consumer surplus from apps is $s(p^c)=\int_{(1-a)p_c}^{\infty} d(i)di=s_m$ in this case and app developer profits are $\pi(p_c)=(1-a)p_c d((1-a)p_c)=p_m d(p_m)$. Therefore,

$$y_c=F(\pi_m)>F((1-a)\pi_m)=y_m(a)$$

This will be a pure strategy equilibrium if

$$\Delta \leq \bar{\Delta} \equiv (s(p_m)-s(p_m/(1-a)))y_c$$

Given this, it has been demonstrated that for that subgame following the choice of a:

Lemma 1 *The unique equilibrium involves all consumers choosing (i) $(P+\Delta,(1-a)p)$ if $\Delta<\underline{\Delta}$ or (ii) all consumers choosing (P,p) if $\Delta>\bar{\Delta}$. If $\bar{\Delta}>\underline{\Delta}$, then for $\Delta\in[\underline{\Delta},\bar{\Delta}]$, there are two pure strategy equilibrium outcomes involving all consumers either choosing (P,p) or $(P+\Delta,(1-a)p)$. If $\bar{\Delta}\leq\underline{\Delta}$, there is a mixed strategy equilibrium outcome with a positive share of consumers choosing (P,p) while the remaining consumers choose $(P+\Delta,(1-a)p)$.*

The lemma demonstrates a multitude of possible equilibrium outcomes in the consumer choice subgame that depend upon the level of Δ and also on a that determines the change in consumer surplus, consumers that results if the consumers deviate from the equilibrium outcome. Regardless, as Δ falls, the conditions for which an equilibrium involves some or all consumers opting for $(P+\Delta,(1-a)p)$ increase.

Example (Continued): *Suppose that $d(p)=1-p$. Then $p_m=\frac{1}{2}$. Given this,*

$$\underline{\Delta}=\frac{1}{32}a(2+a)(1-a)$$

$$\bar{\Delta}=\frac{(2-3a)a}{32(1-a)^2}$$

Note that:

$$\bar{\Delta}>\underline{\Delta}\implies\frac{(2-a)a^2\left(a^2+a-1\right)}{32(1-a)^2}<0\implies a<\tfrac{1}{2}\left(\sqrt{5}-1\right)\approx 0.61$$

Thus, for a greater than this level $\underline{\Delta}>\bar{\Delta}$ there is no pure strategy equilibrium outcome if $\Delta\in(\bar{\Delta},\underline{\Delta})$.

What does the mixed strategy equilibrium look like? Suppose that α consumers choose (P,p) while $1-\alpha$ choose $(P+\Delta,(1-a)p)$. Then an app developer chooses p to maximise $\alpha(1-a)pd(p)+(1-\alpha)(1-a)pd((1-a)p)$. This gives rise to $p_c(\alpha)$. When $d(p)=1-p$, $p_c=\frac{1}{2(1-a(1-\alpha)}$. Developer profits are $\pi_c(\alpha)=\frac{1-a}{4(1-a(1-\alpha))}$ and $y_c(\alpha)=\pi_c(\alpha)$. Thus, for a consumer choosing (P,p), $s_c(p)=\frac{(2a(\alpha-1)+1)^2}{8(a(\alpha-1)+1)^2}$ and, for a consumer choosing $(P+\Delta,(1-a)p)$, $s_c((1-a)p)=\frac{(a(2\alpha-1)+1)^2}{8(a(\alpha-1)+1)^2}$. The equilibrium α will occur at α_c where:

$$s_c(p(\alpha_c))y_c(\alpha_c)=s_c((1-a)p_c(\alpha_c))y_c(\alpha_c)-\Delta\implies\frac{(1-a)a(2-a(3-4\alpha_c))}{32(1-a(1-\alpha_c))^3}=\Delta$$

While this admits a closed form solution it is omitted here because it is unwieldy and of no utility. The important conclusion is that developer profits, $\pi_c(a)$, are decreasing in α con-

firming that as few consumers continue with the choice (P, p) developer profits rise.

It is important to note that in an equilibrium where consumers choose $(P + \Delta, (1 - a)p)$, device maker profits end up being the same as if the commission was regulated to 0. To see this, note that these profits are now:

$$\Pi = (P + \Delta - c)D(P + \Delta - s(p^m)y_c)$$

If $\Delta = 0$, this is equivalent to the problem where a is regulated to be 0. But suppose that $\Delta < \bar{\Delta}$. Then the device price, P, that maximises these profits can be achieved by choosing $P + \Delta$ that maximises profits; that is, $P + \Delta = P(0)$; the price if $a = 0$. This occurs because the device maker does not earn any share of app developer revenue. Thus, as Δ changes, the price of the device changes but the total price, $P + \Delta$ paid by consumers does not change. Thus, in effect, with a low enough Δ, the outcome is the same as if the commission is set equal to 0.

For a given a, depending on Δ, either the device maker-preferred outcome continues to arise or the app developer-preferred outcome is established with having to regulate a to equal 0. As this depends on Δ, it is important to examine what Δ will be set at. Note that given that there is no consumer heterogeneity in app usage, the device maker has no incentive to establish a menu of options. Therefore, a menu would be a regulatory requirement. In that regard, Δ would have to be capped at some level; otherwise, the device maker would choose $\Delta > \bar{\Delta}$.

What level might Δ be capped at? One option is for Δ to equal the expected commission revenue a device maker would have received per consumer prior to a requirement being made. This would mean that even if a consumer chose to opt to incur the subsidy, the previous subsidy would be maintained. That is, $\Delta = a_m \pi_m y_m$.[3] Note that for this device premium, it will not be an equilibrium for consumers to accept (P, p) if:

$$a_m \pi_m y_m(a_m) < (s((1 - a)p_m) - s_m)y_m(a_m) \implies \sigma(a_m) < s((1 - a)p_m)y_m(a_m)$$

This condition will hold for the commission rate chosen post-requirement, a, high enough.

Importantly, this implies that the nature of the equilibrium outcome, even with a regulated Δ, is not outside of the device maker's control. As already demonstrated, the device maker profits will be increasing in a up to a_m. If this condition holds at a_m, the device

[3] In 2023, Apple earned around \$28 billion from app store commissions worldwide over some 2 billion active devices. So this would amount to \$14 per consumer per year. However, a device may last 5 years and so this would put $\Delta = \$70$.

maker will increase profits by reducing a so that $\sigma(a_m) \geq s((1-a)p_m)y_m(a_m)$. At this point, consumers would not opt for $(P+\Delta,(1-a)p)$, and the device maker's profits would be $\Pi(a)$ rather than $\Pi(0)$. This demonstrates that by offering a required menu, then the device maker would have an incentive to reduce commission rates caused by the pressure of consumer choice.

Given this, the following proposition results:

Proposition 3 *Under the required menu model where Δ is set to $a_m\pi_m y_m$, the device maker will set $a_c \leq a_m$ such that $s((1-a_c)p_m)y_m \geq \sigma(a_m)$.*

What this shows is that by basing a required menu on existing rates of device maker earnings from app store commissions, the device maker has an incentive to reduce the app commission to provide an incentive for consumers to choose to let app developers pay that commission. In effect, the consumer is balancing the subsidies being provided (with $s((1-a_c)p_m)y_m$ being the subsidy if the consumer opts to pay a device premium), which creates an incentive for the device maker to ensure that the subsidies are approximately equal.

Example (Continued): *Note that $s((1-a)p_m) = \frac{1}{8}(1+a)^2$ while $\sigma(a_m)/y_m = s_m + a_m\pi_m = s_m(\pi_m - s_m)/\pi_m$ if $\pi_m > s_m$. Thus, the device maker will set a at:*

$$a_r = \max\{4\sqrt{\tfrac{s_m(\pi_m - s_m)}{2\pi_m}} - 1, 0\}$$

which may be equal to 0 for π_m/s_m sufficiently low.

6 Conclusion

This paper has provided a simple analysis of some of the pricing forces at play in mobile app ecosystems. It was motivated by the regulatory discussions regarding the size and role of app store commissions that have been a feature of these ecosystems. The three results presented provide ways of framing the various trade-offs to inform those policy discussions.

The model could be extended in various directions. As already mentioned, prior work by Jeon and Rey (2022) provides a duopoly version of the model here with a focus on competitive pressures to set app store commissions. Another set of extensions may incorporate consumer heterogeneity in app usage. While this is not expected to materially change the first two results of the paper, if a required menu were introduced, then consumers might sort into different pricing options depending on their app usage – with high usage consumers opting for a device premium and app discount. This may introduce a form of price discrimination into the market with the usual welfare implications.

More broadly, the required menu approach reflects some of the conclusions of Tirole and Bisceglia (2023) that the regulation of ecosystem pricing can be viewed more broadly than simply direct price regulation. While the required menu here does not necessarily result in different outcomes than direct price regulation, depending on the information available to regulators, it may represent a preferable approach. However, exploration of this set of issues is left for future work.

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