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Advertiser Competition and Gatekeeping in Ad-Funded Media

Martin Peitz[1]
Anton Sobolev[2]
Paul Wegener[3]

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[1]Department of Economics and MaCCI, University of Mannheim, 68131 Mannheim, Germany; E-Mail: Martin.Peitz@gmail.com; also affiliated with CEPR and CESifo.
[2]Department of Economics and MaCCI, University of Mannheim, 68131 Mannheim, Germany; E-Mail: anton.sobolev@uni-mannheim.de.
[3]Department of Economics and MaCCI, University of Mannheim, 68131 Mannheim; E-Mail: pwegener@mail.uni-mannheim.de.

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Advertiser Competition and Gatekeeping in Ad-Funded Media*

Martin Peitz† Anton Sobolev‡ Paul Wegener§

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Abstract

Advertisers place ads on publishers' websites to attract the attention of multi-homing consumers. Because of competition in the product market, advertisers may have an incentive to partially or fully foreclose their rivals. A gatekeeper may be able to limit publishers' access to some of the consumers. We fully characterize the equilibrium in which the gatekeeper, publishers, and advertisers make strategic pricing decisions. We show how the presence of the gatekeeper affects the advertisers' foreclosure decisions and the surplus of the different market participants.

Keywords: gatekeeper, ad-funded media, advertiser competition, ad blocking, uniform pricing, foreclosure, imperfect competition

JEL-classification: L12, L13, L15, M37

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†Department of Economics and MaCCI, University of Mannheim, 68131 Mannheim, Germany; E-Mail: Martin.Peitz@gmail.com; also affiliated with CEPR and CESifo.

‡Department of Economics and MaCCI, University of Mannheim, 68131 Mannheim, Germany; E-Mail: anton.sobolev@uni-mannheim.de.

§Department of Economics and MaCCI, University of Mannheim, 68131 Mannheim; E-Mail: pwegener@mail.uni-mannheim.de.

1 Introduction

Digital advertising finances a large share of online content, including news, entertainment, and information services. The viability of this ad-supported model depends on advertisers' ability to reach consumers and on publishers' ability to monetize attention. In recent years, this model has come under pressure from intermediaries that act as gatekeepers, influencing which advertisements consumers are exposed to and extracting a share of advertising revenues. For example, news aggregators (including social networks) may limit exposure to particular content bundles and associated advertisements, and general search engines may reduce the visibility of specialized comparison sites or niche publishers.

A further example of a gatekeeper – and our lead example – is ad blockers, which are third-party applications that, when installed on users' devices, prevent advertisements from being displayed on publishers' websites. Prominent ad-blocking firms operate a paid *whitelisting* system, under which "acceptable ads" by selected publishers continue to be displayed in exchange for a fee. Large publishers that join their whitelist reportedly pay 30% of the additional advertising revenue generated through whitelisting to the firm (Adblock Plus, n.d.). The market for ad blockers tends to be highly concentrated: in Germany, Adblock Plus accounted for approximately 95% of ad-blocker usage in 2017 (OLG München, 2017, para. 20). We also note that ad blockers are still in use in the 2020's.[1]

We consider a parsimonious model with one gatekeeper, two publishers, two advertisers, and a continuum of consumers to analyze the strategic and welfare effects of limited ad exposure imposed by a monopoly gatekeeper. Consumers purchase only products they have seen advertised, so reaching consumers with advertisements is essential for trade. Advertisers place ads on publishers' websites to reach consumers, and the gatekeeper may restrict or mediate this interaction. Users are assumed to visit both publishers, each of which offers one advertising slot. Advertisers compete in the product market and may seek to foreclose rivals

[1] According to survey evidence, in 2023, 32% of internet users in the United States and 33% in Germany reported using an ad blocker; numbers and sources for a large range of countries are reported by Statista. Usage appears to be lower on mobile devices than on desktops – according to a 2020 survey, 17% of German users reported using an ad blocker on a smartphone and 12% on a tablet, compared to 39% on desktop computers, see `https://www.statista.com/statistics/875612/ad-blocker-usage-in-germany-by-device/`.

by contracting with both publishers.

In the absence of the gatekeeper, an advertiser can completely foreclose its rival by purchasing the advertising slots on both publishers' websites, thereby obtaining a monopoly position in the product market. Depending on the intensity of competition between advertisers, either one advertiser buys both slots or each advertiser purchases one.

In the presence of the gatekeeper, some consumers access publishers only through the gatekeeper, whereas others continue to visit both publishers directly. Consumers who rely on the gatekeeper can view ads only from publishers that contract with it. This may lead to *partial foreclosure* meaning that one of the advertisers is visible only to consumers outside the gatekeeper and invisible to the consumers with the gatekeeper.

In the simplest setting, advertisers can price discriminate between consumers who are with the gatekeeper and those who are not. While it is conceivable that partial foreclosure occurs, this is never an equilibrium outcome: In equilibrium, the gatekeeper always extracts some of the surplus that advertisers and publishers would obtain without the gatekeeper and consumer surplus is unaffected by the presence of the gatekeeper. Gatekeeping thus makes publishers worse off, consistent with complaints raised by publishers in the context of ad blocking.

In contrast, when advertisers cannot price discriminate and must set uniform prices for consumers on and off the gatekeeper, partial foreclosure arises in equilibrium. The gatekeeper may extract surplus from (i) publishers alone, (ii) publishers and advertisers, or (iii) publishers and consumers. When gatekeeping leads to partial foreclosure, consumers are better off if, in the absence of the gatekeeper, there is full foreclosure and worse off if, in the absence of the gatekeeper, there is no foreclosure. We also show that publishers are not always worse off and may even obtain higher profits in the presence of gatekeeping because the gatekeeper's rent extraction possibility may be more limited under uniform pricing.

We consider two extensions. First, partial foreclosure continues to arise under endogenous consumer adoption of the gatekeeper. We show this in a setting in which consumers differ sufficiently in their nuisance costs of advertising.

Second, moving beyond the setting with two publishers and two advertisers, partial foreclosure may even arise with price-discriminating advertisers. To see this, we allow for three publishers and at least three advertisers. With gatekeeping, there may be partial foreclosure of the following form: Two publishers buy listing and three advertisers buy ad slots. Thus, two advertisers have access to all consumers, whereas one has access only to the consumers who do not use the gatekeeper. In such an equilibrium, consumers are worse off in the product market than in the absence of the gatekeeper because three advertisers would buy an ad slot in the absence of the gatekeeper, obtaining access to all consumers.

The paper proceeds as follows. In Section 2, we review the related literature with a particular focus on the application of ad blocking. In Section 3, we introduce the model with a gatekeeper and an exogenous fraction of consumers who access content and advertising through the gatekeeper. In Section 4, we take a first look at the role of gatekeeping and analyze the strategic interaction between the gatekeeper, publishers, and advertisers when advertisers price-discriminate between consumers who use the gatekeeper and those who do not; we compare the ensuing equilibrium to the one that would obtain if the gatekeeper were not present. In Section 5, we analyze the more complex setting in which advertisers set a uniform price across all consumers. For illustration of the product market interaction, we employ two versions of the Hotelling model of product-market competition with horizontal product differentiation in Sections 4 and 5: one with linear and one with quadratic transport costs. In Section 6, we endogenize the consumer decision on whether to use the gatekeeper. In Section 7, we extend our analysis to more than two publishers. In Section 8, we discuss the three real-world applications mentioned above: ad blockers, news aggregators (including social media platforms), and search engines. Section 9 concludes. All proofs are relegated to the Appendix.

2 Related literature

In this paper, we adopt the informative-advertising view that advertising raises the probability that consumers become aware of a product – either because they had not known about it or because it re-enters their consideration set (Butters, 1977; Grossman and Shapiro, 1984).[2]

[2]Starting with Grossman and Shapiro (1984), one stream of this literature analyzes advertiser competition with differentiated products in symmetric settings that yield symmetric equilibria; see Soberman (2004),

In this framework, advertisers reach consumers through publishers, who can be accessed either directly or through a gatekeeper. Our paper relates to the literature on two-sided platforms that intermediate between sellers and buyers and manage competition among sellers (e.g., Nocke, Peitz, and Stahl, 2007; Hagiu, 2009; Belleflamme and Peitz, 2019; Karle, Peitz, and Reisinger, 2020; Teh, 2022). It also connects to the media-platform literature, where publishers earn revenue from advertisers rather than consumers (Anderson and Coate, 2005; Dukes and Gal-Or, 2003). In our setting, the gatekeeper affects advertiser competition through its listing decisions: if a publisher does not pay the listing fee, its content may be removed or demoted – along with the advertising it carries, as in the case of news aggregators and search engines – or remain available but without advertising, as with ad blockers.

In the context of ad blocking, earlier work on ad blocking focuses on the interaction between the ad blocker and publishers while abstracting from advertiser competition in the product market (Anderson and Gans, 2011; Despotakis, Ravi, and Srinivasan, 2021; Gritckevich, Katona, and Sarvary, 2022).[3] In these models, ad blocking may appear beneficial to consumers by reducing advertising nuisance. However, Anderson and Gans (2011) and Gritckevich, Katona, and Sarvary (2022) show that ad blocking can indirectly harm some consumers. Specifically, Anderson and Gans (2011) show that the presence of ad blockers can lead publishers to increase ad volume: since consumers with high nuisance costs install the blocker, publishers have an incentive to raise ad intensity for consumers who do not use the ad blocker.

Different from the existing literature, our model accounts for the contractual relationship between publishers and the ad blocker. Under this contract, the ad blocker agrees not to block a publisher's ads in exchange for a whitelisting fee. The associated revenues constitute the ad blocker's main source of income. We identify a new mechanism through which consumers may be harmed by ad blocking: by limiting exposure to competing advertisers, ad blocking can reduce product-market competition and raise retail prices. Under uniform pricing, this price increase also affects users who do not use an ad blocker.

Christou and Vettas (2008), and Amaldoss and He (2010).

[3]We do not address the interaction between ad targeting and ad blocking; see Johnson (2013). In a different vein, Chen and Liu (2022) follow Nelson (1974) and Milgrom and Roberts (1986) to analyze the signaling role of advertising and show how ad blocking affects advertising costs.

Ad blocking may also harm publishers by extracting rents without offsetting benefits. Yet, as shown by Despotakis, Ravi, and Srinivasan (2021), competing publishers may sometimes benefit when ad blocking enables discrimination among consumers with different sensitivities to advertising; a similar finding arises for a monopoly publisher in Aseri et al. (2020). We also find that ad blocking can be beneficial for publishers, though for different reasons: when advertisers compete in prices, ad blocking affects the extent to which publishers and the gatekeeper can extract rents from advertisers.

There is also a small empirical literature on ad blocking. Because ad blockers reduce ad exposure and consumers often regard online advertising as a nuisance, one would expect users with ad blockers to spend more time on publishers' websites – a pattern confirmed by Yan, Miller, and Skiera (2022). Consistent with theoretical predictions that ad blocking can reduce publisher revenues (Anderson and Gans, 2011; Gritckevich, Katona, and Sarvary, 2022), ad avoidance in commercial television is found to decrease channel revenues (Wilbur, 2008), and blocking display ads is found to reduce publishers' online revenues (Shiller, Waldfogel, and Ryan, 2018). Such revenue losses may in turn lead to lower content quality, potentially offsetting any increase in usage.[4] The finding by Shiller, Waldfogel, and Ryan (2018) that ad blocking reduces site visits supports this interpretation. Empirical support for the mechanism highlighted in our paper is offered by Todri (2022), who find that by limiting exposure to new or competing products, ad blocking reduces consumers' awareness of alternative options, thereby decreasing spending on previously unadvertised products and shifting purchases toward familiar ones.

Our analysis relates to the literature on uniform-pricing restrictions in product-market competition. We connect to this literature when presenting two Hotelling-type models of product differentiation as a microfoundation for the reduced profit functions.

Finally, there is a long literature in industrial organization on foreclosure. Our duopoly analysis builds on the idea that an advertiser can place ads with both publishers and thereby foreclose its rival in the product market. Most closely related is Prat and Valletti (2022), who study mergers of publishers under consumer multi-homing and the incentives of an incumbent firm to foreclose rivals in the product market by buying ad slots with all publishers.

[4] Widespread ad-blocker adoption may also encourage publishers to erect paywalls.

3 Model

We consider two ad-funded publishers that bundle content with advertising and monetize consumer attention.[5] There is a unit mass of consumers, a fraction $1 - \alpha \in (0, 1]$ of whom access both publishers directly (multi-home) and are exposed to ads on both publishers. The remaining fraction α of consumers reach publishers via a monopolistic gatekeeper that improves their experience by filtering and limiting advertising.[6] The gatekeeper makes profits by offering publishers *listing* at a fixed fee a, which ensures that listed publishers' ads remain visible to consumers using the gatekeeper — either because non-listed content is removed together with its ads or because the ads alone are filtered out.

Each publisher offers at most one advertising slot and charges an advertising fee f_i, $i = 1, 2$.[7] There are two advertisers, A and B, who purchase advertising slots to reach consumer attention and sell their products at prices p_A and p_B, respectively. We assume that advertising is informative in the sense that sales occur only if consumers are reached through at least one publisher. The profit that advertiser $j \in \{A, B\}$ makes from a consumer who observes the ads of both advertisers is denoted by $\pi(p_j, p_{-j})$, where advertiser j sets price p_j, and its rival sets price p_{-j}. If the competing advertiser does not reach this consumer while advertiser j does, then advertiser j enjoys a monopoly position and earns $\pi(p_j, \infty)$ from such a consumer.

To reach consumers who access publishers through the gatekeeper, an advertiser must secure an ad slot from at least one publisher listed with the gatekeeper. In the ad-blocking example, this corresponds to a publisher that has paid a whitelisting fee to the ad-blocking firm. Therefore, an advertiser is active in up to two market segments: one for consumers who access publishers directly and the other for those who do so through the gatekeeper.

[5]These bundles can be interpreted as content tailored to specific advertisers (Athey and Gans, 2010); for example, a travel website offering ads for particular destinations.

[6]In Section 6, this fraction is endogenized by allowing consumers to trade off the benefits and costs of accessing content through the gatekeeper versus directly.

[7]The restriction to a single ad slot per publisher can be motivated by consumers' limited attention to advertising when visiting a publisher's website. If consumers dislike ads and can pay attention to only one on any publisher they visit, the publisher maximizes its revenue by posting a single ad. One can think here of advertising in a particular product category, which motivates advertiser competition in the product market.

These segments are interdependent if advertisers set a uniform retail price across them. They are independent if advertisers can price discriminate – that is, if the price a consumer faces depends on whether the consumer accesses the publisher directly or through the gatekeeper.

Advertisers are assumed to sequentially decide which ad slots to purchase. Sequential arrival can be interpreted as a reduced-form Stackelberg-type timing asymmetry that gives advertiser A an incumbency advantage in securing advertising slots: early commitments (or exclusive placements) secure scarce inventory and limit rivals' exposure.[8] We refer to an outcome in which advertiser A purchases both advertising slots and establishes a monopoly position in the product market as *complete foreclosure*. In contrast, *partial foreclosure* arises when advertiser A becomes a monopolist among consumers who use the gatekeeper, while advertisers compete for consumers who access both publishers directly – this requires that exactly one of the two publishers lists with the gatekeeper.

Timing and equilibrium notion. The timing of the game is as follows:

1. The gatekeeper sets the access fee a for publishers.
2. Publishers simultaneously decide whether to accept the gatekeeper's offer.
3. Publishers simultaneously set their advertising fees f_i.
4. Advertisers arrive sequentially and choose the publisher(s) with which to advertise.
5. Advertisers simultaneously set retail prices, either price-discriminating between consumers who use the gatekeeper and those who do not or setting a uniform retail price for all consumers.

We solve for subgame-perfect Nash equilibria.

[8] Exclusive advertising arrangements are well documented and modeled in media markets (Dukes and Gal-Or, 2003; Sayedi et al., 2018), and early commitments are a salient institutional feature of television "upfront" markets, where premium inventory is allocated before the scatter market (Digiday Editorial Team, 2022; MediaVillage, 2024; Tatari, 2023). Our timing assumption guarantees the existence of a pure-strategy equilibrium.

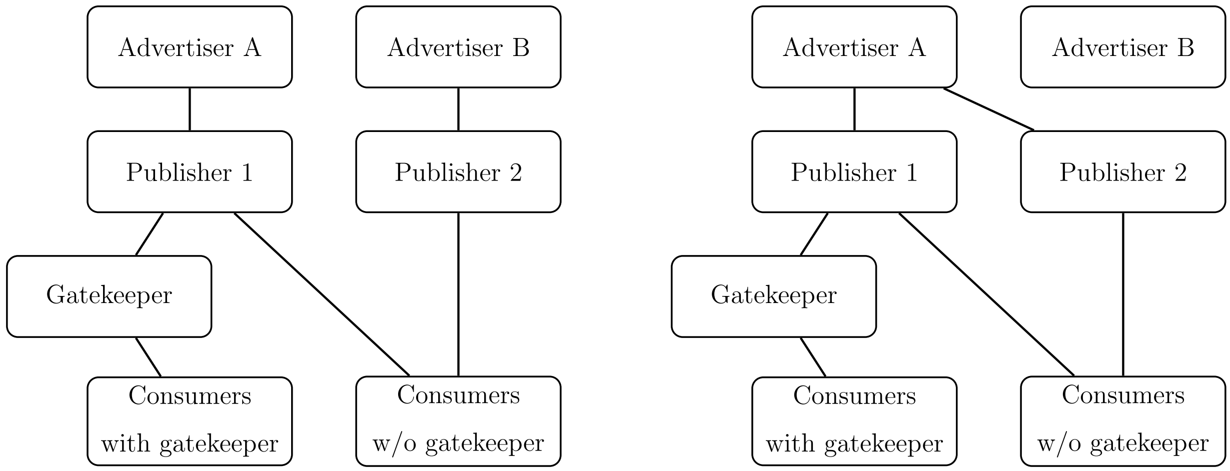

Figure 1: *Consumer choice sets when one publisher pays the gatekeeper: in the left panel, advertisers A and B buy an ad slot each, leading to partial foreclosure; in the right panel, advertiser A buys both ad slots, leading to complete foreclosure*

Illustration of consumer choice sets. Depending on the level of the fee a, none, one, or both publishers list with the gatekeeper. A listed publisher ensures that its ad is shown to all consumers, including those using the gatekeeper. By contrast, the ad with a non-listed publisher is invisible to those consumers and thus reaches only the fraction $(1-\alpha)$ of consumers.

Figure 1 illustrates the consumer choice set in the two cases in which one publisher has paid the gatekeeper and the other has not. A product is visible to a consumer if and only if there is a connecting line between the advertiser and the consumer.

In the figure in the left panel, each advertiser has purchased one ad slot. Consumers who access publishers directly can choose between the two products, whereas consumers using the gatekeeper can purchase only from the advertiser whose ads appear on the publisher's website that contracted with the gatekeeper (advertiser A). In this case, advertiser A partially forecloses advertiser B in the product market.

In the figure in the right panel, advertiser A has purchased both ad slots, so no consumer can buy from advertiser B. Thus, advertiser A fully forecloses advertiser B. In the following section, we characterize the equilibrium of the full game and provide the conditions under which full or partial foreclosure obtains in equilibrium.

4 A first look at the role of gatekeeping

In this section, we do three things. First, we consider competition among advertisers in the product market and introduce the necessary notation. Second, we analyze the setting without a gatekeeper as the relevant benchmark for this and subsequent sections.

Third, we analyze gatekeeping in the model in which advertisers can condition their price in the product market on the market segment. Such conditioning is relevant in the subgame in which both advertisers buy an ad slot, but only one publisher is listed with the gatekeeper, implying that the advertiser with the listed publisher has a monopoly position over those consumers who access via the publisher. As we will show, this subgame is never reached along the equilibrium path, showing that partial foreclosure can not arise in this setting.

Competition in the product market. Advertisers are either duopolists or one of the advertisers operates as a monopolist within a segment of the market. If both advertisers are visible to consumers, there is duopoly competition. We assume that advertisers are symmetric in the product market and that a unique duopoly equilibrium exists, which is symmetric and denoted by (p^d, p^d). The associated equilibrium duopoly profit is denoted by $\pi^d = \pi_i(p^d, p^d)$ for $i \in \{A, B\}$. If only one advertiser is visible to consumers in this segment, the advertiser operates as a monopolist in the market segment. We assume that the corresponding monopoly problem is well-defined. The monopoly price is $p^m = \arg\max \pi_i(p_i, \infty)$ and the associated monopoly profit is denoted by $\pi^m = \pi_i(p^m, \infty)$.

Benchmark: No gatekeeping. We characterize the equilibrium in the absence of a gatekeeper, which serves as the benchmark for comparison with the case in which a gatekeeper is present. We assume that the presence of the gatekeeper does not increase overall consumer participation.

Suppose that publishers set advertising fees f_1 and f_2, where $f_i \leq \pi^m$. In the ensuing subgame, advertiser A either purchases both ad slots, thereby foreclosing its rival and becoming a monopolist, or purchases only the cheapest ad slot. In the latter case, advertiser B either acquires the remaining slot whenever $\pi^d - \max\{f_1, f_2\} > 0$, in which case duopoly competition arises; otherwise, advertiser B abstains from advertising.

We argue that both publishers charge π^d in equilibrium. If, in equilibrium, at least one publisher set a fee strictly less than π^d, it would have an incentive to increase its fee, implying that $f_1, f_2 \geq \pi^d$. If, in equilibrium, at least one publisher set a fee strictly higher than π^d, the publisher with the (weakly) highest fee would fail to fill its ad slot with probability 1. This is because advertiser A would purchase only the cheapest ad slot (or select one at random in the event of a tie), anticipating that the remaining ad slot would remain idle, because it is priced strictly above π^d. Therefore, the publisher with the (weakly) highest fee would make a strictly higher profit by undercutting the other publisher if that publisher's fee is strictly above π^d and by setting the fee equal to π^d otherwise. The following result characterizes the pure-strategy subgame-perfect Nash equilibria; the proof is provided in Appendix A.

Proposition 1. *Suppose that all consumers access both publishers. Then, both publishers set* $f_1 = f_2 = \pi^d$. *If* $\pi^m \geq 2\pi^d$, *advertiser* A *acquires both publishers' ad slots; if instead* $\pi^m < 2\pi^d$, *each advertiser buys one ad slot.*

Duopoly industry profits exceed monopoly profits when products are sufficiently differentiated.[9] In that case, both advertisers buy one slot each; otherwise, advertiser A buys both. In the borderline case $\pi^m = 2\pi^d$, both outcomes – each advertiser buying one slot or advertiser A buying both – can arise in equilibrium. For ease of exposition, we focus on the latter such that $\pi^m \geq 2\pi^d$, advertiser A buys both ad slots.

Buying the second ad slot may appear to be a wasteful expense from advertiser A's point of view, as it already reaches all consumers. However, advertiser A purchases the second slot to foreclose advertiser B. This logic is reminiscent of Prat and Valletti (2022), where an incumbent firm can always reach all consumers and may therefore buy every publisher's ad slot to block a potential competitor for whom advertising is necessary to reach consumers.

As follows from Proposition 1, each publisher earns a profit of π^d, regardless of whether $\pi^m < 2\pi^d$. When the inequality holds, publishers fully extract advertisers' gross profit; otherwise, advertiser A obtains a net surplus of $\pi^m - 2\pi^d$.

[9]Below, we illustrate the relationship between monopoly and duopoly profits using two versions of the Hotelling model of price competition with differentiated products: Example 1 assumes linear transport costs, and Example 2 assumes quadratic transport costs.

The intuition for the lack of full rent extraction in the latter case is that both publishers provide access to consumers' attention. If a publisher raised its fee above π^d, advertiser A would stop buying the corresponding ad slot without jeopardizing its monopoly position in the product market. Up to the threshold π^d, a Bertrand-type undercutting logic applies: for any fee pair (f_1, f_2) with $\max\{f_1, f_2\} > \pi^d$, advertiser A drops the publisher charging the higher fee, whereas at equal fees above π^d it randomizes between them. Advertiser B does not buy a slot at such fees.

Equilibrium under gatekeeping. We now introduce a gatekeeper who offers a listing service to publishers. Depending on the level of the gatekeeper's fee, none, one, or both publishers purchase its service. If neither publisher buys listing, advertising only reach consumers who access publishers directly. Each consumer sees both ads, which may originate from the same advertiser, and publishers earn revenue only from these direct users. If instead both publishers contract with the gatekeeper, all consumers again see both ads. Hence, the subgame starting at stage 3 is identical in both cases, except for the payments made by publishers to the gatekeeper.

In subgames in which both publishers are listed with the gatekeeper, Proposition 1 applies. In subgames in which no publisher is listed with the gatekeeper, Proposition 1 is easily adjusted, accounting for the fact that advertisers can only sell to the fraction $1 - \alpha$ of consumers.

It remains to consider subgames in which only one publisher – say, publisher 1 – is listed. If both advertisers buy an ad slot and advertiser A is visible through the gatekeeper, then advertiser A has exclusive access to the fraction α of consumers who use the gatekeeper.

Because advertisers can price-discriminate between consumers who use the gatekeeper and those who do not, advertiser A earns a per-consumer profit of π^m from consumers with the gatekeeper, while both advertisers earn π^d per consumer from those who access publishers directly (by Proposition 1). Hence, advertiser A's total profit is $\alpha\pi^m + (1 - \alpha)\pi^d$, whereas advertiser B's profit is $(1 - \alpha)\pi^d$. Advertiser A is therefore willing to pay an incremental amount of $\alpha\pi^m$ to advertise with publisher 1 rather than publisher 2. Accordingly, publishers set fees $f_1 = \alpha\pi^m + (1-\alpha)\pi^d$ and $f_2 = (1-\alpha)\pi^d$. The gatekeeper can extract this incremental

Table 1: *Net surplus under price discrimination*

	$\pi^m < 2\pi^d$	$\pi^m \geq 2\pi^d$
Gatekeeper surplus	$2\alpha\pi^d$	$\alpha\pi^m$
Publisher surplus	$2(1-\alpha)\pi^d$	$2(1-\alpha)\pi^d$
Advertiser surplus	0	$(1-\alpha)(\pi^m - 2\pi^d)$
Consumer surplus	$CS(p^d, p^d)$	$CS(p^m, \infty)$

value by setting its listing fee equal to $\alpha\pi^m$ if it aims to contract with a single publisher.

If instead the gatekeeper seeks to contract with both publishers, it can charge a fee of up to $\alpha\pi^d$ to each and induce both to accept. The reason is that a publisher refusing to contract with the gatekeeper would see its gross profit fall from π^d to $(1-\alpha)\pi^d$. Hence, by signing both publishers, the gatekeeper earns $2\alpha\pi^d$. The gatekeeper prefers to contract with only one publisher if $\alpha\pi^m > 2\alpha\pi^d$, which is equivalent to monopoly profits exceeding duopoly industry profits. Otherwise, when $\pi^m < 2\pi^d$, the gatekeeper grants both publishers access to its consumers. In either case, the gatekeeper extracts the entire surplus generated from consumers who use its service.

Proposition 2. *Consider the case in which advertisers price-discriminate. If $\pi^m < 2\pi^d$, the gatekeeper offers access at $a = \alpha\pi^d$; both publishers accept and set $f_1 = f_2 = \pi^d$, and each advertiser buys one ad slot. If $\pi^m \geq 2\pi^d$, the gatekeeper offers access at $a = \alpha\pi^m$, and exactly one publisher accepts. The listed publisher sets its advertising fee $f_1 = \alpha\pi^m + (1-\alpha)\pi^d$, and the non-listed publisher sets $f_2 = (1-\alpha)\pi^d$. Advertiser A buys each publisher's ad slot.*

Table 1 reports the equilibrium net surpluses for the gatekeeper, publishers, advertisers, and consumers.

If $\pi^m < 2\pi^d$, the equilibrium outcomes coincide with those in the model without the gatekeeper, except that each publisher now pays $(1-\alpha)\pi^d$ to the gatekeeper. As a result, the gatekeeper extracts part of the publishers' rents. Advertisers and consumers are unaffected by its presence, and total surplus remains unchanged.

If $\pi^m \geq 2\pi^d$. The gatekeeper then admits only one publisher, and advertiser A buys both ad slots, earning gross profits of π^m, whereas the other advertiser remains inactive. This means that advertiser A fully forecloses its rival; partial foreclosure is never an equilibrium outcome. The foreclosure logic applies also when only one publisher is listed with the gatekeeper, since the non-listed publisher's ad does not expand advertiser A's reach but serves solely to prevent advertiser B from reaching consumers who bypass the gatekeeper. Consumers are again unaffected by the presence of the gatekeeper, and total surplus remains unchanged.

Without the gatekeeper, advertiser A earns a net profit of $\pi^m - 2\pi^d$, whereas in the presence of the gatekeeper its profit is $\pi^m - [\alpha\pi^m + 2(1-\alpha)\pi^d] = (1-\alpha)(\pi^m - 2\pi^d)$. Hence, advertiser A is always better off without the gatekeeper, since $\pi^m - 2\pi^d > (1-\alpha)(\pi^m - 2\pi^d)$ for any $\alpha \in (0,1)$.

Each publisher earns a net profit of $(1-\alpha)\pi^d$ in the presence of the gatekeeper and is therefore worse off than in its absence. Overall, the gatekeeper earns profits at the expense of both publishers and advertisers, while total and consumer surplus remain unchanged.

Corollary 1. *Consider the case with price-discriminating advertisers. The gatekeeper captures the fraction α of the surplus that publishers and advertisers would otherwise obtain in its absence. Consumer surplus is unaffected.*

This result aligns with publishers' complaints about the negative impact of gatekeeping on their advertising revenues, as discussed in the ad-blocking example in the introduction. When $\pi^m \geq 2\pi^d$, the gatekeeper extracts rents not only from publishers but also from advertiser A. Examples 1 and 2 provide microfoundations for π^m and π^d and thus determine the extent of surplus redistribution from publishers – and from advertiser A when $\pi^m \geq 2\pi^d$ – to the gatekeeper. Consumers remain unaffected, abstracting from the possible impact of ad load on consumer surplus.[10]

We next present two specific models of the product market to derive explicit expressions of π^m and π^d. This allows us to determine the market conditions under which monopoly

[10] In the presence of the gatekeeper, when $\pi^m \geq 2\pi^d$, the fraction α of consumers using the gatekeeper are exposed to less advertising since ads on the non-listed publisher are blocked; we discuss advertising nuisance costs in Section 6.

profits are larger than industry duopoly profits and vice versa. We return to these models in the analysis of the setting where advertisers must set uniform retail prices.

Example 1: The Hotelling model with linear transport costs. *A unit mass of consumers is uniformly distributed on the unit interval, and each consumer has a unit demand for one of the products. Consumer x obtains net utility $v - p_i - t|x - l_i|$ from product i sold at price p_i at location l_i; the utility of abstaining from the market is normalized to 0. Advertiser A sells a product located at 0 and advertiser B at 1 on the unit interval. Both have constant marginal costs of production c. Advertisers set retail prices and, after observing prices of advertised products, consumers make purchasing decisions. Let $w \equiv (v - c)/t$ denote the gains from trade $v - c$ relative to transportation costs t.*

We compare monopoly to industry duopoly profits. If only advertiser A advertises, it earns monopoly profits

$$\pi^m = \begin{cases} \frac{w^2 t}{4}, & \text{if} \quad w \leq 2, \\ (w-1)t, & \text{if} \quad w > 2. \end{cases}$$

If consumers see ads from both advertisers, a symmetric duopoly prevails. For some parameters, there are multiple equilibria. Then, we select the equilibrium that maximizes industry profits (which features symmetric choices). The equilibrium duopoly profit is

$$\pi^d = \begin{cases} \frac{w^2 t}{4}, & \text{if} \quad w \leq 1, \\ \frac{(2w-1)t}{4}, & \text{if} \quad 1 < w \leq \frac{3}{2}, \\ \frac{t}{2}, & \text{if} \quad w > \frac{3}{2}. \end{cases}$$

It can be shown that $\pi^m \geq 2\pi^d$ if and only if $w \geq 2$.

Example 2: The Hotelling model with quadratic transport costs. *We modify the previous model by assuming quadratic transport costs; that is, consumer x obtains net utility $v - p_i - t|x - l_i|^2$ from product i sold at price p_i at location l_i.*

The monopoly profit is given by

$$\pi^m = \begin{cases} \frac{2}{3} t \sqrt{\frac{w^3}{3}}, & \text{if} \quad w \leq 3, \\ (w-1)t, & \text{if} \quad w > 3. \end{cases}$$

In duopoly, as in the example with linear transport costs, for some parameters, there are multiple equilibria, and we select the equilibrium that maximizes industry profits (which features symmetric choices). The equilibrium duopoly profit is

$$\pi^d = \begin{cases} \frac{2}{3}t\sqrt{\frac{w^3}{3}}, & \text{if} \quad w \leq \frac{3}{4}, \\ \frac{(4w-1)t}{8}, & \text{if} \quad \frac{3}{4} < w \leq \frac{5}{4}, \\ \frac{t}{2}, & \text{if} \quad w > \frac{5}{4}. \end{cases}$$

It can be shown that $\pi^m \geq 2\pi^d$ *if and only if* $w \geq \left(\frac{27}{4}\right)^{1/3}$.

Both examples feature discrete consumer choice with perfectly negatively correlated match values. In the discrete choice framework of Perloff and Salop (1985), where match values are independent, market coverage would instead be partial. Also, in such a setting, industry duopoly profits exceed monopoly profits when product differentiation is sufficiently large.[11]

Taking stock, we showed that the gatekeeper extracts part of the industry surplus from publishers and advertisers, whereas consumer surplus remains unchanged. It thus rationalizes the complaints made by publishers against ad blockers that they are deprived of parts of their profits. Moreover, we show that advertisers may also fall victim to gatekeeping. In this model with two publishers and retail price discrimination in the product market, under gatekeeping, partial foreclosure could arise, but, as we show, it does not arise in equilibrium. Furthermore, gatekeeping is neutral to consumer surplus and total surplus.

5 Gatekeeping and uniform retail prices

In this section, advertisers are assumed to set uniform prices in the product market. This implies that market segments are now interdependent. We show that, under uniform pricing, *partial foreclosure* — an outcome in which advertiser A has access to all consumers, while advertiser B has access only to consumers who access publishers directly — arises in equilibrium and yields distinct welfare implications. First, consumer surplus is no longer neutral

[11]The comparison between monopoly and duopoly industry profits can also be analyzed in other models of imperfect competition, where parameters other than the degree of product differentiation vary across industries; see, for instance, the discussion in Karle, Peitz, and Reisinger (2020).

to the presence of a gatekeeper: depending on market conditions, consumers are unaffected, better off, or worse off due to the gatekeeper's presence. Second, whereas under discriminatory retail pricing, publishers are unambiguously worse off in the presence of a gatekeeper, under uniform pricing, there are circumstances in which they benefit.

When only one publisher is listed with the gatekeeper and both advertisers buy one ad slot each, product market competition becomes asymmetric: the advertiser associated with the listed publisher enjoys a monopoly position over consumers who use the gatekeeper, while duopoly competition persists among consumers who access publishers directly. Compared to the setting with price discrimination, the advertiser with an ad on the listed publisher behaves less aggressively in the competitive segment.[12]

It is convenient to introduce additional notation. When advertiser A is visible to all consumers and advertiser B only to those without the gatekeeper, advertiser A's gross profit is $\alpha\pi(p_A, \infty)+(1-\alpha)\pi(p_A, p_B)$, whereas advertiser B's gross profit is $(1-\alpha)\pi(p_B, p_A)$. We make three assumptions. First, we assume that the profit function $\pi(p_i, p_j)$ is weakly increasing in the rival's price p_j (and is strictly increasing at prices (p_i, p_j) such that both advertisers' demand is positive). Second, we assume that there exists a unique price equilibrium with prices p^l for the advertiser associated with the listed publisher and p^{nl} for its rival.[13] Third, we assume that $\pi^l > (1-\alpha)\pi^d$; that is, adding a segment in which the advertiser is a monopolist yields higher overall profits. These assumptions hold in our two Hotelling examples. Equilibrium gross profits are then given by $\pi^l \equiv \alpha\pi(p^l, \infty) + (1-\alpha)\pi(p^l, p^{nl})$ for advertiser A and $\pi^{nl} \equiv (1-\alpha)\pi(p^{nl}, p^l)$ for advertiser B. Clearly, $\pi^m \geq \pi(p^l, \infty)$.

Proposition 3. *Consider the case in which advertisers set uniform retail prices.*

- *If* $\pi^l + 2\pi^{nl} < (3-\alpha)\pi^d$*, the gatekeeper offers access at* $a = \pi^d - \pi^{nl}$*; both publishers accept and set* $f_1 = f_2 = \pi^d$*.*

[12] Such asymmetric competition with uniform pricing has been analyzed in the context of universal service obligations; see Anton, Vander Weide, and Vettas (2002) and Valletti, Hoernig, and Barros (2002), the latter using a Hotelling duopoly related to our Example 1. For further work, see Armstrong and Vickers (1993), Bouckaert, Degryse, and van Dijk (2013), and Oertel and Schmutzler (2022).

[13] Oertel and Schmutzler (2022) provide sufficient conditions such that there are uniquely determined equilibrium prices p^l, p^{nl} (see their Lemma 1). However, these assumptions do not hold in our Example 1 for $w < 2$.

- *If* $\pi^l + 2\pi^{nl} \geq (3-\alpha)\pi^d$*, the gatekeeper offers access at* $a = \pi^l - (1-\alpha)\pi^d$*, and exactly one publisher accepts. The listed publisher sets its advertising fee* $f_1 = \pi^l$*, and the non-listed publisher sets* $f_2 = \pi^{nl}$*.*

If $\pi^m > f_1 + f_2$*, advertiser A buys each publisher's ad slot; otherwise, each advertiser buys one slot.*

Under our assumption that $\pi^l > (1-\alpha)\pi^d$, the inequality $\pi^l + 2\pi^{nl} < (3-\alpha)\pi^d$ implies that $\pi^d > \pi^{nl}$ and, therefore, a is always strictly positive. The proof, provided in Appendix A, shows that in equilibrium advertiser A takes at least one of the two ad slots.

To understand the origin of the condition in Proposition 3, note that the gatekeeper can either list one publisher or both. If both publishers list, each earns π^d and pays the listing fee a, so total publisher profit equals $2(\pi^d - a)$. If only one publisher lists – say, publisher 1 – it earns $\pi^l - a$, whereas the non-listed publisher earns π^{nl}. The gatekeeper's choice between these two regimes depends on which configuration yields higher revenue from listing.

Each publisher is willing to list provided that doing so yields at least as much profit as rejecting the offer. When only one publisher lists, this participation constraint binds at $a = \pi^l - (1-\alpha)\pi^d$; when both list, it binds at $a = \pi^d - \pi^{nl}$ provided that $\pi^d > \pi^{nl}$. The gatekeeper compares its profit across these two cases: with one listing, it earns $\pi^l - (1-\alpha)\pi^d$, and with both listings, it earns $2(\pi^d - \pi^{nl})$. It therefore prefers to list only one publisher if and only if

$$\pi^l - (1-\alpha)\pi^d \geq 2(\pi^d - \pi^{nl}),$$

which simplifies to

$$\pi^l + 2\pi^{nl} \geq (3-\alpha)\pi^d.$$

Loosely speaking, this condition holds when the advertising advantage conferred by being listed is sufficiently strong that the gatekeeper earns more by charging a higher fee to a single publisher rather than smaller fees to both. When only one publisher is listed, both advertisers buy an as slot if $\pi^l + \pi^{nl} > \pi^m$. This implies that advertiser B is partially foreclosed by advertiser A.

Table 2 reports equilibrium surpluses for consumers, advertisers, publishers, and the gatekeeper across all possible configurations. In the two columns on the left, both publishers

Table 2: *Net surplus under uniform pricing*

	$\pi^l + 2\pi^{nl} < (3-\alpha)\pi^d$		$\pi^l + 2\pi^{nl} \geq (3-\alpha)\pi^d$	
	$\pi^m < 2\pi^d$	$\pi^m \geq 2\pi^d$	$\pi^m < \pi^l + \pi^{nl}$	$\pi^m \geq \pi^l + \pi^{nl}$
Gatekeeper surplus	$2(\pi^d - \pi^{nl})$	$2(\pi^d - \pi^{nl})$	$\pi^l - (1-\alpha)\pi^d$	$\pi^l - (1-\alpha)\pi^d$
Publisher surplus	$2\pi^{nl}$	$2\pi^{nl}$	$\pi^{nl} + (1-\alpha)\pi^d$	$\pi^{nl} + (1-\alpha)\pi^d$
Advertiser surplus	0	$\pi^m - 2\pi^d$	0	$\pi^m - (\pi^l + \pi^{nl})$
Consumer surplus	$CS(p^d, p^d)$	$CS(p^m, \infty)$	$\alpha CS(p^l, \infty)$ $+(1-\alpha)CS(p^l, p^{nl})$	$CS(p^m, \infty)$

pay the listing fee, whereas in the two columns on the right, only one publisher does. In the first and third columns, each advertiser buys one ad slot, whereas in the second and fourth columns advertiser A buys both. Consumer surplus is denoted by $CS(p_A, p_B)$ and depends on the prices p_A and p_B set by the advertisers that reach consumers.

Example 1 continued. *For $w \equiv (v-c)/t \in (3/2, 7/2)$, it can be shown that there exists a unique pure-strategy equilibrium for all $\alpha \in (0,1)$, which we consider here.*[14]

As can be shown for any given $\alpha \in (0,1)$, asymmetric duopoly industry profits satisfy $\pi^l + \pi^{nl} \in (\min\{2\pi^d, \pi^m\}, \max\{2\pi^d, \pi^m\})$. Thus, asymmetric duopoly industry profits lie between symmetric duopoly industry profits and monopoly profits. Then, the outcome in the third column of Table 2 cannot constitute an equilibrium outcome: if $2\pi^d < \pi^l + \pi^{nl} < \pi^m$, then $\pi^l + 2\pi^{nl} > 2\pi^d + \pi^{nl} > 2\pi^d + (1-\alpha)\pi^d = (3-\alpha)\pi^d$. Furthermore, inequality $\pi^m + 2\pi^{nl} \geq (3-\alpha)\pi^d$ is satisfied if and only if $w \geq 2$, which is also the condition for inequality $\pi^m \geq 2\pi^d$ to hold. Thus, only the first and the fourth columns in Table 2 apply and we have the following result: If $w < 2$, then the gatekeeper lists both publishers at price $\pi^d - \pi^{nl}$; the publishers set fees π^d; and each advertiser buys one slot each. If $w \geq 2$, then the gatekeeper lists a single publisher at price $\pi^m - (1-\alpha)\pi^d$; the listed publisher sets its fee equal to π^l and the non-listed publisher sets π^{nl}; and advertiser A buys the ad slot on each publisher's website.

[14]Further below, we also consider a region with higher values of w in which there also exists a unique pure-strategy equilibrium, but which is characterized differently.

To summarize, in Example 1, the results reported so far are qualitatively the same as in the setting with discriminatory pricing.

Example 2 continued. *With quadratic transport costs, given that one advertiser has a slot with the listed publisher and the other with the non-listed publisher, consider price equilibria in the parameter range* $w \in \left(\frac{3}{2}, \frac{7}{2}\right)$*.It can be shown that there exists a non-empty parameter region such that inequality* $\pi^l + 2\pi^{nl} \geq (3-\alpha)\pi^d$ *holds and therefore the third column of Table 2 applies.*

In Figure 2, we report how the parameters in the example map into the configurations in Table 2. The upper line gives the parameter values (α, w) *such that* $\pi^m = \pi^l + \pi^{nl}$ *and the lower line gives the parameter values* $(\alpha, w))$ *such that* $\pi^l + 2\pi^{nl} = (3 - \alpha)\pi^d$*. These lines delineate three parameter regions. In the bottom parameter region, both publishers are listed and each advertiser buys an ad slot – this corresponds to the first column of Table 2. In the top parameter region, one publisher is listed and advertiser A buys both ad slots – this corresponds to the fourth column of Table 2. In the intermediate region, one publisher is listed and sells its ad slot to advertiser A, while advertiser B buys the ad slot from the non-listed publisher – this corresponds to the third column of Table 2. In this intermediate range, there is asymmetric competition in the product market along the equilibrium path.*

We have verified the conditions reported in Table 2 within two examples, but it is useful to understand what sets the two examples apart. When only advertiser A is visible to all consumers and advertiser B reaches only a fraction of them, pricing becomes asymmetric. Compared to the case in which both advertisers compete symmetrically, this asymmetry softens price competition in both examples. In Example 2, the effect is reinforced because demand responds less sensitively to a marginal price change when evaluated at asymmetric rather than symmetric prices. In Example 1, by contrast, the slope of the demand curve is independent of the price difference.

Exclusive listing. A natural question is whether the gatekeeper could earn higher profits by committing to *exclusive listing* – that is, by promising to sign with at most one publisher. If more than one publisher requests exclusive listing, a random draw determines which one is selected.

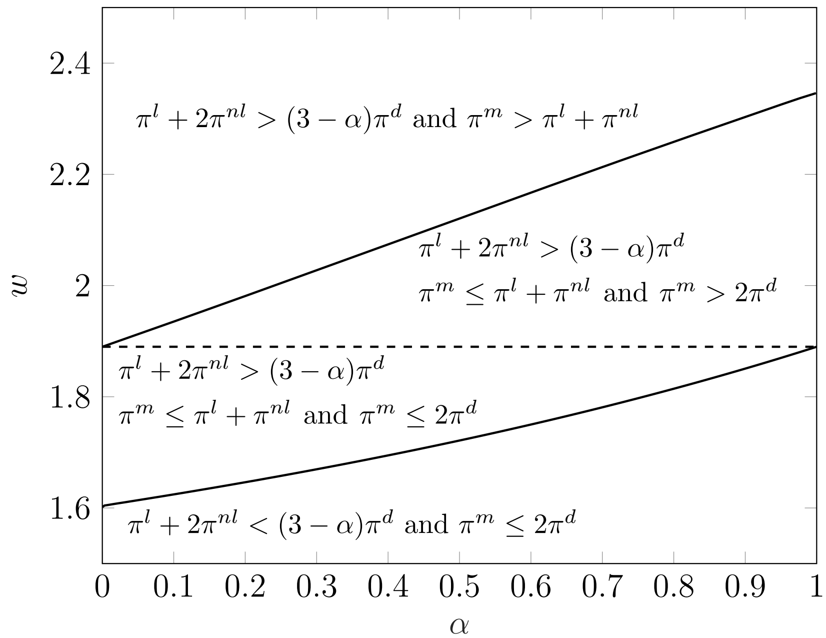

Figure 2: *Configurations of Table 2 in the Hotelling model with quadratic transport costs*

If one publisher is willing to accept the offer of exclusive listing, the other would be as well. A publisher that deviates and refuses the offer would then remain non-listed while the other publisher is listed. The deviating publisher would obtain

$$\pi^{nl} = (1-\alpha)\pi(p^{nl}, p^l).$$

If $\pi(p^{nl}, p^l) > \pi^d$, the gatekeeper is strictly worse off under a commitment to exclusive listing.

This conclusion is also reflected in the payments the gatekeeper can extract. Under exclusive listing, when both publishers apply for listing, the gatekeeper can charge

$$a^{ux} \equiv \pi^l - \pi^{nl},$$

since rejecting the fee leads to the other publisher being listed, leaving the deviating publisher with the outside option π^{nl}. If $\pi(p^{nl}, p^l) > \pi^d$, this fee is lower than the corresponding listing fee

$$a^u = \pi^l - (1-\alpha)\pi^d,$$

derived in Proposition 3.

A sufficient condition for $\pi(p^{nl}, p^l) > \pi^d$ is that $p^l > p^d$. This inequality always holds in our Example 2 but not in our Example 1 when $w < 2$.[15]

Comparison to no gatekeeping. We next examine how gatekeeping affects total surplus and the distribution of surplus across market participants. In our two examples of product market competition, we compare how surpluses change with the introduction of a gatekeeper.

The presence of a gatekeeper may reduce total surplus, increase it, or leave it unchanged. For total surplus to fall, the gatekeeper must induce an allocation in which consumers who use the gatekeeper buy only advertiser A's product at price p^l, whereas consumers outside the gatekeeper face prices (p^{nl}, p^l) instead of (p^d, p^d) in the absence of gatekeeping. In other words, advertisers compete in an *asymmetric duopoly* in the presence of the gatekeeper, whereas they would compete in a *symmetric duopoly* without it. Conversely, total surplus rises when, absent the gatekeeper, advertiser A would operate as a monopolist and the introduction of gatekeeping induces asymmetric duopoly competition instead.

The same reasoning applies to consumer surplus because, in our base model, consumer surplus depends only on the product market outcome. Hence, consumer surplus remains unchanged whenever the degree of product market competition does not change. Otherwise, consumers benefit from the presence of the gatekeeper if it transforms monopoly into asymmetric duopoly, but are worse off if it transforms symmetric duopoly into asymmetric duopoly. We analyze these surplus effects in detail in our two examples below.

Example 1 continued. *With linear transport costs, the first and the third column of Table 2 never apply. Thus, total surplus is not affected by the introduction of a gatekeeper. Surplus effects for publishers, advertisers, and consumers are qualitatively the same as in the setting with discriminatory pricing. They depend on whether or not* $\pi^m \geq 2\pi^d$*. If* $\pi^m < 2\pi^d$*, in the presence of the gatekeeper, both publishers pay to be listed, and the gatekeeper extracts surplus from publishers only. If* $\pi^m \geq 2\pi^d$*, in the presence of the gatekeeper, only one publisher pays*

[15]The reason for the latter is that in the linear Hotelling model a monopolist sets a lower price than symmetric duopolists in equilibrium. Oertel and Schmutzler (2022) provide sufficient conditions such that uniquely determined equilibrium prices p^l, p^{nl} increase in α (see their Lemma 1). Then, for any given $\alpha \in (0,1)$ this implies that $\pi(p^d, p^l) > \pi(p^d, p^d)$. As $\pi(p^{nl}, p^l) > \pi(p^d, p^l)$ always holds, one obtains $\pi(p^{nl}, p^l) > \pi(p^d, p^d)$.

to be listed and, as a result, the gatekeeper extracts some of the combined surplus of publishers and advertisers. Here, advertisers are necessarily worse off.

Example 2 continued. *With quadratic transport costs, the surplus results are captured in Figure 3. As shown in Figure 2, for intermediate values of w, the parameter region can be divided into two subregions, one below and the other above the dashed line, which reports the values of w such that $\pi^m = 2\pi^d$. In the area above the dashed line, advertiser A would be a monopolist in the absence of the gatekeeper, whereas, below the dashed line, advertisers would be in a symmetric duopoly. Hence, in the upper subregion, advertiser A would buy both ad slots, leading to the monopoly outcome in the product market, whereas below it, both advertisers would buy one ad slot each, leading to the symmetric duopoly outcome. Introducing the gatekeeper leads to more competition in the intermediate range above the dashed line. By contrast, it leads to less competition in the intermediate range below the dashed line. As a result, in the upper subregion, the introduction of the gatekeeper increases total surplus, whereas in the lower subregion, this leads to a reduction of total surplus.*

Changes in total surplus and consumer surplus go hand in hand: consumers benefit from lower prices and more variety after the introduction of the gatekeeper in the upper subregion, whereas the opposite is true in the lower subregion. Thus, consumers are better off with the introduction of the gatekeeper in the upper, but worse off in the lower subregion.

Publishers' complaints about gatekeeping rest on the claim that they are made worse off. It is therefore useful to examine whether publishers are necessarily worse off. Under discriminatory pricing, the condition for publishers to be better off with gatekeeping is $2(1-\alpha)\pi^d > 2\pi^d$, which can never be satisfied. Under uniform pricing, in the case of partial foreclosure, publishers' total surplus is higher with gatekeeping than without it if $\pi^{nl} + (1-\alpha)\pi^d > 2\pi^d$, which is equivalent to

$$\pi^{nl} > (1+\alpha)\pi^d.$$

The difference between uniform and discriminatory pricing arises because, under uniform pricing, the non-listed publisher benefits from the other publisher's listing decision, as its profit satisfies $\pi^{nl} > (1-\alpha)\pi^d$. This reduces the gatekeeper's ability to extract publisher rents. In both examples, we show that the condition $\pi^{nl} > (1+\alpha)\pi^d$ can be satisfied, so

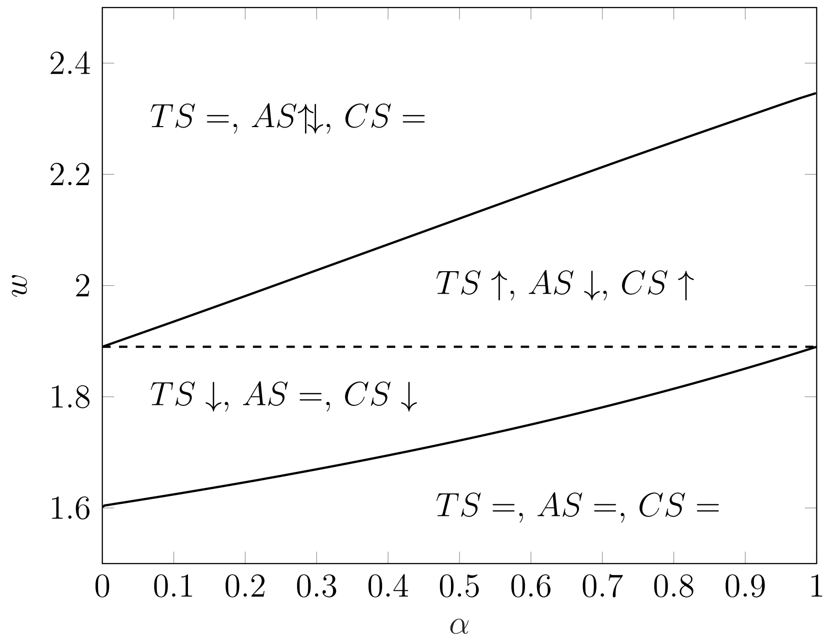

Figure 3: *Total surplus (TS), advertiser surplus (AS), and consumer surplus (CS) effects of the introduction of the gatekeeper in the Hotelling model with quadratic transport costs*

publishers may in fact gain from the presence of the gatekeeper.

Examples 1 and 2 continued. *With linear and quadratic transport costs, it can be shown that publisher surplus is higher in the presence of the gatekeeper if* $\alpha > \frac{3}{5}$ *and* $w \in \left(2 + \frac{1}{2}\frac{1+\alpha}{1-\alpha}, \frac{1+\alpha}{1-\alpha}\right)$ *(the same conditions apply to both examples).*

The examples illustrate that gatekeeping can benefit publishers when a sufficiently large share of consumers uses the gatekeeper and product differentiation is moderate.

To summarize the key findings under uniform pricing, the equilibrium with gatekeeping may feature partial foreclosure. When this occurs, total surplus and consumer surplus may be either higher or lower than without gatekeeping. We also show that publishers may benefit from gatekeeping.

6 Gatekeeper installation

In this section, we endogenize the consumer decision whether to access publishers directly or through the gatekeeper. We examine how our previous results change when consumers are averse to advertising, take into account that using the gatekeeper may affect their ad exposure, and decide whether to use the gatekeeper.

Suppose that a fraction α of consumers have a "high" nuisance cost $\mu_h > 0$ per ad they are exposed to, while the remaining $1-\alpha$ fraction either do not mind ads or have sufficiently "low" nuisance costs $\mu_l \geq 0$. The opportunity cost of using the gatekeeper, denoted by F_I, is such that consumers with high nuisance costs install the gatekeeper app if it reduces their ad exposure by at least one ad ($F_I < \mu_h$), whereas consumers with low nuisance costs do not ($F_I > \mu_l$).[16]

We consider the timing according to which consumers decide whether to install the gatekeeper after it has committed to its listing fee and analyze what happens under uniform pricing. We restrict attention to the setting in which consumers base their installation decision on expected ad exposure and do not internalize the product-market implications of their choice. In a pure-strategy equilibrium, the gatekeeper will then never list both publishers. If both were listed, the gatekeeper would not reduce ad exposure, which removes the consumers' incentive to install it. As we have explained in the proof of Proposition 3, if $\pi^d - \pi^{nl} \geq \pi^l - (1-\alpha)\pi^d$, either no publisher or both publishers buy listings. Hence, when this inequality holds, the gatekeeper is not viable.[17] Therefore, we restrict attention to the opposite case and assume in this section that $\pi^d - \pi^{nl} < \pi^l - (1-\alpha)\pi^d$ holds.

Consequently, under endogenous adoption, at most one publisher contracts with the gatekeeper in a pure-strategy equilibrium.

We assume that the gatekeeper does not prefer a listing fee that induces a mixed-strategy equilibrium among publishers. Formally, we assume that $\frac{F_I}{\mu_h}$ is sufficiently large when $\pi^m < 2\pi^d$, namely

$$\frac{F_I}{\mu_h} > \max\left\{2 - \frac{\pi^l - (1-\alpha)\pi^d}{\pi^d - \pi^{nl}}, 0\right\}. \tag{1}$$

Under this assumption, the gatekeeper sets its fee so that exactly one publisher pays to

[16] Heterogeneous ad nuisance costs are one possibility to endogenize partial gatekeeper installation. Alternatively, the gatekeeper may offer stand-alone benefits, which are regarded as more valuable by some consumers.

[17] Here, exclusivity clauses would allow the gatekeeper to operate profitably: By committing to exclusivity, the gatekeeper would be able to make a positive profit $\pi^l - \pi^{nl}$ (see Section 5), as high-nuisance-cost consumers then are induced to use the gatekeeper.

be listed. Listing gives the advertiser with the listed publisher a monopoly position over consumers who use the gatekeeper.

If both advertisers buy one ad slot each, then under uniform pricing the gross profit of the advertiser with the listed publisher is π^l, and that of the other advertiser is π^{nl}, which the publishers can fully extract. If the listed publisher deviated and did not pay the listing fee, its gross profit would be $(1-\alpha)\pi^d$. Hence, the gatekeeper can extract $\pi^l - (1-\alpha)\pi^d$.

If advertiser A buys both ad slots, it earns a profit of π^m. If the fee charged by the non-listed publisher exceeds π^{nl}, advertiser A will not buy the ad slot from the non-listed publisher, since advertiser B would not purchase it for such a fee once advertiser A has acquired the ad slot from the listed publisher. Similarly, if the listed publisher charges a fee above π^l, advertiser A will buy only the ad slot from the non-listed publisher, since advertiser B would not buy the remaining ad slot from the listed publisher at such a high fee. Thus, equilibrium fees are $f_1 = \pi^l$ and $f_2 = \pi^{nl}$. As above, if the listed publisher deviated and did not pay to be listed, its gross profit would be $(1-\alpha)\pi^d$, so the gatekeeper can extract $\pi^l - (1-\alpha)\pi^d$.

If advertiser A does not buy both ad slots, its profit is zero; if it buys both, its profit is $\pi^m - f_1 - f_2 = \pi^m - \pi^l - \pi^{nl}$. Hence, advertiser A prefers to buy both ad slots if and only if $\pi^m \geq \pi^l + \pi^{nl}$.

Proposition 4. *Consider the case in which the gatekeeper first commits to its listing fee, after which consumers decide whether to install the gatekeeper app, and advertisers set uniform prices. The gatekeeper offers access at $a = \pi^l - (1-\alpha)\pi^d$, and exactly one publisher accepts. The listed publisher sets its advertising fee $f_1 = \pi^l$, and the non-listed publisher sets $f_2 = \pi^{nl}$. If $\pi^m \geq \pi^l + \pi^{nl}$, advertiser A buys the ad slot from both publishers; otherwise, each advertiser buys one slot.*

The gatekeeper extracts some surplus either from advertisers or from consumers. Publisher surplus may increase or decrease in the presence of the gatekeeper. Publishers benefit from gatekeeper entry if and only if $\pi^{nl} + (1-\alpha)\pi^d > 2\pi^d$; otherwise, they are worse off. Proposition 4 strengthens our foreclosure results under exogenous gatekeeper installation. According to the proposition, there is either partial or full foreclosure and the no foreclosure outcome under exogenous gatekeeper installation is replaced by partial foreclosure.

Appendix B contains additional material on endogenous gatekeeper installation. First, we provide the corresponding analysis under discriminatory pricing. Then, we analyze the reverse timing according to which consumers' adoption of the gatekeeper is an inflexible decision; that is, consumers make their adoption decision before the gatekeeper sets its fee. We also comment on the setting in which consumers anticipate the consequences of their adoption decision on their experience in the product market. Overall, our main insights closely align with those obtained under exogenous gatekeeper use, and the foreclosure results are even strengthened.

7 Gatekeeping with more than two publishers

To keep our analysis parsimonious, we allowed for one ad slot per publisher, two publishers, and two advertisers in an ex ante symmetric setting (with the exception of the sequential decision of advertisers which ad slots to buy). In this section, we extend the analysis to three publishers 1,2, and 3, and at least three advertisers, A, B, C, etc. We characterize the equilibrium under gatekeeping and discriminatory pricing for a particular parameter range and compare it to the equilibrium without gatekeeping. The timing of the model in Section 3 is maintained, and advertisers move sequentially in alphabetic order.

Denote by π^m, π^d, and π^t the equilibrium profit of an active advertiser under monopoly, symmetric duopoly, and symmetric triopoly in the respective product market. We assume throughout that $\pi^m > \pi^d > \pi^t \geq 0$; that is, an advertiser's profit (gross of any payment to the publisher) is decreasing in the number of competitors.

No gatekeeping with three publishers. First, we consider the setting without gatekeeping. We characterize all equilibria in which all publishers set symmetric fees $f_i = f$, $i \in \{1, 2, 3\}$.

Proposition 5. *Consider the model with $n = 3$ publishers and $m \geq n$ advertisers. Suppose that consumers are exposed to all ads.*

1. *(No foreclosure) If $\pi^m < 3\pi^t$ and $\pi^d < 2\pi^t$, publishers set $f = \pi^t$ and advertisers A, B, and C purchase one ad slot each.*

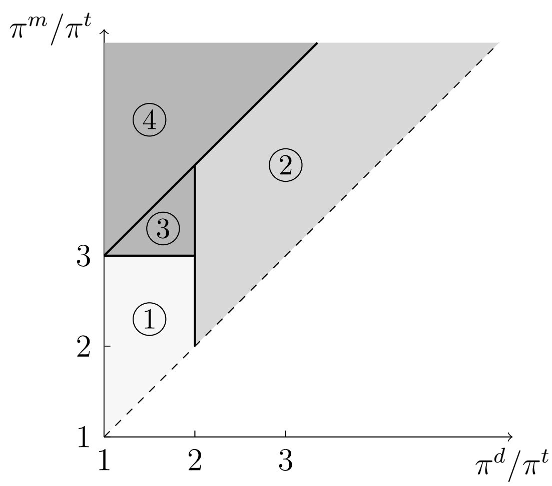

Figure 4: The region of parameters $(\pi^d/\pi^t, \pi^m/\pi^t)$, $\pi^m > \pi^d > \pi^t > 0$, corresponding to the four different cases: (1) No foreclosure, (2) Duopoly foreclosure, (3) Monopoly foreclosure with $f = \pi^t$ and (4) Monopoly foreclosure with $f = \min\{(\pi^m - \pi^d)/2, \pi^d\}$.

2. *(Duopoly foreclosure) If $\pi^m < \pi^d + 2\pi^t$ and $\pi^d \geq 2\pi^t$, publishers set $f = \pi^t$, and advertiser A buys one ad slot and advertiser B two.*

3. *(Monopoly foreclosure I) If $\pi^m \in [3\pi^t, \pi^d + 2\pi^t)$ and $\pi^d < 2\pi^t$, publishers set $f = \pi^t$, and advertiser A purchases all three ad slots.*

4. *(Monopoly foreclosure II) If $\pi^m \geq \pi^d + 2\pi^t$, publishers set $f = \min\left\{\frac{\pi^m - \pi^d}{2}, \pi^d\right\}$, and advertiser A purchases all three ad slots.*

We note that if industry profits are increasing in the number of sellers (i.e. $\pi^m < 2\pi^d < 3\pi^t$) there will be no foreclosure. By contrast, if industry profits are decreasing in the number of sellers (i.e., $\pi^m > 2\pi^d > 3\pi^t$) there will be monopoly foreclosure. To obtain duopoly foreclosure, it is necessary that industry profits are non-monotone in the number of firms (first increasing and then decreasing). This may be the case if the product space is such that duopoly advertisers are strongly differentiated in the product market, whereas the triopoly leads to much closer substitution patterns and thus much lower retail prices. Figure 4 illustrates the possible equilibrium outcomes.

Equilibrium with three publishers under gatekeeping and discriminatory pricing. In the presence of a profit-maximizing gatekeeper, in equilibrium, at least one publisher decides to buy listing at a fee a. In the following proposition, we provide the conditions for a particular partial foreclosure result: Two publishers buy listing and three advertisers buy an ad slot.

Proposition 6. *Consider price-discriminating advertisers and suppose that* $\pi^d \in (3/2\pi^t, 2\pi^t)$ *and* $\pi^m < 3\pi^t$. *Then the gatekeeper lists two publishers at price* $\alpha\pi^d$. *The listed publishers set* $f_l = (1-\alpha)\pi^t + \alpha\pi^d$ *and the non-listed publisher sets* $f_{nl} = (1-\alpha)\pi^t$. *Each advertiser buys one ad slot.*

If these conditions are satisfied, then three advertisers would buy an ad slot and obtain access to all consumers in the absence of the gatekeeper (or if the gatekeeper were to provide free listings). Thus, there would be no foreclosure. This implies that consumers suffer from the presence of the gatekeeper: the consumers with the gatekeeper are harmed by only two advertisers being visible, whereas the consumers who do not use the gatekeeper are not affected.

We have thus established that partial foreclosure may be an equilibrium outcome even under discriminatory pricing, in contrast to what can happen in the setting with two publishers. For the particular parameter range that we consider, partial foreclosure arises under gatekeeping, whereas no foreclosure would occur without gatekeeping. Thus, consumers are harmed by gatekeeping.[18]

A different way to look at our model is to consider the exogenous entry of a publisher (restricting attention to situations in which the conditions in Proposition 6 are satisfied). Before entry, there is no foreclosure, whereas partial foreclosure is the equilibrium outcome after the entry of a third publisher. Nevertheless, consumers are overall still better off in the product market after publisher entry because all consumers experience duopoly competition before entry, whereas consumers using the gatekeeper continue to experience duopoly competition and those who access publishers directly experience triopoly competition after entry.

[18] However, with endogenous gatekeeper adoption, rational consumers would be willing to access the gatekeeper only if doing so provides a benefit that more than compensates for the harm.

8 Real-world examples: Ad blockers, news aggregators, and search engines

We provide three real-world examples of gatekeepers to further motivate our analysis. In addition to ad blockers as our lead example, we also discuss the applicability of our analysis to news aggregators and search engines.

Ad blockers. Our lead example of a gatekeeper is an ad blocker, as discussed in the introduction. Ad blocking remains a contentious issue. In Germany, large media companies such as RTL and Axel Springer have repeatedly challenged the market leader in ad blocking, Eyeo, the owner of Adblock Plus. The plaintiffs advanced a range of arguments, claiming that ad blocking as practiced by Adblock Plus constitutes an unfair trade practice, violates constitutional rights, and infringes copyright, media, and antitrust law. These disputes have resulted in numerous court proceedings, including cases before the district courts of Cologne, Hamburg, and Munich I in 2015, the Higher Regional Court of Munich in 2017, the Federal Court of Justice in 2018 and 2019, the Constitutional Court in 2019, and further cases before the Hamburg and Munich Higher Regional Courts in 2023. As of October 2025, litigation concerning an alleged violation of copyright law remains pending – in July 2025 the Federal Court of Justice referred the case back to the Higher Regional Court (Case I ZR 131/23).

While publishers have been most vocal – both publicly and as plaintiffs – our results indicate that other parties, notably advertisers and consumers, may also be negatively affected by ad blocking.

Ad-blocking firms have defended their practices by arguing that they create value for consumers and improve the digital experience. Eyeo, the owner of Adblock Plus, states on its website that its "ad-filtering tech offers incremental revenue, more effective ads, and a better user experience."[19] Adblock Plus and AdBlock jointly operate the Acceptable Ads Committee (AAC), which sets criteria defining which ads are non-intrusive enough to appear on whitelisted publishers' websites (AAC, bylaws 2019). The criteria relate primarily to size and distinctiveness from surrounding text. Although consumers can adjust their settings to

[19] See `https://eyeo.com/`, last accessed 24 April 2025.

block all ads, most do not: in Germany, 90% of Adblock Plus users retain the default settings and see filtered ads (BGH, 2019, decision KZR 73/17 – *Werbeblocker III*, para. 3).

In our model, we abstract from this filtering dimension of ad blocking – that is, from the reduction in the intrusiveness of ads. Such filtering would make the ad blocker more attractive to consumers but could reduce advertisers' willingness to pay for ad slots. Our main insights, however, are unaffected by this simplification.

In the model, the ad blocker earns revenue only by taking a share of publishers' advertising income. In practice, some ad blockers (including Adblock Plus) also offer premium subscription models. Yet, this source of income appears negligible: in a 2020 survey, only 5% of internet users in Germany reported subscribing to a paid ad-blocking service, while 93% stated they did not.[20]

News aggregators. News aggregators can also act as gatekeepers to users' attention. Some users search online for a specific news event covered by different publishers, visiting several websites and being exposed to the associated advertising. Others access media content through a news aggregator that provides personalized recommendations based on users' preferences, as in the case of news feeds on social media platforms.[21] In this case, the user no longer experiments with multiple publishers but instead relies on the aggregator's recommendations, thereby being exposed to content – and advertising – from only one publisher. This applies particularly to media that is front-loaded with advertising, such as video or audio formats.

Personalized aggregation thus reduces the number of publishers whose content a consumer tries and, consequently, the amount of advertising exposure, especially for front-loaded ads. More generally, when advertising exposure is coordinated for consumers accessing content through the aggregator, advertisers face less competitive pressure for these consumers than for those who access content directly through publishers (even if total ad consumption remains

[20] See `https://de.statista.com/statistik/daten/studie/873815/umfrage/nutzung-von-kostenpflichtigen-werbeblockern-in-deutschland/`.

[21] In other theoretical work on news aggregators, publishers must pay for links (Dellarocas et al., 2013), and the aggregator offers users content of higher expected value (Jeon and Nasr, 2016). These studies do not consider interaction on the advertiser side.

constant across consumers). This mechanism mirrors the driving force in the product market underlying our results in Sections 4–7.

Search engines. Many consumers begin their product search on a general search engine (in most countries, Google Search) and continue on a vertical search engine or portal that selectively displays certain products. A case in point is specialized product search engines – often functioning as price comparison sites – that typically host only a subset of all sellers. Sellers pay these engines for the sales they facilitate.

The general search engine can be viewed as a monopoly gatekeeper. The mechanism explored in this paper continues to apply if consumers differ in how they use the general search engine.

To fix ideas, suppose that all consumers searching for a particular product first go to Google Search. The search engine lists relevant vertical (product) search engines in its organic search results and also sells sponsored slots to these same engines. Suppose that a fraction of consumers visit only the sponsored links, while the remaining consumers also explore the organic results.

Our base model features two product search engines and two sellers, with each product search engine hosting one seller.[22] Partial foreclosure arises when one of the product search engines appears only in sponsored listings. The seller hosted on that engine then becomes a monopolist among consumers who restrict their search to the sponsored results.[23]

These examples illustrate how differential access to consumers – whether through ad blocking, aggregation, or search intermediation – can partially foreclose competition among advertisers in the product market. The framework developed in this paper provides a simple way to interpret these market settings through the lens of gatekeeping and its effects on advertising reach and product-market competition.

[22]As explained in Section 7, this setting can be extended to allow for multiple sellers on each product search engine.

[23]Admittedly, this is a highly stylized representation of search engine operation. Sponsored search slots are typically allocated via auctions (see, e.g., Edelman et al., 2007; Athey and Ellison, 2011), and consumers may derive utility from organic listings that affects their engagement with the general search engine (see, e.g., White, 2013; Burguet et al., 2015).

9 Conclusion

Gatekeepers determine which advertisements consumers are exposed to. Many publishers rely entirely on advertising revenues rather than charging consumers directly, so gatekeepers affect not only which ads are displayed but also publishers' ad revenues. Some consumers, however, bypass the gatekeeper and remain unaffected by its filtering decisions. For example, an ad blocker prevents its users from seeing certain ads, while other consumers who have not installed it continue to view all ads.

We analyze the equilibrium effects of gatekeeping when publishers must pay a listing fee to the gatekeeper for their ads to reach consumers and when advertisers compete in product markets characterized by a small number of firms. By altering which advertisers can reach consumers, gatekeeping affects the intensity of price competition and, consequently, retail prices in these markets.

Our analysis shows that gatekeeping affects market participants in different ways. Publishers are often harmed by the presence of a gatekeeper, but harm may also fall on advertisers or consumers. In some market environments, however, publishers benefit. The reason is that the gatekeeper may soften price competition between advertisers under asymmetric conditions. The resulting increase in advertiser profits enables publishers to charge higher advertising fees. Because the gatekeeper cannot extract all of these additional revenues – since the non-listed publisher also earns more – publishers may be better off when the gatekeeper is active.

These findings show that the welfare implications of gatekeeping are nuanced once product-market competition is taken into account. In the context of ad blocking, publishers have often criticized such intermediaries as purely extractive. Our analysis suggests instead that ad blocking is not merely a rent-shifting device from publishers to the ad blocker. Similar mechanisms arise in other forms of digital intermediation, such as news aggregators and search engines, where gatekeepers influence which ads reach consumers.

More broadly, our results highlight the complex interactions among gatekeepers, publishers, advertisers, and consumers. Gatekeepers can create value for users by reducing exposure to ads that consumers perceive as a nuisance. This benefit can come with a cost: by limiting consumers' exposure to competing ads, gatekeeping may soften product-market competition and raise retail prices. Whether consumers are better off therefore depends on the trade-off between lower ad nuisance and higher prices. When advertisers set uniform prices, the resulting price increase also affects consumers outside the gatekeeper, extending the effect beyond its users. Gatekeeping may make some consumers worse off in the product market even when advertisers price-discriminate in an extended setting with more than two publishers and two advertisers.

Overall, our analysis highlights that the effects of gatekeeping depend on how control over advertising access interacts with product-market competition. Gatekeeping can reduce advertising clutter and generate value for consumers, yet it may also shift surplus among advertisers, publishers, and consumers in non-trivial ways. Understanding these interactions is essential for evaluating the competitive and welfare consequences of digital intermediaries.

Future work may look at related environments and focus on questions that we did not explore. We assumed that the gatekeeper makes take-it-or-leave-it offers to publishers and that publishers make take-it-or-leave-it offers to advertisers. It may be interesting to investigate how bargaining power at the different layers affects market outcomes. By assuming fixed fees, the issue of cost pass-through does not arise. It may be interesting to look at different fee structures charged by publishers to advertisers. Finally, we considered a simple model of product market competition in which the gatekeeper's possible data advantage did not play any role. It may be interesting to explore how the presence of the gatekeeper affects product market outcomes when accessing consumers through the gatekeeper opens the door for personalization strategies by advertisers.

Appendix

A Relegated proofs

Proof of Proposition 1. Suppose that publishers set advertising fees f_1, f_2. Clearly, $f_i \leq \pi^m$ for each publisher $i = 1, 2$, since otherwise publisher i would not sell its ad slot. If advertiser A buys both ad slots, its net profit will be $\pi^m - f_1 - f_2$ because it will operate as a monopolist. If, instead, advertiser A purchases the slot at the lowest fee, advertiser B either purchases the remaining slot or forgoes the opportunity to advertise. In this case, advertiser A makes profit $\pi^d - \min\{f_1, f_2\}$ and advertiser B makes $\max\{0, \pi^d - \max\{f_1, f_2\}\}$. If advertiser A does not buy an ad slot, then advertiser B purchases the slot with the lowest fee (since $f_i \leq \pi^m$).

First, we show that $f_1, f_2 \geq \pi^d$ in equilibrium. If $f_k < \pi^d$ for some publisher $k \in \{1, 2\}$, then advertiser A purchases at least one ad slot, since $\pi^d - \min\{f_1, f_2\} > 0$. If advertiser A buys only one ad slot from the rival publisher $-k$, then advertiser B purchases the remaining ad slot from publisher k, because $\pi^d - \max\{f_k, f_{-k}\} = \pi^d - f_k > 0$. This implies that, for any fee of the competing publisher $f{-k}$, publisher k sells its ad slots with probability one at any $f_k < \pi^d$ and can profitably raise it. Therefore, it must be that $f_1, f_2 \geq \pi^d$ in equilibrium.

Next, we establish that, in equilibrium, publishers do not set advertising fees strictly above π^d. Suppose, for the sake of contradiction, that publishers set asymmetric advertising fees and $f_k > f_{-k} \geq \pi^d$ for some publisher k. Then, advertiser A purchases only the cheapest ad slot offered by publisher $-k$, anticipating that advertiser B abstains from advertising (since $\pi^d < f_k$). However, we established that advertiser A can always ensure profits of π^d by setting $f_k = \pi^d$. It follows that $f_k > f_{-k} \geq \pi^d$ cannot occur in equilibrium. If, instead, publishers set symmetric fees $f_1 = f_2 > \pi^d$, then advertiser A randomly selects one ad slot to buy, and the remaining ad slot remains unsold. In this case, each publisher can slightly undercut its rival and sell to advertiser A with probability one. We conclude that $f_1 = f_2 = \pi^d$. It is straightforward to verify that this is the unique equilibrium profile of publishers' fees.

It remains to describe advertisers' equilibrium strategies when $f_1 = f_2 = \pi^d$. Advertiser

A acquires both ad slots if $\pi^m - f_1 - f_2 \geq \pi^d - f_1$, or equivalently if $\pi^m - 2\pi^d \geq 0$. If instead $\pi^m < 2\pi^d$, each advertiser purchases one advertising slot.

□

Proof of Proposition 2. In any equilibrium of the game with the gatekeeper and price-discriminating advertisers at least one publisher lists on the gatekeeper app.

Consider the case in which both publishers buy listing. Then, an ad slot of each publisher guarantees access to all consumers in the market. Consequently, if both publishers decide to list the subgame that begins with publishers setting the advertising fees coincides with the game in which no gatekeeper is present (barring the listing fee that must be paid to the gatekeeper). By Proposition 1, publishers set fees $f_1 = f_2 = \pi^d$. If $\pi^m < 2\pi^d$, each advertiser buys an ad slot. Otherwise, advertiser A buys both. Each publisher's profit is π^d.

Next, we determine the highest fee the gatekeeper can set to induce both publishers to buy to be listed. Consider a publisher's deviation to opt out of being listed when the other publisher is listed on the equilibrium path. If one publisher is listed, it can charge $\alpha\pi^m$ for its ad slot on top of the fee it would set if it were not listed. Thus, the listed and the non-listed publishers set $f_1 = \alpha\pi^m + (1-\alpha)\pi^d$ and $f_2 = (1-\alpha)\pi^d$, respectively. As a result, if the competing publisher buys to be listed, the maximal listing fee that a publisher is willing to pay for access is $\pi^d - (1-\alpha)\pi^d = \alpha\pi^d$. The maximal profit of the gatekeeper inducing both publishers to pay for access is $2\alpha\pi^d$.

Now, consider the case in which only one publisher pays the listing fee in equilibrium. Then, the profit of the listed publisher is $\alpha\pi^m + (1-\alpha)\pi^d$ and the profit of the non-listed publisher is $(1-\alpha)\pi^d$. The willingness to pay for listing if the other publisher opts out of listing is $\alpha\pi^m + (1-\alpha)\pi^d - (1-\alpha)\pi^d = \alpha\pi^m$. Then, the maximal profit of the gatekeeper inducing only one publisher to be listed is $\alpha\pi^m$.

In any equilibrium in which publishers randomize between listing and not listing, the gatekeeper profits are strictly lower than $\max\{\alpha\pi^m, 2\alpha\pi^d\}$. If $a \in [\alpha\pi^d, \alpha\pi^m]$, there is a unique symmetric mixed-strategy equilibrium in which publishers list with probability $\beta = \frac{\alpha\pi^m - a}{\alpha\pi^m - \alpha\pi^d}$. The gatekeeper profit is $\beta^2 2a + 2(1-\beta)\beta a = 2\beta a = \frac{2a(\alpha\pi^m - a)}{\alpha\pi^m - \alpha\pi^d}$. The fee that maximizes this profit is $\max\{\alpha\pi^m/2, \alpha\pi^d\}$. If $2\pi^d > \pi^m$, then the maximal profit is $2\alpha\pi^d$. Otherwise, if $2\pi^d \leq \pi^m$, the maximal profit in the mixed-strategy equilibrium is $\alpha\pi^m \frac{\alpha\pi^m/2}{\alpha\pi^m - \alpha\pi^d} < \alpha\pi^m$. We conclude that the gatekeeper chooses between setting $\alpha\pi^d$ and inducing both publishers to be listed and setting $\alpha\pi^m$ and inducing only one publisher to be listed.

Hence, if $\pi^m \geq 2\pi^d$, then only one publisher is listed. The listed publisher sets $f_1 = \alpha\pi^m + (1-\alpha)\pi^d$ and the non-listed publisher sets $f_2 = (1-\alpha)\pi^d$. Advertiser A buys both ad slots. By contrast, if $\pi^m < 2\pi^d$, then both publishers pay $\alpha\pi^d$ to be listed. They set advertising fees $f_1 = f_2 = \pi^d$, and each advertiser buys an ad slot. □

Lemma 1. *Consider the case in which advertisers set uniform retail prices. Suppose that one publisher is listed. Then, in equilibrium, advertiser A buys at least one ad slot.*

Proof. Recall that $\pi^l = \alpha\pi(p^l, \infty) + (1-\alpha)\pi(p^l, p^{nl})$ and $\pi^{nl} = (1-\alpha)\pi(p^{nl}, p^l)$. Towards a contradiction, suppose that advertiser A does not buy any slot in equilibrium. If advertiser A buys only the listed ad slot, then its profit is equal to $\pi^l - f_1$ if advertiser B buys the non-listed ad slot, and is equal to $\pi^m - f_1$ otherwise. This implies that $f_1 > \pi^l$, as otherwise the advertiser A would find it more profitable to buy the listed ad slot than to refrain from buying altogether.

Now consider advertiser A buying only the non-listed ad slot. Since $f_1 > \pi^l$, we have that advertiser B does not buy the listed ad slot, and advertiser A earns monopoly profits from consumers who do not use the gatekeeper, yielding profits $(1-\alpha)\pi^m - f_2$ for advertiser A. Advertiser A does not find it profitable to buy only slot 2, implying that $f_2 > (1-\alpha)\pi^m$.

Note that $f_2 > (1-\alpha)\pi^m > \pi^{nl}$ as $\pi^m > \pi(p^{nl}, +\infty) > \pi(p^{nl}, p^l)$. Thus, $f_2 > (1-\alpha)\pi^m$ implies that advertiser B would not buy the non-listed ad slot in case advertiser A decides to buy the listed ad slot only. This implies that advertiser A would be a monopoly if it decides to buy only the listed ad slot. Since this deviation is unprofitable, we have that $f_1 > \pi^m$.

We showed that $f_1 > \pi^m$ and $f_2 > (1-\alpha)\pi^m$, which implies that advertiser B does not buy any slot in the equilibrium either. This leads to non-positive profits for both publishers, which cannot be an equilibrium, a contradiction.

□

Proof of Proposition 3. We have to distinguish between two possible pure-strategy equilibrium outcomes of the full game: either one publisher lists on the gatekeeper app or both publishers do so. It cannot be an equilibrium that none lists because the gatekeeper would make zero profit, which is dominated by selling listing at any positive price.

Consider the subgame in which both publishers are listed. Then Proposition 1 applies and each publisher sets $f_i = \pi^d$.

Consider now the subgame in which one publisher is listed (without loss of generality, publisher 1) and publishers have set fees f_1 and f_2. Recall that the first advertiser A decides which ad slots to buy, and then the remaining slots are offered to advertiser B. By Lemma 1, advertiser A buys at least one ad slot. Therefore, three cases remain to be considered.

First, suppose that advertiser A has bought both slots. It thus operates as a monopolist and earns profits $\pi^m - f_1 - f_2$.

Second, suppose that advertiser A has bought slot 2 only. Then advertiser B either buys slot 1 or foregoes the possibility to advertise. Advertiser A makes $\pi^{nl} - f_2$ if advertiser B buys the remaining slot and $(1-\alpha)\pi^m - f_2$ otherwise. Advertiser B buys slot 1 if and only if $\pi^l - f_1 \geq 0$.

Third, suppose that advertiser A has bought slot 1 only. If advertiser B buys slot 2, advertiser A makes $\pi^l - f_1$ and otherwise $\pi^m - f_2$. Advertiser B buys slot 2 if and only if $\pi^{nl} - f_2 \geq 0$.

We show that, in equilibrium of this subgame, publishers set $f_1 = \pi^l$ and $f_2 = \pi^{nl}$ and both ad slots are taken by the advertisers. As shown above, if at a fee $f_1 \leq \pi^l$ advertiser A does not buy slot 1 and buys slot 2 only, then advertiser B will buy slot 1. Thus, in equilibrium of the subgame starting with publishers simultaneously setting fees, f_1 can not be strictly lower than π^l. Correspondingly, f_2 can not be strictly lower than π^{nl}.

If exactly one publisher $i \in \{1,2\}$ sets a higher fee (i.e. either $f_2 > \pi^{nl}$ or $f_1 > \pi^l$), advertiser B would not buy ad slot i. Would advertiser A have an incentive to buy ad slot i? First, if $f_2 > \pi^{nl}$, buying both slots gives $\pi^m - f_1 - f_2$, buying only slot 1 gives $\pi^m - f_1$, and buying only slot 2 gives $\pi^{nl} - f_2 < 0$. Thus, advertiser A buys slot 1 only and slot 2 remains idle. Second, if $f_1 > \pi^l$, buying both slots gives $\pi^m - f_1 - f_2$, buying only slot 1 gives $\pi^l - f_1 < 0$, and buying only slot 2 gives $(1-\alpha)\pi^m - f_2$. Since $\pi^l \geq \alpha\pi^m + (1-\alpha)\pi(p^m, p^l) > \alpha\pi^m$, advertiser A will buy only slot 2. Hence, slot i will remain idle and no single publisher has an incentive to set a higher fee.

If both publishers set higher fees with $f_1 \leq \pi^m$ and $f_2 \leq (1-\alpha)\pi^m$, advertiser A will select the ad slot that gives it the largest net surplus leading to asymmetric Bertrand competition between publishers. This implies that, in the equilibrium of the subgame in which one publisher is listed, $f_1 = \pi^l$ and $f_2 = \pi^{nl}$.

Given publisher fees, we next characterize advertiser decisions given $f_1 = \pi^l$ and $f_2 = \pi^{nl}$. For advertiser A to buy both slots, it must be that $\pi^m - f_1 - f_2 \geq 0$ at those fees. Thus, we must have $\pi^m \geq \pi^l + \pi^{nl}$.

If $\pi^m < \pi^l + \pi^{nl}$, advertiser A will buy only one slot (it is indifferent as to which one). In this case, both advertisers are active and both make zero net surplus.

The next step is to analyze publishers' listing decisions for a given advertising fee a. When one publisher is listed, this publisher makes $\pi^l - a$, while it would make $(1-\alpha)\pi^d$ if it were to reject the listing offer. Thus, for any $a \leq a^u \equiv \pi^l - (1-\alpha)\pi^d$, each publisher is better off accepting the listing offer given that the other publisher rejects it. By assumption, we have that a^u is positive.

When both publishers are listed, each publisher makes $\pi^d - a$, while a publisher would make π^{nl} if it were to reject the listing offer given the other publisher accepted the offer. If $\pi^d > \pi^{nl}$, then for any $a \leq \pi^d - \pi^{nl}$, both publishers accept the listing offer. If instead $\pi^d \leq \pi^{nl}$, then it cannot be that both publishers buy listing at any positive listing fee.

The last step is to determine the profit-maximizing listing fee. If $\pi^d - \pi^{nl} \geq \pi^l - (1-\alpha)\pi^d$, then any listing fee $a < \pi^d - \pi^{nl}$ is strictly dominated by $a = \pi^d - \pi^{nl}$ (as both publishers buy listing with probability one). For any fee exceeding $\pi^d - \pi^{nl}$, no publisher buys listing. Hence, under this condition the gatekeeper optimally sets $a = \pi^d - \pi^{nl}$ and both publishers buy listing.

In the remainder of the proof, we consider the opposite case $\pi^d - \pi^{nl} < \pi^l - (1-\alpha)\pi^d$. If the gatekeeper chooses a to induce a pure-strategy equilibrium in the subgame played by the publishers it either sets $a = \pi^l - (1-\alpha)\pi^d$ and makes profit $\pi^l - (1-\alpha)\pi^d$ or $a = \pi^d - \pi^{nl}$ and makes profits $2(\pi^d - \pi^{nl})$.

The latter strategy is more profitable than the former if $\pi^l + 2\pi^{nl} < (3-\alpha)\pi^d$, which is the condition stated in the proposition. Note that the resulting profits are positive since $2(\pi^d - \pi^{nl}) > \pi^l - (1-\alpha)\pi^d > 0$, where the latter inequality follows from our assumption. If instead $\pi^l + 2\pi^{nl} \geq (3-\alpha)\pi^d$, then, under our assumption that $\pi^l > (1-\alpha)\pi^d$, we have that the gatekeeper prefers listing one publisher at $a = \pi^l - (1-\alpha)\pi^d$ to listing two publishers at $a = \pi^d - \pi^{nl}$.

In the following, we show that all other listing fees $a \notin \{\pi^d - \pi^{nl}, \pi^l - (1-\alpha)\pi^d\}$ are suboptimal for the gatekeeper. For any $a < \pi^d - \pi^{nl}$, the gatekeeper continues to sell listings to both publishers, as with $a = \pi^d - \pi^{nl}$ but at a lower fee. For any $a > \pi^l - (1-\alpha)\pi^d$, no publisher buys listing. It remains to consider an intermediate listing fee $a \in (\pi^d - \pi^{nl}, \pi^l - (1-\alpha)\pi^d)$, which induces mixing by the publishers. In the unique symmetric mixed-strategy equilibrium of such a subgame, each publisher buys listing with probability γ, where γ makes each publisher indifferent between buying and not buying listing; that is, $\gamma\pi^d + (1-\gamma)\pi^l - a = \gamma\pi^{nl} + (1-\gamma)(1-\alpha)\pi^d$. This gives the explicit solution

$$\gamma = \frac{\pi^l - (1-\alpha)\pi^d - a}{\pi^l + \pi^{nl} - (2-\alpha)\pi^d}.$$

The gatekeeper's expected profit is equal to $\gamma^2 2a + 2\gamma(1-\gamma)a = 2\gamma a$. Plugging the expression for γ, we have that the gatekeeper maximizes $2a(a^u - a)/(\pi^l + \pi^{nl} - (2-\alpha)\pi^d)$. If $a^u/2 > \pi^d - \pi^{nl}$, then the gatekeeper will make expected profit $2\gamma a^u/2 < a^u$, which implies that setting any intermediate a is dominated by setting $a = a^u$. If instead $a^u/2 \leq \pi^d - \pi^{nl}$, then any intermediate a is dominated by setting $a = \pi^d - \pi^{nl}$ and thereby selling listings to both publishers. Hence, it is never optimal for the gatekeeper to induce a mixed-strategy equilibrium.

□

Proof of Proposition 4. The gatekeeper does not maximize its profit if it sets $a > \pi^l - (1-\alpha)\pi^d$. Even if all high-nuisance-cost consumers install the gatekeeper app, Proposition 3 implies that no publisher decides to list at such a high fee. Consider the case $a \leq \pi^l - (1-\alpha)\pi^d$. Then, at least some high-nuisance-cost consumers install the gatekeeper app in equilibrium. Suppose, towards a contradiction, that no consumer installs the gatekeeper app. Then, publishers decide not to list. This, in turn, implies that high-nuisance-cost consumers can avoid two ads by installing the gatekeeper app and have an incentive to do so.

For $\pi^d \leq \pi^{nl}$, the gatekeeper sets $a = \pi^l - (1-\alpha)\pi^d$ and all high-nuisance-cost consumers are strictly better off from installing the gatekeeper app (since $\mu_h > F_I$). For $\pi^d > \pi^{nl}$, since nuisance cost μ_h is the same for all high-nuisance-cost consumers, we have that either all high-nuisance-cost consumers are strictly better off from installing the gatekeeper app or they are indifferent and a fraction $\alpha' \in (0, \alpha]$ install the gatekeeper app. We analyze these two cases separately and show that in each case the gatekeeper maximizes its profits by setting $a = \pi^l - (1-\alpha)\pi^d$.

First, suppose that $a \leq \pi^l - (1-\alpha)\pi^d$ and all high-nuisance-costs consumers strictly prefer to install the gatekeeper app. If $a = \pi^l - (1-\alpha)\pi^d$, then only one publisher decides to list, and all high-nuisance-cost consumers install the gatekeeper app. The gatekeeper profit is $\pi^l - (1-\alpha)\pi^d$. If $a \leq \pi^d - \pi^{nl}$, then by Proposition 3 both publishers decide to list. In turn, all high-nuisance-cost consumers become exposed to two ads and refuse to install the gatekeeper app, a contradiction. If $a \in (\pi^d - \pi^{nl}, \pi^l - (1-\alpha)\pi^d)$, then there is an equilibrium in which only one publisher decides to list resulting in gatekeeper profits of a. The gatekeeper can make strictly higher profits by setting fee $\pi^l - (1-\alpha)\pi^d$. It remains to consider the publishers' mixed strategy. If publishers decide to list with probability γ, then the expected cost of ad nuisance of the high-nuisance-cost consumers is $2\gamma^2\mu_h + 2\gamma(1-\gamma)\mu_h = 2\gamma\mu_h$ if they install the gatekeeper app. Since all consumers are strictly better off installing the gatekeeper app we have that $\gamma \leq 1 - \frac{F_I}{2\mu_h} < \min\left\{\frac{\pi^l - (1-\alpha)\pi^d}{2(\pi^d - \pi^{nl})}, 1\right\}$, where the latter inequality holds because of our assumption in the main text that Inequality (1) holds. The resulting gatekeeper profit is $2\gamma a$, where $\gamma = \frac{\pi^l - (1-\alpha)\pi^d - a}{\pi^l + \pi^{nl} - (2-\alpha)\pi^d}$. If $\pi^l + 2\pi^{nl} \geq (3-\alpha)\pi^d$, then the gatekeeper profit is maximized at $a = \frac{1}{2}(\pi^l - (1-\alpha)\pi^d)$ and is equal to $\gamma(\pi^l - (1-\alpha)\pi^d) < \pi^l - (1-\alpha)\pi^d$, where the last expression is the profit that the gatekeeper can always obtain by setting $\pi^l - (1-\alpha)\pi^d$ and listing only one publisher. If $\pi^l + 2\pi^{nl} < (3-\alpha)\pi^d$, then the gatekeeper profit is $2\gamma a < 2\frac{\pi^l - (1-\alpha)\pi^d}{2(\pi^d - \pi^{nl})}(\pi^d - \pi^{nl}) = \pi^l - (1-\alpha)\pi^d$. We showed that if all high-nuisance-cost consumers install the gatekeeper app, then the gatekeeper finds it optimal to set $a = \pi^l - (1-\alpha)\pi^d$ and list only one publisher.

Second, suppose that the high-nuisance-cost consumers are indifferent and $\alpha' < \alpha$ consumers install the gatekeeper app in equilibrium. We note that π^l and π^{nl} correspond to profits of the listed and the non-listed publishers for α' respectively. If $a > \pi^l - (1-\alpha')\pi^d$, then no publisher decides to list, and the high-nuisance-cost consumers are strictly better off from installing the gatekeeper app. If $a \leq \pi^d - \pi^{nl}$, then both publishers decide to list and the high-nuisance-cost consumers will not install the gatekeeper app. If $a \in (\pi^d - \pi^{nl}, \pi^l - (1-\alpha')\pi^d)$, then if only one publisher decides to list, then the high-nuisance-cost consumers are strictly better off from installing the gatekeeper app. It remains to consider the mixed-strategy equilibrium. Suppose that publishers decide to list with probability γ. Since the high-nuisance-cost consumers are indifferent, we have that $\gamma = 1 - \frac{F_I}{2\mu_h} < \min\left\{\frac{\pi^l-(1-\alpha')\pi^d}{2(\pi^d-\pi^{nl})}, 1\right\}$, where the latter inequality holds because of our assumption in the main text that Inequality (1) holds. The resulting gatekeeper profit is $2\gamma a$, where $\gamma = \frac{\pi^l-(1-\alpha')\pi^d-a}{\pi^l+\pi^{nl}-(2-\alpha')\pi^d}$. Following the previous analysis for α, we find that the gatekeeper profit cannot be higher than $\pi^l - (1-\alpha')\pi^d$. This expression is higher for higher α' and is maximal when all high-nuisance-cost consumers install the gatekeeper app.

We conclude that in the unique equilibrium, the gatekeeper sets $a = \pi^l - (1-\alpha)\pi^d$, all high-nuisance-cost consumers install the gatekeeper app, and only one publisher decides to list.

□

Proof of Proposition 5. We first show that the publishers' equilibrium fee satisfies $f \geq \pi^t$. This is obviously the case if $\pi^t = 0$. If $\pi^t > 0$, suppose that, by contradiction, each publisher sets $f < \pi^t$. Then, each publisher sells its ad slot with probability 1, as even in the worst case – when two advertisers purchase one ad slot each – the net gain from purchasing the remaining slot is positive, that is, $\pi^t - f > 0$. Thus, each publisher can slightly increase its fee and continue selling with probability 1, implying that $f \geq \pi^t$ holds in any equilibrium.

Next, suppose that, by contradiction, publishers set a strictly positive fee $f \geq \pi^t$ and only $\ell < 3$ ad slots are purchased by the advertisers, leaving $3-\ell$ slots vacant. At least one publisher sells its ad slot with a probability strictly less than 1. By setting $f - \varepsilon$ and thereby slightly undercutting the fee, such a publisher can guarantee the sale of their ad slot. Since this constitutes a profitable deviation, all ad slots have to be purchased in equilibrium.

Note that at any $f \in (\pi^d, \pi^m]$, two slots remain unsold, which cannot occur in equilibrium by the preceding argument. Therefore, any symmetric equilibrium candidate for the publishers' fee f lies within the interval $[\pi^t, \pi^d]$.

Next, we show that advertiser A, who is first in line, never purchases two ad slots. If $f \in (\pi^t, \pi^d]$ and advertiser A buys one ad slot, then advertiser B also buys only one ad slot, and the last ad slot stays idle (since $f > \pi^t$). Clearly, for advertiser A, purchasing two ad slots is dominated by purchasing only one, as both strategies yield the same gross profits π^d, while the former requires purchasing two rather than one ad slot. If $f = \pi^t$ and advertiser A buys one ad slot, then advertiser B buys the two remaining ad slots to foreclose advertiser C if $\pi^d \geq 2\pi^t$ and buys one ad slot, otherwise. If $\pi^d \geq 2\pi^t$, advertiser A can free-ride on the common incentives to foreclose advertiser C, purchase only one ad slot, and let advertiser B foreclose advertiser C. If $\pi^d < 2\pi^t$ and advertiser A purchases two ad slots, it earns $\pi^d - 2\pi^t$, which is strictly negative and is dominated by buying only one ad slot, which results in zero profits. We conclude that advertiser A buys either one or all three ad slots for any $f \in [\pi^t, \pi^d]$.

The profit of advertiser A from purchasing all three slots and foreclosing all the rivals is $\pi^m - 3f$. The profit of advertiser A from purchasing a single ad slot is $\pi^d - f$ if $f \in (\pi^t, \pi^d]$ or $f = \pi^t$ and $\pi^d \geq 2\pi^t$. If $f = \pi^t$ and $\pi^d < 2\pi^t$, then the profit from purchasing a single ad slot is zero. Therefore, advertiser A prefers to buy all three ad slots if $\pi^m - 3f \geq \pi^d - f$ ($f \leq (\pi^m - \pi^d)/2$) in case either $f \in (\pi^t, \pi^d]$ or $f = \pi^t$ and $\pi^d \geq 2\pi^t$. If $f = \pi^t$ and $\pi^d < 2\pi^t$, then advertiser A prefers to buy all ad slots if $\pi^m \geq 3\pi^t$.

Suppose that $\pi^m \geq \pi^d + 2\pi^t$. Advertiser A purchases all three slots for any publishers' fee f that satisfies $\pi^t \leq f \leq \min\left\{\frac{\pi^m - \pi^d}{2}, \pi^d\right\}$. Any fee $f < \min\left\{\frac{\pi^m - \pi^d}{2}, \pi^d\right\}$ cannot occur in equilibrium, as publishers can slightly increase their fees and advertiser A would still buy all three ad slots. At any fee $f > \min\left\{\frac{\pi^m - \pi^d}{2}, \pi^d\right\}$, advertiser A purchases only one ad slot, advertiser B purchases at most one ad slot and one slot remains unsold (since $f > \pi^t$), which cannot be in equilibrium as each publisher has incentives to slightly undercut its fee. Given the argument above, it is straightforward to check that $f = \min\left\{\frac{\pi^m - \pi^d}{2}, \pi^d\right\}$ is indeed the equilibrium fee set by all publishers. This gives rise to the monopoly foreclosure outcome in the last item of the proposition.

If $\pi^m < \pi^d + 2\pi^t$, then at any $f \in (\pi^t, \pi^d]$ advertisers A and B purchase one ad slot each and advertiser C stays out of the market. Since any equilibrium has the feature that all ad slots are purchased, such a fee cannot prevail in equilibrium. If $f = \pi^t$ and $\pi^d \geq 2\pi^t$, then advertiser A purchases one ad slot and advertiser B forecloses advertiser C by buying two ad slots. This is an equilibrium, since any unilateral increase in the fee by a publisher leads to zero profits – see the duopoly foreclosure outcome in the proposition.

Otherwise, if $\pi^m < \pi^d + 2\pi^t$ continues to hold, and if $f = \pi^t$ and $\pi^d < 2\pi^t$, then advertiser B does not foreclose advertiser C in case advertiser A purchases only one ad slot, yielding zero profits for all advertisers. Thus, advertiser A purchases all three ad slots provided that $\pi^m \geq 3\pi^t$ (leading to the monopoly foreclosure as the third item of the proposition). Otherwise, if $\pi^m < 3\pi^t$, each advertiser buys only one ad slot (leading to the no foreclosure outcome in the proposition). □

Proof of Proposition 6. The equilibrium listing fee is weakly greater than $\alpha\pi^t$, since for any $a < \alpha\pi^t$ all publishers purchase listings with probability 1 and earn strictly positive profits on the consumers who use the gatekeeper by charging an additional $\alpha\pi^t$. The maximal listing fee that the gatekeeper can set is $\alpha\pi^m$, in which case at most one publisher buys listing. Since, $\pi^m < 3\pi^t$, the gatekeeper strictly prefers to sell listings to all publishers at price $\alpha\pi^t$, rather than selling a single listing to one publisher at price $\alpha\pi^m$.

Next, we determine the highest fee $a > 0$ that the gatekeeper can set and induce two publishers to buy a listing with probability 1. Suppose that two publishers buy listings and one publisher does not. We characterize the equilibrium publishers' fees and the advertising purchasing decisions in this subgame.

First, note that $f_l \geq (1-\alpha)\pi^t + \alpha\pi^d$ and $f_{nl} \geq (1-\alpha)\pi^t$ in equilibrium. Indeed, if $f_{nl} < (1-\alpha)\pi^t$, the non-listed publisher can slightly raise its fee and still sell its slot with probability 1. Likewise, if $f_l < (1-\alpha)\pi^t + \alpha\pi^d$, the listed publisher can marginally increase its fee and continue to sell with probability 1. This follows because, even in the worst case, when both advertisers purchase exactly one ad slot each, the net gain from acquiring the remaining slot remains positive.

We argue that all slots have to be purchased in equilibrium with probability 1. Since all publishers can guarantee positive profits from selling their ad slots (gross of the gatekeeper fee a), the equilibrium probability of sale must be nonzero. If, instead, the sale probability lies in the interior, any publisher can profitably deviate by marginally lowering its fee, thereby strictly increasing its expected profit.

Note that if $f_l > \pi^d$, then one of the listed publishers would fail to sell its ad slot, which cannot occur in equilibrium by the argument made above. Therefore, $(1-\alpha)\pi^t + \alpha\pi^d \leq$

$f_l \leq \pi^d$. Similarly, if $f_{nl} > (1-\alpha)\pi^d$, then, given that the listed publishers' ad slots are sold in equilibrium, the non-listed publisher's slot is priced too high and would remain unsold. Thus, $(1-\alpha)\pi^t \leq f_{nl} \leq (1-\alpha)\pi^d$.

In the following, we show that advertiser A does not buy more than one ad slot. The profits of advertiser A from buying all ad slots is

$$\begin{aligned}\pi^m - 2f_l - f_{nl} &\leq \pi^m - 2((1-\alpha)\pi^t + \alpha\pi^d) - (1-\alpha)\pi^t \\ &= (1-\alpha)(\pi^m - 3\pi^t) + \alpha(\pi^m - 2\pi^d) < 0,\end{aligned}$$

where we used the fact that $\pi^m < 3\pi^t < 2\pi^d$ to obtain the last inequality. If firm A purchases two listed ad slots, then advertiser B buys the remaining non-listed ad slot. The resulting profits for advertiser A is also negative, since

$$\begin{aligned}(1-\alpha)\pi^d + \alpha\pi^m - 2f_l &\leq (1-\alpha)\pi^d + \alpha\pi^m - 2((1-\alpha)\pi^t + \alpha\pi^d) \\ &= (1-\alpha)(\pi^d - 2\pi^t) + \alpha(\pi^m - 2\pi^d) < 0.\end{aligned}$$

If advertiser A buys one listed and one non-listed ad slots, then advertiser B purchases the remaining listed ad slot. This yields the negative profits for advertiser A:

$$\begin{aligned}\pi^d - f_l - f_{nl} &\leq \pi^d - ((1-\alpha)\pi^t + \alpha\pi^d) - (1-\alpha)\pi^t \\ &= (1-\alpha)(\pi^d - 2\pi^t) < 0.\end{aligned}$$

We conclude that advertiser A buys at most one ad slot.

Next, we show that publishers set $f_l = (1-\alpha)\pi^t + \alpha\pi^d$ and $f_{nl} = (1-\alpha)\pi^t$ in equilibrium. For a contradiction, assume that in equilibrium the fees satisfy $\pi^d \geq f_l > (1-\alpha)\pi^t + \alpha\pi^d$ and $(1-\alpha)\pi^d \geq f_{nl} > (1-\alpha)\pi^t$. Then, advertiser A earns positive profits by buying one ad slot (listed or non-listed, depending on whether $\pi^d - f_l$ exceeds $(1-\alpha)\pi^d - f_{nl}$), advertiser B also buys only one ad slot, and consequently one slot remains unsold with probability 1. This cannot occur, since all slots must be sold in equilibrium. If $f_l = (1-\alpha)\pi^t + \alpha\pi^d$ and $f_{nl} > (1-\alpha)\pi^t$, then advertisers A and B buy one listed slot each and the non-listed slot remains idle. If instead $f_l > (1-\alpha)\pi^t + \alpha\pi^d$ and $f_{nl} = (1-\alpha)\pi^t$, then advertiser A buys one ad slot (listed or non-listed, depending on whether $(1-\alpha)\pi^d + \alpha\pi^m - f_l$ exceeds

$(1-\alpha)\pi^d - (1-\alpha)\pi^t)$, advertiser B also buys one ad slot, and one slot remains unsold. This cannot occur in equilibrium.

Therefore, it must be that $f_l = (1-\alpha)\pi^t + \alpha\pi^d$ and $f_{nl} = (1-\alpha)\pi^t$ in equilibrium. In this case, each advertiser purchases exactly one ad slot and earns zero profits. Note that the advertisers are indifferent over which slot to buy. Next, we show that the publishers do not have profitable deviations in their fees. If a non-listed publisher deviates to a fee $f_{nl} > (1-\alpha)\pi^t$, then advertisers A and B buys one listed ad slot each and the non-listed slot remains unsold. This implies that such a deviation is unprofitable. If a listed publisher deviates to a higher fee, then advertisers A and B purchase the cheapest listed and the non-listed ad slots (one each), and the more expensive ad slot remains idle. Hence, listed publishers do not have profitable deviations. We conclude that in the subgame where only two publishers are listed, the publishers' fees are given by $f_l = (1-\alpha)\pi^t + \alpha\pi^d$ and $f_{nl} = (1-\alpha)\pi^t$, each advertiser buys one ad slot and earns zero profits.

Suppose that a listed publisher deviates by foregoing the listing, so that only one publisher remains listed. Then, following the arguments of Proposition 5, the listed and the non-listed publishers charge $f_l = (1-\alpha)\pi^t + \alpha\pi^m$ and $f_{nl} = (1-\alpha)\pi^t$, respectively. Each advertiser buys one ad slot and earns zero profits. The profit of the non-listed publisher from such a deviation is $(1-\alpha)\pi^t$, which implies that the highest price that the gatekeeper can charge while still selling listings to two publishers with probability 1 is $\alpha\pi^d$. Since $2\pi^d > 3\pi^t$, we have that the gatekeeper strictly prefers selling to two publishers with probability 1 over selling to all publishers with probability 1.

It remains to show that any fee $a \in (\alpha\pi^t, \alpha\pi^d)$ or $a \in (\alpha\pi^d, \alpha\pi^m)$ yields profits strictly below $2\alpha\pi^d$. For $a \in (\alpha\pi^t, \alpha\pi^d)$, we characterize an equilibrium in which one firm buys the listing with probability 1 and the remaining two publishers buy the listing with probability $\beta \in (0,1)$. The indifference condition of the publishers that randomize is

$$(1-\alpha)\pi^t + \beta\alpha\pi^t + (1-\beta)\alpha\pi^d - a = (1-\alpha)\pi^t,$$

implying that $\beta = (\alpha\pi^d - a)/(\alpha\pi^d - \alpha\pi^t)$. The gatekeeper's expected profit is $2\beta^2 a + 2\beta(1-\beta)a = 2\beta a = 2a(\alpha\pi^d - a)/(\alpha\pi^d - \alpha\pi^t)$. Since $\alpha\pi^d/2 < \alpha\pi^t$, the gatekeeper's profit decreases in a on $(\alpha\pi^t, \alpha\pi^d)$. We conclude that the gatekeeper strictly prefers to charge $\alpha\pi^d$ and induce two publishers to buy listings with probability 1, rather than to set a lower fee and have one publisher buy the listing with certainty while the other two randomize over their listing decisions.

For $a \in (\alpha\pi^d, \alpha\pi^m)$, we characterize an equilibrium in which one publisher does not buy listing with probability 1 and the remaining two publishers purchase listing with probability $\gamma \in (0,1)$. The indifference condition of the publishers who randomize is

$$(1-\alpha)\pi^t + \gamma\alpha\pi^d + (1-\gamma)\alpha\pi^m - a = (1-\alpha)\pi^t,$$

implying that $\gamma = (\alpha\pi^m - a)/(\alpha\pi^m - \alpha\pi^d)$. Since $\pi^m/2 < 3\pi^t/2 < \pi^d$, we have that the gatekeeper's profit function $2\gamma a$ decreases in a on $(\alpha\pi^d, \alpha\pi^m)$. We conclude that the gatekeeper strictly prefers to charge $\alpha\pi^d$ and induce two publishers to buy listings with probability 1, rather than to set a higher fee and have one publisher opt out of listing with certainty while the other two randomize over their listing decisions.

For any $a \in (\alpha\pi^t, \alpha\pi^m)$ and $a \neq \alpha\pi^d$, there exists also a symmetric equilibrium, in which firms purchase listing with probability $\delta \in (0,1)$. We show that the gatekeeper strictly prefers to charge $\alpha\pi^d$ and serve two publishers with certainty, rather than to set a fee $a \neq \alpha\pi^d$ and have all publishers to randomize over the listing decisions. The indifference condition of publishers implies that

$$(1-\alpha)\pi^t + \delta^2\alpha\pi^t + 2\delta(1-\delta)\alpha\pi^d + (1-\beta)^2\alpha\pi^m - a = (1-\alpha)\pi^t,$$

or, equivalently, $a = \delta^2\alpha\pi^t + 2\delta(1-\delta)\alpha\pi^d + (1-\delta)^2\alpha\pi^m$. The expected profit of the gatekeeper is $3\delta^3 a + 6\delta^2(1-\delta)a + 3\delta(1-\delta)^2 a = 3\delta a$. We have that

$$\begin{aligned} 3\delta a &= 3\alpha(\delta^3\pi^t + 2\delta^2(1-\delta)\pi^d + \delta(1-\delta)^2\pi^m) \\ &< 3\alpha(\delta^3\pi^t + 3\delta^2(1-\delta)\pi^t + 3\delta(1-\delta)^2\pi^t) \\ &= 3\alpha(1-(1-\delta)^3)\pi^t < 2\pi^d, \end{aligned}$$

which establishes that the gatekeeper strictly prefers to charge $\alpha\pi^d$ and sell listings to two publishers with certainty.

The relevant parameter range is illustrated in Figure 5.

□

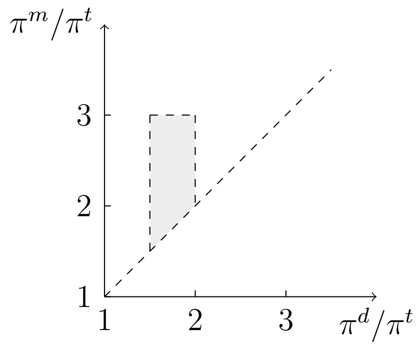

Figure 5: The region of parameters in Proposition 6.

B Additional material on gatekeeper adoption

In this appendix, we analyze the three alternative settings with endogenous gatekeeper installation. Proofs to all propositions in this appendix are collected at the end.

Committed gatekeeper and retail price discrimination. We analyze the case in which, as in the main text, the gatekeeper commits to its listing fee before consumers decide whether to install the gatekeeper app, but, different from the main text, advertisers price-discriminate.

To ensure that the gatekeeper does not prefer a listing fee that induces a mixed-strategy equilibrium among publishers, we assume in this model that $\frac{F_I}{\mu_h}$ is sufficiently large in case $\pi^m < 2\pi^d$, namely that the inequality

$$\frac{F_I}{\mu_h} > \max\left\{2 - \frac{\pi^m}{\pi^d}, 0\right\}.$$

holds. The gatekeeper then sets its fee such that exactly one publisher pays to be listed. Hence, in contrast to the case of exogenous gatekeeper installation, only one publisher is listed even if $\pi^m < 2\pi^d$.

Listing gives the advertiser on the listed publisher's website a monopoly position over consumers with high nuisance costs, as they are the ones who install the gatekeeper app. The associated increase in advertising profits, $\alpha\pi^m$, can be extracted as an incremental advertising fee by the listed publisher relative to the non-listed publisher. Consequently, the listing is worth $\alpha\pi^m$ to the publisher, and the gatekeeper captures this value through its listing fee (we set $\mu_l = 0$ for simplicity).

Proposition 7. *Consider the case in which the gatekeeper first commits to its listing fee, after which consumers decide whether to install the gatekeeper app, and advertisers price-discriminate. The gatekeeper offers access at* $a = \alpha\pi^m$*, and exactly one publisher accepts. The listed publisher sets its advertising fee* $f_1 = \alpha\pi^m + (1-\alpha)\pi^d$*, and the non-listed publisher sets* $f_2 = (1-\alpha)\pi^d$*. If* $\pi^m \geq 2\pi^d$*, advertiser A buys the ad slot from both publishers; otherwise, each advertiser buys one slot.*

Upfront gatekeeper installation and retail price discrimination. Consider the extension in which consumers decide whether to install the gatekeeper app before the first stage of the game. With retail price discrimination, consumers correctly anticipate that both publishers will be listed if $2\pi^d > \pi^m$. In this case, gatekeeping does not reduce ad exposure, and therefore no consumer installs the gatekeeper app. The gatekeeper can be active only if $2\pi^d \leq \pi^m$, in which case a single publisher will be listed.

When only one publisher is listed, advertiser A purchases the ad slot from each publisher. The advertisement on the non-listed publisher's website does not affect consumer choice in the product market and merely adds to advertising nuisance. Hence, consumers with high nuisance costs have a strict incentive to install the gatekeeper app. Proposition 2 is therefore modified as follows.

Proposition 8. *Consider an environment with endogenous consumer installation of the gatekeeper app and price-discriminating advertisers.*

- *If* $\pi^m < 2\pi^d$*, then no consumer installs the gatekeeper app; both publishers set* $f_1 = f_2 = \pi^d$*; and each advertiser buys one ad slot.*
- *If* $\pi^m \geq 2\pi^d$*, then consumers with high nuisance costs install the gatekeeper app; the gatekeeper offers access at* $a = \alpha\pi^m$*; and one publisher accepts. The listed publisher sets its fee* $f_1 = \alpha\pi^m + (1-\alpha)\pi^d$*, and the non-listed publisher sets* $f_2 = (1-\alpha)\pi^d$*. Advertiser A buys the ad slot on each publisher's website.*

This proposition implies that gatekeepers operate only in environments where product-market competition is intense under duopoly – that is, when product differentiation is not too large in our illustrative examples.

Upfront gatekeeper installation and uniform retail prices. We now turn to the case in which advertisers must set uniform retail prices. Suppose first that consumers exhibit limited cognition when deciding whether to install the gatekeeper app, in the sense that they do not internalize how this decision affects their experience in the product market. Their adoption decision is then based solely on the comparison between the nuisance from advertising and the opportunity cost of installing the app.

Proposition 9. *Consider the case in which consumers endogenously decide whether to install the gatekeeper app before the gatekeeper sets its listing fee, and advertisers set uniform prices.*

- *If* $\pi^l + 2\pi^{nl} < (3-\alpha)\pi^d$, *then none of the consumers installs the gatekeeper app and both publishers set* $f_1 = f_2 = \pi^d$; *and each advertiser buys one slot.*

- *If* $\pi^l + 2\pi^{nl} \geq (3-\alpha)\pi^d$, *then consumers with the high nuisance cost install the gatekeeper app and the gatekeeper lists a single publisher at price* $\pi^l - (1-\alpha)\pi^d$. *The listed publisher sets its fee equal to* π^l *and the non-listed publisher sets* π^{nl}. *If* $\pi^m > 2\pi^d$, *advertiser* A *buys the ad slot on each publisher's website and otherwise each advertiser buys one slot each.*

In Example 2, the surplus results reported in Figure 3 continue to hold.

Finally, consider the case in which consumers are fully rational and internalize that using the gatekeeper app may worsen their product-market experience, since doing so limits them to purchasing from advertiser A. When $\pi^l + 2\pi^{nl} \geq (3-\alpha)\pi^d$ and $\pi^m < 2\pi^d$, advertiser A fully forecloses advertiser B, and the results of Proposition 9 continue to apply.

However, when $\pi^l + 2\pi^{nl} \geq (3-\alpha)\pi^d$ and $\pi^m > 2\pi^d$, advertiser A partially forecloses advertiser B. By using the gatekeeper a consumer reduces their net surplus in the product market by $CS(p^l, p^{nl}) - CS(p^l, \infty)$. Recall that there are two consumer groups, one with high nuisance costs of advertising and another with low nuisance costs. Suppose that the incremental ad nuisance from two instead of one ad is μ_h for the high-nuisance type and μ_l for the low-nuisance type. Suppose furthermore that the low-nuisance type never installs the gatekeeper app. If all consumers expect that only the high type installs the app, then the condition supporting this equilibrium is $\mu_h > CS(p^l, p^{nl}) - CS(p^l, \infty) > \mu_l$. Alternatively, consumers may expect that none of the others installs the app. Not installing the app is then also preferred by a consumer with high nuisance costs if $CS(p^d, p^d) - CS(p^d) > \mu_h$. If $CS(p^l, p^{nl}) - CS(p^l, \infty) < \mu_h < CS(p^d, p^d) - CS(p^d)$, both outcomes can be supported in equilibrium. Moreover, for $\mu_h \in (\min\{CS(p^d, p^d) - CS(p^d), CS(p^l, p^{nl}) - CS(p^l, \infty)\}, \max\{CS(p^d, p^d) - CS(p^d), CS(p^l, p^{nl}) - CS(p^l, \infty)\})$, there exists a mixed equilibrium in which the high-nuisance type randomizes.

The key takeaway is that if consumers with high nuisance costs experience sufficiently large disutility from advertising, they continue to install the gatekeeper app despite the loss in product-market surplus, and our partial foreclosure result continues to hold when consumers are fully rational and account for the product-market implications of their adoption decision. The presence of the gatekeeper may still reduce consumer surplus because consumers who do not use the gatekeeper face higher prices than in the absence of the gatekeeper.[24]

Proofs of the propositions in Appendix B.

Proof of Proposition 7. We first note that the gatekeeper can make profits of $\alpha\pi^m$. If the gatekeeper sets $a = \alpha\pi^m$, then only one publisher decides to be listed and all high-nuisance-cost consumers prefer to install the gatekeeper app.

Next we explore the profit-maximizing listing fee. We start by showing that the gatekeeper does not set a listing fee $a \leq \alpha\pi^d$.

Suppose that $a \leq \alpha\pi^d$. By contradiction, suppose that all high-nuisance-cost consumers are strictly better off from installing the gatekeeper app. Then, by Proposition 2 both publishers decide to list and consumers see both ads. This implies that consumers prefer not to install the gatekeeper app, a contradiction. Next, by contradiction, suppose that the high-nuisance-cost consumers are indifferent and a fraction $\alpha' < \alpha$ of consumers install the gatekeeper app. If $a \leq \alpha'\pi^d$, then both publishers decide to and the previous argument applies. If $a > \alpha'\pi^m$, then no publisher decides to list and all high-nuisance-cost consumers are strictly better off installing the gatekeeper app. If $a \in (\alpha'\pi^d, \alpha'\pi^m]$, then only one publisher decides to list and all high-nuisance-cost consumers are strictly better off installing

[24] One could extend the analysis to a continuum of consumer types differing in their nuisance costs of advertising. In such a setting, consumers with nuisance costs above a threshold would adopt the gatekeeper, while those below would not, leading to an endogenously determined adoption rate. We conjecture that our qualitative results would remain robust in this more general environment.

the gatekeeper app, a contradiction.

It remains to consider the publishers' mixed strategy in this case. If publishers decide to list with probability β, then the expected cost of ad nuisance of the high-nuisance-cost consumers if they install the gatekeeper app is $2\mu_h\beta^2 + 2\beta(1-\beta)\mu_h = 2\beta\mu_h$. In addition, they must bear the installation cost F_I. Since consumers are indifferent, we have that $\beta = 1 - \frac{F_I}{2\mu_h}$. The indifference condition of the publishers implies that $\beta = \frac{\alpha'\pi^m - a}{\alpha'\pi^m - \alpha'\pi^d}$. The resulting gatekeeper profit is $2\beta a$, which is maximized at $\alpha' \max\{\pi^m/2, \pi^d\}$. If $\pi^m \geq 2\pi^d$, then the resulting profit $2\beta a$ satisfies $2\beta a \leq \frac{\alpha'\pi^m/2}{\alpha'\pi^m - \alpha'\pi^d}\alpha'\pi^m \leq \alpha'\pi^m < \alpha\pi^m$, where the last expression is the profit that the gatekeeper can always obtain by setting $a = \alpha\pi^m$ and listing only one publisher. Otherwise, if $\pi^m < 2\pi^d$, then $2\beta a = 2\left(1 - \frac{F_I}{2\mu_h}\right) a < \frac{\pi^m}{\pi^d} a \leq \alpha'\pi^m < \alpha\pi^m$. We conclude that $a \leq \alpha\pi^d$ will not be set by the gatekeeper in equilibrium.

Next, suppose that the gatekeeper sets the listing fee $a \in (\alpha\pi^d, \alpha\pi^m)$ and all high-nuisance-cost consumers are strictly better off from installing the gatekeeper app. In the pure strategy equilibrium in which only one publisher decides to list, we have that all high-nuisance-cost consumers install the gatekeeper app. The resulting profit is a, which is less than what the gatekeeper can make if it sets $a = \alpha\pi^m$.

It remains to consider the mixed-strategy equilibrium. Suppose that all high-nuisance-cost consumers install the gatekeeper app. Then, $\beta \leq 1 - \frac{F_I}{2\mu_h} < \min\left\{\frac{\pi^m}{2\pi^d}, 1\right\}$. The resulting gatekeeper profit is $2\beta a$, where $\beta = \frac{\alpha\pi^m - a}{\alpha\pi^m - \alpha\pi^d}$. If $\pi^m \geq 2\pi^d$, then the profit is maximized at $\alpha\pi^m/2$ and is equal to $\beta\alpha\pi^m < \alpha\pi^m$. Otherwise, if $\pi^m < 2\pi^d$, then the profit $2\beta a < 2\frac{\pi^m}{2\pi^d}\alpha\pi^d = \alpha\pi^m$. A similar argument can be made if high-nuisance-cost consumers are indifferent and a fraction of $\alpha' < \alpha$ consumers install the gatekeeper app. This concludes the proof. □

Proof of Proposition 8. Suppose that a positive fraction of consumers install the gatekeeper app upfront. The subgame, which starts from the gatekeeper setting the listing fee, is characterized by Proposition 2.

First, if $\pi^m < 2\pi^d$, the gatekeeper sells listing to both publishers and all consumers become exposed to both ads irrespective of whether or not they initially installed the gatekeeper app. Since installing the gatekeeper app is costly ($F_I > 0$) and consumers can not reduce ad exposure with the gatekeeper app, no consumer installs the gatekeeper app in equilibrium, and the game is played according to Proposition 1.

Second, if $\pi^m \geq 2\pi^d$, then the gatekeeper sells listing to one publisher only. If consumers do not take into account that the app installation affects their surplus in the product market, then the high nuisance cost consumers install the gatekeeper app since $\mu_h > F_I$.[25] Thus, if $\pi^m \geq \pi^d$, α consumers install the gatekeeper app, and the game is played according to Proposition 2.

□

Proof of Proposition 9. Suppose that there is a positive fraction of consumers who installed the gatekeeper app. Then, Proposition 3 applies.

First, if $\pi^l + 2\pi^{nl} < (3-\alpha)\pi^d$, the gatekeeper sells listing to both publishers and each consumer sees both ads independent of whether they installed the gatekeeper app. Thus, none of the consumers installs the gatekeeper app and Proposition 1 applies.

Second, if $\pi^l + 2\pi^{nl} > (3-\alpha)\pi^d$, then only one publisher lists. Since $\mu_h > F_I > \mu_l$ the consumers with high nuisance cost prefer to install the gatekeeper app.[26] This concludes the proof. □

[25] If consumers are fully rational, then the high nuisance cost consumers install the gatekeeper app if $\mu_h > F_I + (CS(p^d, p^d) - CS(p^m, \infty))$.

[26] If consumers are fully rational, then they install the gatekeeper app if $\mu_h > F_I + (CS(p^l, p^{nl}) - CS(p^l, \infty))$.

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