# The Beneficial Effects of Ad Blockers

(Preliminary Draft)

Stylianos Despotakis, R. Ravi, and Kannan Srinivasan

Tepper School of Business, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213
{steliosdes, ravi, kannans}@cmu.edu

September 7, 2017

**Abstract**

While online advertising is the lifeline of many internet content platforms, the usage of ad blockers has surged in recent years presenting a challenge to platforms dependent on ad revenue. Using a simple analytical model with two competing platforms, we show that the presence of ad blockers can actually benefit platforms. In particular, there are conditions under which the optimal equilibrium strategy for the platforms is to allow the use of ad blockers (rather than using an adblock wall, or charging a fee for viewing ad-free content). The key insight is that allowing ad blockers serves to differentiate platform users based on their disutility to viewing ads. This allows platforms to increase their ad intensity on those that do not use the ad blockers and achieve higher returns than in a world without ad blockers. We show robustness of these results when we allow a larger combination of platform strategies, as well as by explaining how ad whitelisting schemes offered by modern ad blockers can add value. Our study provides general guidelines for what strategy a platform should follow based on the heterogeneity in the ad sensitivity of their user base.

*Keywords*: ad blocking; ad sensitivity; ad intensity; competitive strategy; advertising; game theory

# 1 Introduction

## 1.1 Background

Online advertising is like taxes. Nobody likes them, but they exist because people understand that they are necessary. Millions of websites, including some of the largest internet companies, depend on advertising as their main source of revenue. Online advertising revenue in the US in 2015 was $59.6 billion[1], almost half of it accounted for by Google.[2][3] Google, Facebook[4], and Twitter[5] together make up more than 65% of the total revenue.[6] Advertising is the main source of revenue for all these companies. Another example of an industry that depends heavily on advertising is the US news industry, with 69% of its revenue coming from advertising.[7] More generally, advertising is the key reason many content-providing websites are able to offer their services to users for "free" (other than the implicit payment of user attention to the ads). In short, today's internet would not be what it is without advertising.

Of course advertising is not a new phenomenon. Even before the era of the internet, companies advertised products on billboards, newspapers, radio stations, TV channels, and other mass media. However, there is a key difference between advertising on the internet today and the other media. The interactive nature of the internet gives users the easy ability to block ads with ad blockers. An ad blocker is a type of software, usually added conveniently as an extension to an internet browser, that will prevent any ads from appearing on the browsed web pages. When a user with an ad blocker visits a website with ads, the

[1] http://www.iab.com/wp-content/uploads/2016/04/IAB-Internet-Advertising-Revenue-Report-FY-2015.pdf (accessed May 2017)

[2] https://www.statista.com/statistics/266249/advertising-revenue-of-google/ (accessed May 2017)

[3] http://www.businessinsider.com/stats-on-googles-revenues-from-youtube-and-google-play-2015-7 (accessed May 2017)

[4] http://www.businessinsider.com/facebook-us-ad-revenue-2016-1 (accessed May 2017)

[5] https://www.emarketer.com/Article/Twitter-Ad-Revenues-Expected-Continue-Robust-Growth/1013571 (accessed May 2017)

[6] https://www.bloomberg.com/news/articles/2016-04-22/google-and-facebook-lead-digital-ad-industry-to-revenue-record (accessed May 2017)

[7] http://www.journalism.org/2014/03/26/the-revenue-picture-for-american-journalism-and-how-it-is-changing/ (accessed May 2017)

blocker identifies the ad content and blocks it from loading. Consequently, the website does not receive any ad revenue for that user.[8]

Ad blocking is not something new either. After VCRs became popular in the 1980s, there was a trend among viewers for commercial skipping. To combat this, advertisers tried to make ads more entertaining. In 1999, ReplayTV launched the first DVR with a built-in feature to skip commercials.[9] Since then, providers of commercial skipping features have been plagued by lawsuits that claim damages to the copyright of the original content.[10] A difference between these precursors and ad blockers on the internet is that now it is easier than ever before to block ads, since several ad-blocking extensions are just a few clicks away in most browsers.[11]

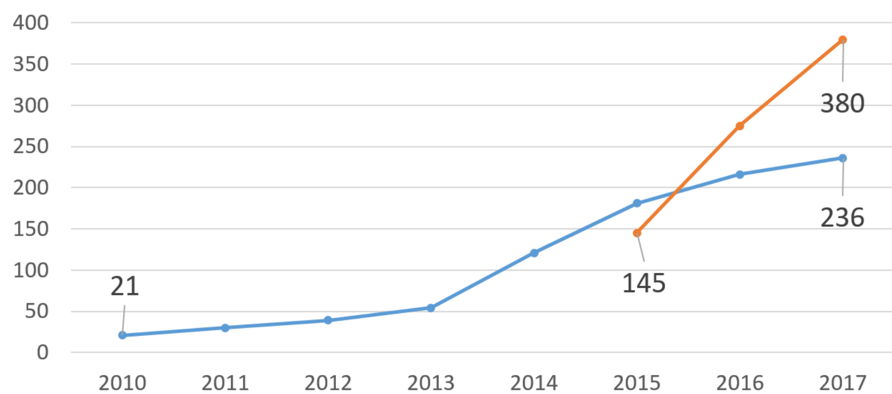


Figure 1: Millions of devices with adblock software over the years (**Desktop**, **Mobile**). (PageFair, 2017)

In Figure 1, we can see how adblock usage is changing over the years for desktop and mobile devices. We observe a steady increase in both categories with an average of 44.8% increase for desktop and 63.9% increase for mobile per year. Even though mobile ad blockers were not as popular as their desktop counterparts in 2015, in the beginning of 2017 we see the opposite, since more than 380 million mobile devices have an installed ad blocker versus 236

[8]See e.g., http://alternativeto.net/software/adblock-plus/ (accessed May 2017).
[9]https://en.wikipedia.org/wiki/Commercial_skipping (accessed May 2017)
[10]https://www.techdirt.com/articles/20160211/10423633579/dish-agrees-to-cripple-ad-skipping-dvr-to-settle-fox-lawsuit.shtml (accessed May 2017)
[11]https://adblockplus.org/getting_started (accessed May 2017)

million desktop devices. PageFair and Adobe (2015) estimated that the cost of ad blockers for publishers in terms of lost revenue in 2015 was $21.8 billion, which was around 14% of the global ad spend. Today with many more devices with ad blockers than in 2015 (Figure 1), we expect this number to be much larger.

## 1.2 How do Platforms Respond?

Websites hosting content and supported by ads act as platforms for gathering viewers and advertisers. Their revenue stream is directly affected by the deployment of ad blockers by the viewers. The response of these platforms to ad blockers have varied considerably.[12][13]

Some platforms disallow the use of ad-blocking software when viewing their sites, by using an **adblock wall**. This is the name for currently available technology that allows websites to detect if a visitor is using an ad blocker and if so, refuse to give access to him. Forbes is an example of a website that uses an adblock wall.[14] City A.M. was the first UK newspaper website to ban the use of ad blockers and prevent adblock users from reading content.[15]

Other platforms offer ad-free or ad-light subscription services for viewing content, by using a **paywall**. Financial Times[16], The Wall Street Journal[17], and The Washington Post[18] are a few examples of news sites with such a paywall. A slightly different but related strategy was adopted by Youtube: it was originally dependent solely on advertising, but in 2015 it launched YouTube Red, a subscription based service that offers ad-free access to all YouTube videos with some additional exclusive content.[19]

[12] https://www.pubnation.com/blog/publishers-fight-back-how-the-top-50-websites-combat-adblock (accessed May 2017)

[13] http://adage.com/article/media/publishers-weigh-ways-fight-ad-blocking/299116/ (accessed May 2017)

[14] https://digiday.com/media/forbes-ad-blocking/ (accessed May 2017)

[15] https://www.theguardian.com/media/2015/oct/20/city-am-ban-ad-blocker-users (accessed May 2017)

[16] https://www.ft.com/products (accessed May 2017)

[17] https://subscribe.wsj.com (accessed May 2017)

[18] https://subscribe.washingtonpost.com (accessed May 2017)

[19] https://www.theverge.com/2015/10/21/9566973/youtube-red-ad-free-offline-paid-subscription-service (accessed May 2017)

Many platforms use a combination of the aforementioned options. They use an adblock wall that offers two choices to the users, either to disable their ad blocker or pay a fee for an ad-free version of the site. Some examples of websites using this plan is Wired[20], Bild[21], and Business Insider[22]. The New York Times has also experimented with an adblock wall of this type for some time.[23] This option mirrors ad-free services that have been available in more traditional media, e.g. an alternate to watching a movie or show for free on network TV is to buy or rent an ad-free copy.

Finally, there are some platforms, like The Guardian, that request viewers to disable ad blockers as a gesture of support for the content in the site (without preventing access if they do not).[24] There are also sites that simply ignore the use of ad blockers and **allow** their use by a subset of the viewers. In fact, the majority of the content providing websites in the internet today follow this simple strategy of doing nothing about the existence of ad blockers other than simply allowing their use.

## 1.3 Research Questions

Internet ad blockers motivate some fundamental questions: What is the optimal response of platforms to their presence? Are adblock walls the solution to the ad-blocker problem? Why should platforms ever allow ad blockers, if they can prevent them using a simple adblock wall? When should they erect a paywall and charge a fee for ad-free or ad-light content? Under what conditions should they use these different options? In this paper, we address the central questions above, and explore further the effects ad blockers have on platforms and users. For instance, if we compare a world without ad blockers and the current world

[20] https://www.wired.com/how-wired-is-going-to-handle-ad-blocking/ (accessed May 2017)

[21] http://www.reuters.com/article/us-axelspringer-adblock-idUSKCN0S70S020151013 (accessed May 2017)

[22] http://adage.com/article/media/business-insider-testing-paywall-ad-blocking-response/305951/ (accessed May 2017)

[23] https://www.wsj.com/articles/new-york-times-experiments-with-ways-to-fight-ad-blocking-1457378218 (accessed May 2017)

[24] http://www.economist.com/news/business/21653644-internet-users-are-increasingly-blocking-ads-including-their-mobiles-block-shock (accessed May 2017)

with them, are the effects of ad blocking only negative for platforms? How do platforms' ad-revenues change with the availability of ad blockers? How is overall user welfare affected by ad blocking? To answer these questions, there are three important elements we model: competition, ad intensity, and heterogeneity in the ad sensitivity.

**Competition.** There are several reports that adblock walls do not work.[25] Several websites that implemented some type of adblock wall, like Wired, Bild, and Forbes, have seen their traffic deteriorate right after the introduction of the adblock wall.[26] The main explanation for this is that most adblock users who visit such websites and face a wall prefer to leave the website instead of disabling their ad blocker, even temporarily. In fact, in a survey by PageFair (2017), 74% of adblock users said that they leave websites when faced with an adblock wall, and only 26% disable their ad blockers to read the content.

Competition is the key reason for why adblock walls do not work. Most websites do not offer unique content that users cannot find elsewhere. As a result, instead of disabling their ad blocker and facing the inconvenience of ads, users prefer to look for the same or similar content elsewhere.

**Ad intensity.** Websites can control how many ads they will show, how intrusive or annoying the ads will be, their size, their position, and so on. All these affect the user experience and how much disutility a user will get from the ads. As an example, Forbes.com, when presenting an adblock wall to a user, shows a message promising users that if they disable their ad blocker, they will be presented with an "ad-light" experience in return. In the survey by PageFair (2017), 77% of adblock users said that they were willing to view some ad formats and are not totally against ads. Therefore, ad intensity is a key decision for platforms, since it directly affects how users react.

**Heterogeneity in ad sensitivity.** The increase in the adoption of ad blockers has other reasons in addition to their ease of installation. Digital ads offering rich-media content such

[25] http://www.businessinsider.com/ad-blocking-walls-not-working-2016-2 (accessed May 2017)

[26] https://thestack.com/world/2016/04/21/sites-that-block-adblockers-seem-to-be-suffering/ (accessed May 2017). However, it is unclear whether the loss in traffic after an adblock wall implementation directly translates to loss in revenue.

as audio, video, pop-ups and flashing banners have become increasingly intrusive to the content absorption experience. The rise of the mobile internet also puts a premium on the space available for content viewing that is jeopardized by ads that take up too much real-estate, mobile data consumption, and battery life. Finally, re-targeting practices associated with digital ads have increased the perception of privacy intrusion among viewers.

Nevertheless, the adoption of ad blockers among viewers is not likely to be universal since the sensitivity of viewers to ads is sufficiently heterogeneous across sites and devices from which the sites are accessed. Users that access the platforms from public or corporate machines may not have the ability to install new uncertified software such as ad blockers. Casual users who do not spend too much time on sites with annoying ads will not take the effort to employ ad blockers and update/maintain them. Less technical users may not even be aware of the existence and convenience of ad blockers. Many technically-savvy users may also continue to allow ads to support the sites they visit by acknowledging that they indirectly pay for the content they consume. Some users simply continue to view ads so as be kept informed of new products and promotions over time.

In a survey by PageFair and Adobe (2015), when non-adblock users were asked what would cause them to start using an ad blocker, 50% of the respondents stated that misuse of their personal information would be a reason to enable ad blocking. 41% of them responded that an increase in the number of ads from what they typically encounter today would also be a good reason. There was an 11% saying that they would never use an ad blocker, and this proportion increases to 23% for those aged between 35 and 49 years old. In contrast, when adblock users were asked for their main motivation behind adblock usage in PageFair (2017), only 6% of them stated privacy as the main reason. Security and interruption were the two leading reasons at 30% and 29% respectively, while page speed and the fact that there are too many ads came next with 16% and 14% respectively.

This provides evidence that there are fundamentally two classes of users based on whether they use ad blockers or not, and there is a lot of heterogeneity in the ad sensitivity of users in both classes. Furthermore, there is also difference in ad sensitivity between these two classes of adblock and non-adblock users.

## 1.4 Contributions

In this paper we devise a simple analytical model to answer the questions of Section 1.3. We model sites as two competing platforms for hosting content and attracting users. We assume two classes of users: one that uses ad blockers and the other that does not; note that the former are typically more ad-sensitive than the latter. Each platform has three options:

- Ban strategy: Continue displaying ads and ban ad blocking (e.g., using an adblock wall). If a viewer uses an ad blocker, he has to disable it to get access to the site.[27]
- Allow strategy: Continue to display ads and allow ad-blocking software by any user that installs it.
- Fee strategy: Stop displaying ads and offer only an ad-free site with a subscription fee.

Note that in the second option, the platform will make no revenue from adblock users, but only from those who do not use an ad blocker and can see ads.

Given that banning ad blockers is an option for both platforms, we would expect that this would always emerge as an equilibrium strategy since it would curb the loss of revenues compared to the allow strategy. However the competitive dynamics between even two symmetric platforms results in a surprising equilibrium. Our first result argues that **there are conditions where both platforms arrive at Allow as their symmetric optimal strategies** (Proposition 1 in Section 4). The intuition is that the action of installing ad blockers serves as a filter for more ad-sensitive users that employ ad blockers; with these

[27]Another strategy some platforms use to bypass ad blockers is placing advertising content, e.g. mentions of products, that is organically mixed in with their native content. For the purposes of our model, this strategy can be considered the same as the Ban strategy, since it is just a different way to make adblock users see ads.

users gone, each platform can move to a higher intensity of advertising to users and hence increase revenue.

While allowing ad blockers results in increased advertising by both platforms, we may expect the utility of users exposed to this increased advertising to decrease substantially as a result. However, our second result argues that *when platforms* Allow *ad blockers, this can increase the overall welfare of users* (Proposition 2 in Section 4). The result follows from the filtering effect, which can raise the utility of ad-sensitive users substantially by allowing them to filter ad content, overshadowing the potential loss of utility to less ad-sensitive users who might now be subject to more advertising. Perhaps even more surprisingly though, **there are cases where no user is worse off when ad blockers are allowed, while platforms and some users are better off** resulting in a Pareto-improvement in overall welfare as a result of introducing ad blockers.

In Section 5.1, we extend the main model by adding the following option for platforms:

- Ads or Fee strategy: Give the choice to users to either disable their ad blockers and be exposed to ads, or pay a fee for an ad-free version of the site (e.g., using a paywall).

The argument in favor of this new strategy is that it can achieve the filtering effect that the Allow strategy had by making ad-sensitive users pay the subscription fee, while users with lower ad sensitivity see ads. However, we show that **even with the addition of the Ads or Fee strategy, there is still an equilibrium where both platforms Allow ad blockers** (Proposition 3). To show this, we further split the class of non-adblock users into two further classes with different ad sensitivities. In this context, Ads or Fee is a better strategy for platforms when there is heterogeneity in the ad sensitivity between the two classes of non-adblock users, because it helps separate very ad-sensitive non-adblock users from the rest, while Allow is a better strategy when the two non-adblock user classes are more homogeneous in their ad sensitivity.

In Section 5.2, we extend the main model in a different direction by adding the following option for each platform:

- Whitelist strategy: Allow ad blockers and pay a fee to the ad-blocker company to put the platform in the default whitelist.

This strategy is motivated by the "Acceptable Ads initiative"[28]. This is a program introduced by Adblock Plus, the most popular adblock extension, according to which publishers and advertisers who comply with certain criteria could get whitelisted so that their ads may pass through the filter of the ad blocker. This strategy seems to be inferior to the previous strategies, since this option simply requires platforms to pay for something they had for free before the advent of ad blockers. However, we show that **there is an equilibrium where platforms use the Whitelist strategy and this equilibrium can sometimes increase their revenue even more than when ad blockers did not exist** (Proposition 4). For this, we now split the class of adblock users into two further classes with different ad sensitivities. In this context, Whitelist is a better strategy when there is heterogeneity in the ad sensitivity between the two classes of adblock users, since it can help platforms separate ad-sensitive adblock users from the rest, while Allow is a better strategy when the two adblock user classes are more homogeneous in their ad sensitivity.

Finally, in Section 6, we extend the main model to include content creators who generate the content of the platforms and share the revenue with them. We show the robustness of our earlier results in this extension; we also show that allowing ad blockers can result in an increased quality of content. This provides an additional benefit for users when ad blockers are allowed.

## 2 Literature Review

Our paper is related to the advertising and marketing avoidance literature (Clancey, 1994; Cho and Cheon, 2004; Speck and Elliott, 1997; Li and Huang, 2016; Seyedghorban et al., 2016). Below we discuss some of the more closely related papers.

[28] https://adblockplus.org/acceptable-ads

Anderson and Gans (2011) consider a model of a content provider who chooses a level of advertising while consumers decide if they will adopt ad-avoidance technology or not. They show that ad-avoidance penetration can increase advertising clutter, but it decreases the content provider's profit. One difference with our setting is that in their model, there is a price for consumers to adopt ad-avoidance technology.[29] As a result, their setting is more appropriate for more traditional ways of ad avoidance, like DVRs or other physical appliances, where there is a non-zero sunk cost for their adoption. In our setting, where the most popular ad blockers are free of charge and they are just a few clicks away to install in most browsers, this assumption is not as realistic. Another difference is that we consider a model with competition where platforms can actually decide if they will allow ad blocking or not. This is a more appropriate model for a website trying to decide if they will implement an adblock wall or not, instead of just assuming that adblock usage is unavoidable as in their model.

Johnson (2013) examines a model with firms that can target their ads to consumers and consumers who can avoid advertising. He shows that improved targeting can benefit firms but not necessarily consumers. He also shows, that in equilibrium, consumers may under-utilize their ability to block ads. A difference with our model is that there is a direct link between advertising firms and consumers, where firms can target the consumers with the higher probability of buying their product. In other words, there is no intermediate publisher who takes part in the decision process. He also assumes that there is some (positive) cost to consumers for avoiding ads and that the firm has a cost for sending an ad regardless of whether the ad is avoided or not. All these make his setting a better model for more traditional direct advertising campaigns, like direct mail with intentional avoidance by consumers.

[29] In that sense, ad avoidance from the perspective of consumers is more like the Ads or Fee plan of our model, but the content provider does not receive the fee. This can explain some of their results when viewed in our framework.

Hann et al. (2008) take a different approach by focusing more on the privacy of consumers. In their setting, sellers market their products to consumers through solicitations. Consumers have two ways to avoid solicitations: either by concealment (e.g. registering in a do-not-call list) or by deflection (e.g. with call screening). There are also two types of consumers, consumers with high demand and those with low demand for the products. They show that concealment by low-demand consumers can lead sellers to market more, while the opposite is true when there is concealment by high-demand consumers. They also show that concealment is worse for consumer welfare than deflection.

Wilbur (2008) studies a two-sided empirical model of the television industry with advertisers on one side and viewers on the other. One of his counterfactual findings is that ad avoidance tends to increase advertising quantities and decrease network revenues. Goh et al. (2015) investigate the externalities imposed by consumers who avoid ads on other consumers in the context of the US Do Not Call registry (DNC). They found that the number of subsequent DNC registrations was positively correlated with the number of first wave registrations. This suggests that perhaps telemarketers increased the number of calls to unregistered consumers after the first wave driving even more subsequent registrations.

Several papers also study settings where a media provider has to decide between an ad-based and a subscription-based strategy (Prasad et al., 2003; Peitz and Valletti, 2008; Tåg, 2009; Stühmeier and Wenzel, 2011; Vratonjic et al., 2013). Armstrong et al. (2009) study consumer protection policies and their impact on the consumers' incentives to become informed of market conditions. They show that when consumers are able to refuse marketing, price competition can decrease, which can harm consumers. Spam filters can also be considered a form of ad avoidance. Falkinger (2008) studies the equilibria in a model about spam filters with different levels of tolerance. In relation to ad annoyance, Goldstein et al. (2014) study the costs of annoying ads to publishers and users.

To the best of our knowledge, none of the previous work has considered ad avoidance from a perspective of a publisher who has the ability to prevent or limit it in a competitive setting.

This is because prior work focused on traditional media providers, like TV stations, or direct marketing actions, like mail, calls, or email. Our setting, on the other hand, is inspired by web ads, ad blockers, and the available anti-adblock technology used by many websites today.[30] We extend the strategy space of publishers to include the most popular responses to ad blockers by websites, like adblock walls, pay walls, combinations of the two, allowing ad blockers, or paying for whitelisting services. This leads to quantitatively different results, with the general surprising conclusion that ad blockers can actually benefit both publishers and users in several different ways.

Outside the ad-avoidance literature, our results are also related (in terms of model mechanics) to price discrimination and price sensitivity. As an example of a related result, Jain (2008) uses a model of digital piracy to show that when more price-sensitive consumers are the ones who copy software, then piracy can help firms. Shaffer and Zhang (1995) study the effects of price-discriminating customers by offering promotions based on their past purchase behavior and show that this can reduce the profits of the firms in a competitive environment.

# 3 Model

In this section, we describe the main model that we will use for the results in Section 4. In Sections 5.1 and 5.2, we extend this basic model by adding additional strategies to platforms' strategy space as well as additional segments of users.

## 3.1 Platform Model

There are two platforms, platform 1 and platform 2, competing over a set of users. Each platform can choose one of three different strategies, Ban, Allow, or Fee.

In the Ban strategy, the platform bans ad blockers by using an adblock wall. If a user with an ad blocker wants to access the site, she has to disable the ad blocker and see ads. The de-

[30] https://www.wsj.com/articles/the-rise-of-the-anti-ad-blockers-1465805039 (accessed May 2017)

cision variable for a platform $i \in \{1, 2\}$ with the BAN strategy is the ad intensity $a_i \geq 0$. The revenue of a platform $i$ with the BAN strategy is $r_i =$ (mass of users who pick platform $i$) $\cdot$ $a_i$.[31]

In the ALLOW strategy, the platform allows the use of ad blockers. In this case, a user with an ad blocker can access the site without seeing any ads and the platform does not get any ad revenue from them. The decision variable for a platform $i \in \{1, 2\}$ with the ALLOW strategy is again the ad intensity $a_i \geq 0$. The revenue of a platform $i$ with the ALLOW strategy is now $r_i =$ (mass of users who pick platform $i$ and see ads) $\cdot$ $a_i$.

In the FEE strategy, the platform offers content without any ads using a paywall. A user who wants to access the content has to pay a subscription fee for it. The decision variable for a platform $i \in \{1, 2\}$ with the FEE strategy is now the subscription fee $p_i \geq 0$. The revenue of a platform $i$ with the FEE strategy is $r_i =$ (mass of users who pick platform $i$) $\cdot$ $p_i$.

## 3.2 User Model

We model users using a Hotelling line. We assume that the two platforms are positioned on the two endpoints of the interval $[0, 1]$. Each user draws a value $x$ uniformly at random from $[0, 1]$ that indicates her position in the interval. Users who are closer to a platform prefer that platform more than the other.

Any user's utility consists of three parts. The first part is some intrinsic value they have for accessing the platforms' service, e.g. for reading news, and it is independent of the platform. We use the variable $m$ to indicate this value. The second part is some intrinsic value each user has for the platform. This is where the Hotelling model is used. For a user at position $x$, this intrinsic value is $1 - x$ if they pick platform 1, and $x$ if they pick platform 2. The third part is the disutility a user gets either from ads they have to see or from the

[31] This simple form of revenue proportional to the ad intensity best models display advertising where the platform is compensated proportional to the number of ads shown under a cost-per-mille (thousand impressions) or CPM payment scheme. However, similar arguments as those in the paper can be used for more involved revenue schemes like CPC/cost-per-click and CPA/cost-per-action. The logic then is that removing more ad-sensitive users from the market can increase click-through-rates for platforms.

price they have to pay when they choose a platform. We normalize the price sensitivity of users to 1 and we let their ad sensitivity vary. Throughout the paper we will see how the heterogeneity in the ad sensitivity between users can affect how platforms behave.

In the basic model, we assume that there are two segments of users. The first segment consists of users without an ad blocker.[32] This segment is of mass $\lambda$ and its users have ad sensitivity $\beta$. The second segment consists of users with an ad blocker who use it whenever possible. This second segment is of mass $\mu$ and its users have ad sensitivity $\gamma$. In other words, in this basic model, we assume some heterogeneity in the ad sensitivity between non-adblock and adblock users. Later, in extensions of the model, we will explore what happens when there is further heterogeneity in the ad sensitivity inside the segment of non-adblock users and inside the segment of adblock users.

Figure 2 summarizes the utility expressions for a user at position $x$ who picked platform 1, based on the strategy the platform chose and the type of the user. To get the user utility for platform 2, we need to change $(1-x)$ to $x$, $a_1$ to $a_2$, and $p_1$ to $p_2$. Note the difference in ad sensitivity between the two types of users, and also that the adblock users do not suffer any disutility when the platform chooses the ALLOW strategy.

| Platform 1 | BAN | ALLOW | FEE |
|---|---|---|---|
| ADS Non-adblock users (mass $\lambda$) | $m + (1-x) - \beta \cdot a_1$ | $m + (1-x) - \beta \cdot a_1$ | $m + (1-x) - p_1$ |
| ADS Adblock users (mass $\mu$) | $m + (1-x) - \gamma \cdot a_1$ | $m + (1-x)$ | $m + (1-x) - p_1$ |

Figure 2: Utility of the user at position $x$ who picks platform 1 based on the platform's strategy (columns) and the type of the user (rows).

Each user can pick at most one platform. We also assume that $m$, the intrinsic utility for the service, is large enough so that every user picks at least one of the platforms.[33]

[32]As mentioned earlier, some possible reasons that these users do not use an ad blocker are either ethical/moral, or because they do not know how to use one, or because they want to support the sites they visit.

[33]This assumption, which is standard in Hotelling models, reduces the number of cases we need to analyze. When it is not true, i.e. when there are users in the middle of the Hotelling interval who do not pick any platform, there is no interaction between platforms making each platform act as a monopoly in their own

## 3.3 Information Setting and Timeline

For simplicity we assume that all parameters are common knowledge. This is because any information uncertainty in the model would add extra complications without necessarily add any insights regarding the effects of ad blockers. Moreover, in reality, even if a platform does not know the size of each segment of users or their ad sensitivity, there are ways to estimate these quantities. For example, they can use A/B testing with varying ad intensity to observe how users respond.

The timeline of the game is as follows. First, platforms choose the strategy they want to follow. This is the first step as this is the major decision platforms have to make. For example, using ads or subscription fees as their main business model usually means a different infrastructure for their website. Second, platforms decide the values of their decision variables (either ad intensity or price, depending on the strategy), as this is an easier decision to adjust. Third, users pick which platform to join based on the plan each platform offers so as to maximize their utility.

## 3.4 Benchmark

In this section, we consider a world without ad blockers as a benchmark to compare the performance of the above model with ad blockers. This way, we can determine the effects of the presence of ad blockers on platforms and users.

When ad blockers do not exist, platforms can choose one of two different strategies: the Ads plan or the Fee plan. A platform with the Ads plan offers its content for free to the users and its revenue comes from showing ads to them. In that case, since there are no ad blockers, every user has to be exposed to ads. A platform with the Fee plan offers its content without ads for a subscription fee.[34]

part of the market. The fact that there is no competition then leads to less interesting results regarding ad blockers.

[34] The Ads plan is similar to the Ban plan of the main model and the Fee plan is the same as the one in the main model.

|  |  | Platform 2 |  |
|---|---|---|---|
|  |  | ADS | FEE |
| Platform 1 | ADS | $\frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}, \frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}$ | $\frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}, \frac{\lambda+\mu}{2}$ |
|  | FEE | $\frac{\lambda+\mu}{2}, \frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}$ | $\frac{\lambda+\mu}{2}, \frac{\lambda+\mu}{2}$ |

Table 1: Payoff matrix in the benchmark model.

If we analyze the game between the two platforms, we get the payoff matrix in Table 1.[35] In this game there are two symmetric equilibria, one where both platforms choose the ADS option and the other where both platforms choose the FEE option.[36] In Figure 3, we see the parameter regions of these two equilibria as a function of $\beta$ (the ad sensitivity of the first segment of non adblock users) and $\frac{\gamma}{\beta}$ (the ratio of the ad sensitivities of the adblock users to that of the non-adblock users). As expected, when the ad sensitivities $\beta$ and $\gamma$ of users are low, platforms choose to show ads, while in the opposite case they decide to offer a subscription fee. The curve that separates the two equilibria is the line $\lambda + \mu = \beta\lambda + \gamma\mu$. The (ADS, ADS) strategy profile is an equilibrium iff $\lambda + \mu \geq \beta\lambda + \gamma\mu$, while the (FEE, FEE) strategy profile is an equilibrium iff $\lambda + \mu \leq \beta\lambda + \gamma\mu$.

# 4 Ad Blockers can be Beneficial

In this section we analyze the basic model and show how ad blockers can be beneficial for platforms in Subsection 4.1 and for users in Subsection 4.2.

## 4.1 Platforms' Welfare

Our first proposition shows that there is an equilibrium where both platforms allow ad blockers. In this equilibrium, even though both platforms get no revenue from adblock users and can ban ad blockers if they want, they still allow adblock users to access the content

[35] For the proof, see the first part of the proof of Proposition 1 in Appendix A.1.

[36] Asymmetric equilibria can occur only in the degenerate case where $\lambda + \mu = \beta\lambda + \gamma\mu$. In that case, all possible pair of strategies give the same revenue to the platforms. Since this is a region of measure zero in the parameter space, we ignore it for the remainder of the discussion.

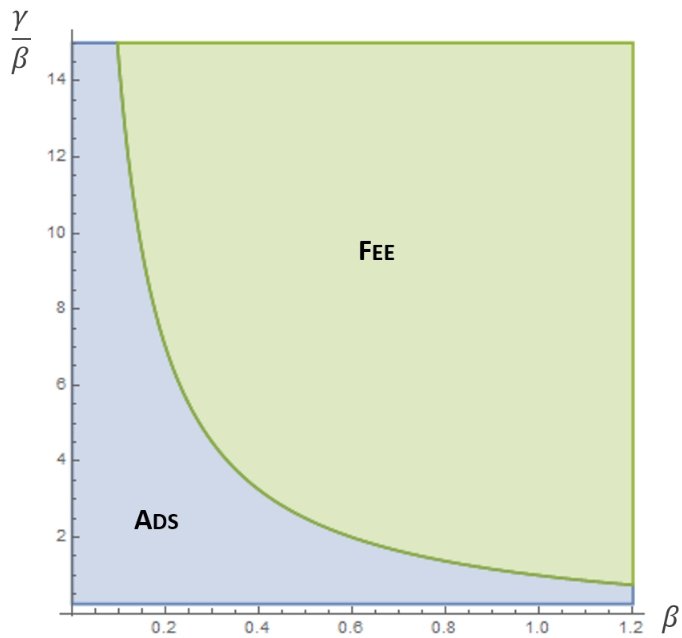


Figure 3: Equilibria regions of the benchmark model for $\lambda = 1$ and $\mu = 2$.

for free. Moreover, the revenue of the platforms when they allow ad blockers is sometimes higher than their revenue when they ban ad blockers or when they use a fee. As a result, the presence of ad blockers can make platforms better off compared to the benchmark model. (All proofs are in Appendix A.1.)

**Proposition 1.** *There is an equilibrium where both platforms* ALLOW *ad blockers. In this equilibrium, when $\beta$ is sufficiently low and $\frac{\gamma}{\beta}$ is sufficiently high, platforms are better off than they would be if ad blockers did not exist.*

The intuition for this result is as follows. Let's assume that the ad sensitivity $\gamma$ of the adblock users is larger than $\beta$, the ad sensitivity of non-adblock users (Figure 4). When platforms ban ad blockers, they show ads to both segments of users. However, the competition between the two platforms for the ad-sensitive segment will drive the optimal ad intensity of both platforms down. As a result, platforms can end up with low ad-revenue. On the other hand, when platforms allow ad blockers, they do not get any revenue from the segment of adblock users, but they have to compete only for the segment of non-adblock users that are less ad-sensitive. This allows them to increase the advertising intensity, which can result in

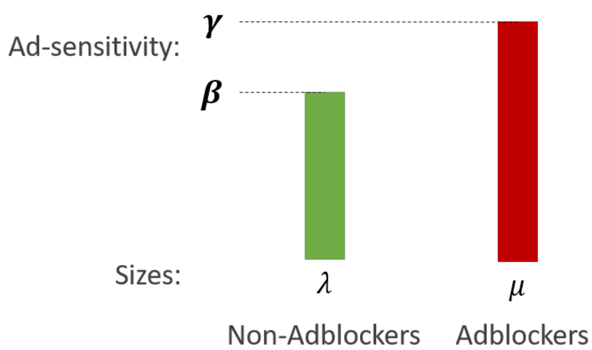


Figure 4: Illustration of the ad sensitivities of the two segments of users in the main model.

higher ad-revenue.

The higher the difference in the ad sensitivities of the two segments, the more incentive platforms have to filter ad-sensitive users from the market and focus only on the users with low ad sensitivity. As a result, higher $\frac{\gamma}{\beta}$ makes the Allow option more attractive to platforms than the Ban option. Moreover, the lower the ad sensitivity of those who see ads in the Allow strategy (i.e., low $\beta$), the more attractive the Allow plan becomes over the Fee plan. This gives the two conditions in Proposition 1.

If we analyze all possible pair of strategies for the two platforms, we get the payoff matrix in Table 2. As in the benchmark model, there are three symmetric equilibria in this game, one where both platforms ban ad blockers, one where they allow ad blockers, and one where they choose a fee. A difference is that now there are regions in the parameter space with more than one equilibria. In Figure 5, we can see the equilibria regions as a function of $\beta$ (the ad sensitivity of non-adblock users) and $\frac{\gamma}{\beta}$ (the ratio of the ad sensitivity of adblock users over the ad sensitivity of non-adblock users). In regions with more than one equilibria, we list all of them and the first one in the list is the best one for platforms.

| | Ban | Allow | Fee |
|---|---|---|---|
| Ban | $\frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}, \frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}$ | $\frac{(3\lambda+2\mu)^2(\beta\lambda+\gamma\mu)}{2(3\beta\lambda+4\gamma\mu)^2}, \frac{\lambda(3\beta\lambda+\beta\mu+2\gamma\mu)^2}{2\beta(3\beta\lambda+4\gamma\mu)^2}$ | $\frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}, \frac{\lambda+\mu}{2}$ |
| Allow | $\frac{\lambda(3\beta\lambda+\beta\mu+2\gamma\mu)^2}{2\beta(3\beta\lambda+4\gamma\mu)^2}, \frac{(3\lambda+2\mu)^2(\beta\lambda+\gamma\mu)}{2(3\beta\lambda+4\gamma\mu)^2}$ | $\frac{\lambda}{2\beta}, \frac{\lambda}{2\beta}$ | $\frac{9\lambda(\lambda+\mu)^2}{2\beta(3\lambda+4\mu)^2}, \frac{(\lambda+\mu)(3\lambda+2\mu)^2}{2(3\lambda+4\mu)^2}$ |
| Fee | $\frac{\lambda+\mu}{2}, \frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}$ | $\frac{(\lambda+\mu)(3\lambda+2\mu)^2}{2(3\lambda+4\mu)^2}, \frac{9\lambda(\lambda+\mu)^2}{2\beta(3\lambda+4\mu)^2}$ | $\frac{\lambda+\mu}{2}, \frac{\lambda+\mu}{2}$ |

Table 2: Payoff matrix in the main model.

If we examine the plot in Figure 5 from the bottom towards the top, we see that when $\frac{\gamma}{\beta}$ is low, i.e. when adblock users are less ad-sensitive than non-adblock users or when the ad sensitivity of the two segments is similar, both platforms prefer to ban ad blockers. However, as $\frac{\gamma}{\beta}$ increases, the ALLOW option becomes more and more attractive for platforms. Thus, first we get a region where both BAN and ALLOW are equilibria but BAN is the better one for platforms, then a region where both are equilibria but ALLOW is better, and finally a region where ALLOW is the unique equilibrium.

If we now review the plot from the right towards the left, we see that as $\beta$ (the ad sensitivity of non-adblock users, who see ads when platforms allow ad blockers) becomes lower, the ALLOW option becomes more and more attractive to platforms than the FEE option. This is because the lower the $\beta$, the more the platforms can increase the ad intensity, and as a result their ad revenue.

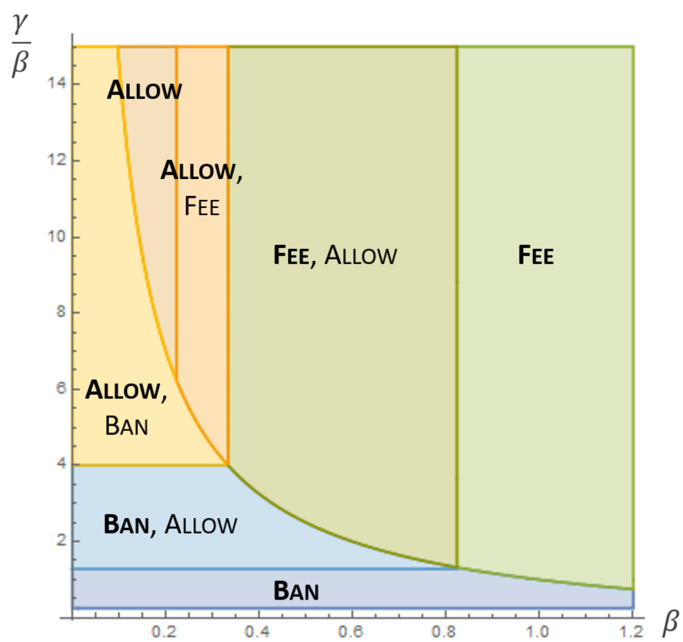


Figure 5: Equilibria regions of the main model for $\lambda = 1$ and $\mu = 2$. When there are two equilibrium strategies in the same region, the first one (in bold) is better for platforms.

### 4.2 User Welfare

The next proposition shows that total user welfare goes up when platforms allow ad blockers. In other words, not only platforms benefit from the presence of ad blockers, but users could benefit too. Moreover, there are cases where total user welfare goes up and no user is worse off compared to the benchmark.

**Proposition 2.** *When both platforms allow ad blockers, total user welfare is higher than in the other two equilibria. Moreover, there are regions in the parameter space where platforms are better off, total user utility goes up, and no user is worse off compared to a world without ad blockers.*

The total user utility in the Ban equilibrium is the same as the one in the Fee equilibrium, while in the Allow equilibrium it is higher. The reason is that when both platforms allow ad blockers the segment of adblock users get no disutility from ads since they block them. This improves the overall user utility even if non-adblock users are sometimes worse off because they have to see more ads.

The regions mentioned in the second part of Proposition 2 are the regions labeled "Allow" and "Allow, Fee" in Figure 5. In these same two regions in the benchmark model, there is only one equilibrium where both platforms use a subscription fee. The disutility non-adblock users get from the fee in the benchmark model is the same as the disutility they get from ads when platforms allow ad blockers. As a result, their utility in these regions is the same as it was in the benchmark, while every other user and the platforms are better off.

## 5 Additional Plans

In this section, we investigate the effect of adding additional options to the strategy space of the platforms, motivated by platform actions in the advertising market. We explore the two different additional options by expanding the basic model further by refining the set of adblock users or non-adblock users into two further subsegments with differing ad sensitivities.

## 5.1 The Ads or Fee Plan

The reason the Allow plan can benefit platforms in the basic model is that it provides a natural way for them to "discriminate" users with different ad sensitivities. Ideally platforms would like to be able to choose a different ad intensity for segments of users with different ad sensitivity. When they cannot do that, ad blockers provide an exogenous mechanism to achieve a similar effect. Ad-sensitive users self select themselves out of the market by using ad blockers, and this way they help not only themselves but also the competing platforms.

However, there is another natural way to "discriminate" users without the help of ad blockers that a lot of web sites currently use.[37] This is by letting users choose between two different options: either get free access to the site with ads (no ad blockers are allowed) or pay a fee for an ad-free version of the site (behind a paywall). We call this new plan the Ads or Fee plan.

The Ads or Fee plan is a combination of the Ban and the Fee plan from the basic model that tries to achieve the best of both worlds. The rationale is that users who are not very ad-sensitive will decide to see ads, while ad-sensitive users will choose the fee option. This solves the problem the Ban strategy had in the basic model of the ad-sensitive segment forcing platforms to decrease ad intensity. With the Ads or Fee strategy platforms can choose a high ad intensity for non-adblock users and also make sensitive adblock users pay a fee to access the content. Thus, this new strategy has the benefits of the Allow strategy plus some potential extra revenue from adblock users that platforms could not get earlier by allowing ad blockers.

The main question we want to answer in this section is whether the Ads or Fee strategy always dominates the benefits of allowing ad blockers. In other words, does the addition of

[37] Some notable examples are Wired, Bild, and Business Insider.

the Ads or Fee plan wipe out the beneficial effects of the Allow strategy and prevents it from ever becoming an equilibrium. To answer this question, we extend the model from Section 3 by adding the Ads or Fee strategy to platforms' strategy space. If a platform chooses this strategy they will have two decision variables, an ad intensity $a_i$ and a price $p_i$. Users who pick a platform with the Ads or Fee plan will choose between being exposed to ads or paying the price, based on which option gives them higher utility.

To get a more refined view of the user ad sensitivities, we also add a third segment of users to the model in this case. This segment has mass $\nu$ and is made of non-adblock users with ad sensitivity $\eta$ with $\beta \leq \eta \leq \gamma$ (Figure 6). The reason we add this third segment of users is that the comparison of the Ads or Fee plan with the Allow plan will depend on how heterogeneous the ad sensitivity of non-adblock users is, which we refine by splitting into two subsegments. Then, by allowing $\frac{\eta}{\beta}$ to change, we can compare the two plans.

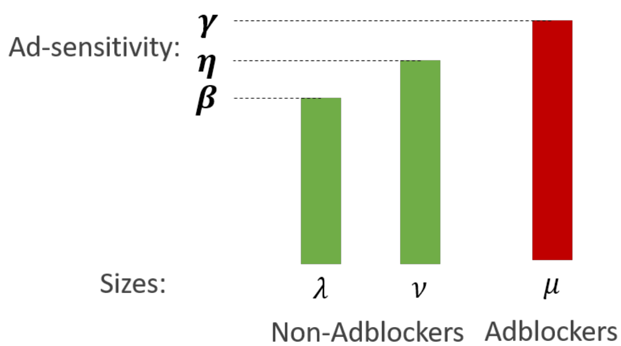


Figure 6: Illustration of the ad sensitivities of the three segments of users in the model with the additional Ads or Fee strategy.

The following proposition shows that even after we add the Ads or Fee strategy to the game, ad blockers can still be beneficial for platforms. There is still an equilibrium where platforms allow ad blockers, while sometimes this is the unique equilibrium and sometimes it is the best among others, including one where both platforms choose the Ads or Fee plan.

**Proposition 3.** *When we add the* Ads or Fee *plan to platforms' strategy space, there is still an equilibrium where both platforms* Allow *ad blockers. There are regions in the parameter* *space where this is the unique equilibrium and regions where it is the best equilibrium for platforms among others.*

The reason the Ads or Fee strategy does not always dominate the Allow strategy and there are still cases platforms get higher revenue by allowing ad blockers is the following. When a platform allows ad blockers, it will get revenue only from non-adblock users (first and second segment in Figure 6) by showing them ads. When the same platform chooses the Ads or Fee plan, it gets some revenue from all three segments but the two most ad-sensitive segments will choose to pay the fee instead of seeing ads. Even though the ad intensity in the Ads or Fee plan is higher than the one in the Allow plan (because the platform shows ads to less ad-sensitive users in the first case), when the ad-revenue the platform gets from the Allow plan is sufficiently higher than the revenue it gets from the fees in the Ads or Fee plan, Allow is the better option. In other words, there are cases where the platform prefers the second segment of non-adblock users to see ads instead of paying the fee, because they can generate more revenue from ads. In the Ads or Fee plan though, the platform cannot force these users to see ads instead of paying the fee, because users do what is best for them. This is why in these cases Allow is the best option for platforms.

We now describe the conditions under which Allow is the best strategy for platforms. For the Allow strategy to be better than Fee, we want the users who see ads in Allow to have relatively low ad sensitivity, i.e. we want low $\beta$ and $\eta$. To make Allow better than Ban, we want the ad sensitivity of those who see ads in Ban but not in Allow to be higher than those who see ads in both, i.e. we want high $\frac{\gamma}{\beta}$ and $\frac{\gamma}{\eta}$. Finally, for Allow to be better than Ads or Fee, we want those we see ads in Allow but do not see ads in Ads or Fee to have similar ad sensitivity as those who see ads in both, i.e. we want low $\frac{\eta}{\beta}$. This is because otherwise Ads or Fee would be the better option to separate non-adblock users of different ad sensitivities.

After we analyze all possible strategy combinations for the two platforms, we obtain the payoff matrix in Table 3. As before, there are four different symmetric equilibria, one for each strategy that is available to the platforms. In Figures 7, 8, and 9, we can see the equilibria regions for different parameters. To make the pictures a bit simpler, when there are more than one equilibria we list the best one for platforms. Thus, the regions where Allow is the unique equilibrium are subregions of the regions labeled Allow in the plots and near the borders there are multiple equilibria, one for each region that shares the border.

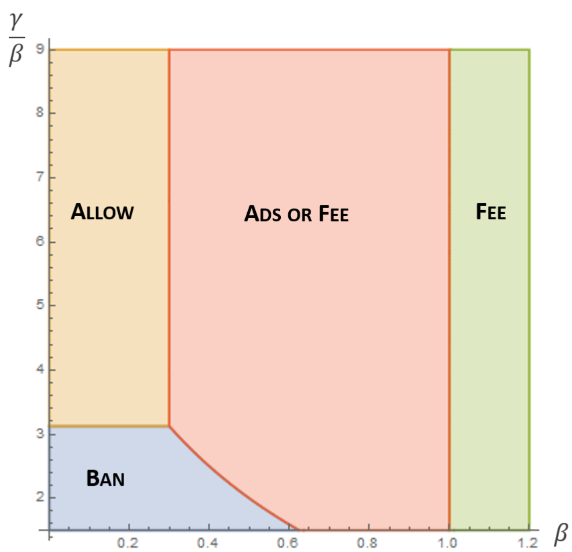


Figure 7: Equilibria regions of the model with the Ads or Fee strategy for $\lambda = \mu = \nu = 1$ and $\frac{\eta}{\beta} = \frac{3}{2}$. When there are more than one equilibria, only the best one for platforms is listed.

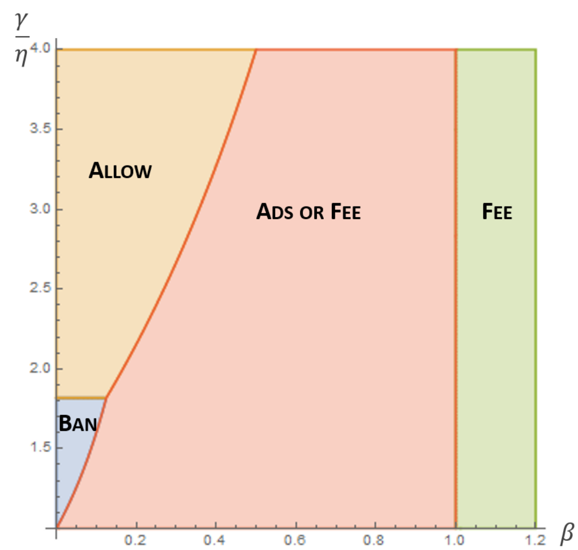


Figure 8: Equilibria regions of the model with the Ads or Fee strategy for $\lambda = \mu = \nu = 1$ and $\frac{\gamma}{\beta} = 4$. When there are more than one equilibria, only the best one for platforms is listed.

In Figure 7, we can see that Allow is the preferred option for platforms when $\beta$ is low and $\frac{\gamma}{\beta}$ is high. Moreover, Ads or Fee is better than Allow for relatively higher values of $\eta$ and because $\frac{\eta}{\beta}$ is fixed in that plot, that means higher values of $\beta$ make Ads or Fee better than Allow.

Similarly, we can see in Figure 8 that Allow is the preferred option when $\beta$ is low and $\frac{\gamma}{\eta}$ is high. Moreover, when we compare Allow with Ads or Fee, higher $\eta$ is better for Ads or Fee, which means lower $\frac{\gamma}{\eta}$ is better for it.

Finally, in Figure 9, we see that lower $\frac{\eta}{\beta}$ makes Allow better than Ads or Fee. This plot is also an example where the Ban region disappears. Even though Ban is an equilibrium

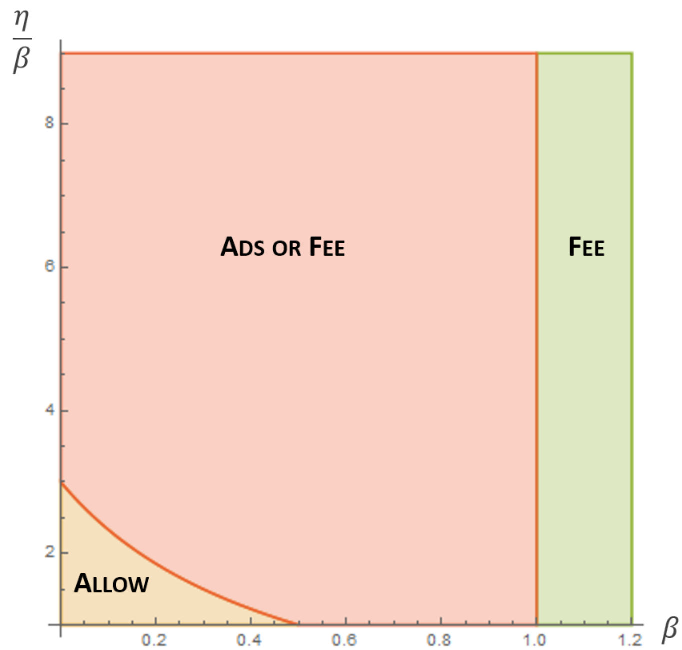


Figure 9: Equilibria regions of the model with the ADS OR FEE strategy for $\lambda = \mu = \nu = 1$ and $\frac{\gamma}{\eta} = 4$. When there are more than one equilibria, only the best one for platforms is listed.

when $\beta$ and $\frac{\eta}{\beta}$ are low, it is never the best for the particular choice of parameter values ($\gamma$ is too high compared to the other ad sensitivities).

## 5.2 Acceptable Ads and Whitelisting

In 2011, Eyeo, the company that developed Adblock Plus, the most popular adblock extension for browsers, started a program called the "Acceptable Ads initiative".[38] They set a list of criteria of what are considered acceptable ads based on placement, size, etc., and ads that complied with those criteria would be whitelisted by default in their ad blocker. Large companies, like Google, Microsoft, and Amazon were paying monthly fees to Eyeo to participate in this program and let their ads pass through the ad blocker.[39][40] These whitelisting services were also the main source of revenue for Adblock Plus.[41] In 2016, Eyeo extended this

[38] https://adblockplus.org/acceptable-ads (accessed May 2017)

[39] https://www.ft.com/content/80a8ce54-a61d-11e4-9bd3-00144feab7de (accessed May 2017)

[40] http://www.businessinsider.com/google-microsoft-amazon-taboola-pay-adblock-plus-to-stop-blocking-their-ads-2015-2 (accessed May 2017)

[41] https://adblockplus.org/about#monetization (accessed May 2017)

program by launching their own ad marketplace where they also started selling "acceptable" ads to publishers.[42][43]

The controversial nature of these moves by Adblock Plus created a lot of backlash. As an example, the CEO of Interactive Advertising Bureau (IAB) characterized Adblock Plus an "extortion-based business" and their actions "unethical and immoral".[44][45] The main argument is that first the company created an ad blocker that allowed millions of users to block ads on websites and now the same company charges money from advertisers and publishers to unblock their ads. This could be seen as a form of blackmail by those publishers and advertisers who now have to share part of their revenue with the ad-blocker company.

The key question we address in this context is whether this new option where platforms have to pay the ad-blocker company to whitelist their ads could ever be beneficial for them. In the presence of ad blockers, we may expect that sometimes platforms will have to follow this strategy, first if ad blockers hurt their ad revenue a lot, and second to get an advantage over competitors with blocked ads. However, more importantly, when they follow this strategy, how does their revenue compare to a world without ad blockers? In other words, can the option of paying the ad blocker to let their ads go through ever benefit them over the benchmark model without ad blockers where their ads were shown "for free"?

To answer this question we use another extension of the basic model. First, we add a new strategy to platforms' strategy space, called Whitelist. When a platform chooses this Whitelist option, they allow ad blockers and at the same time they pay a fee $f \geq 0$ [46] to the ad-blocker company to whitelist their ads by default. As in the real world, some users who do not like this whitelist feature and do not want to watch even "acceptable" ads, have

[42] https://www.theverge.com/2016/9/13/12890050/adblock-plus-now-sells-ads (accessed May 2017)

[43] https://acceptableads.com/en/solutions/ (accessed May 2017)

[44] https://techcrunch.com/2016/05/09/interactive-adverting-bureau-ceo-adblock-plus-is-an-extortion-based-business/ (accessed May 2017)

[45] http://www.businessinsider.com/interactive-advertising-bureau-comments-on-ad-block-plus-2016-1 (accessed May 2017)

[46] In the case of Adblock Plus and their program, this fee is zero for small entities without a lot of ad impressions and strictly positive for larger entities.

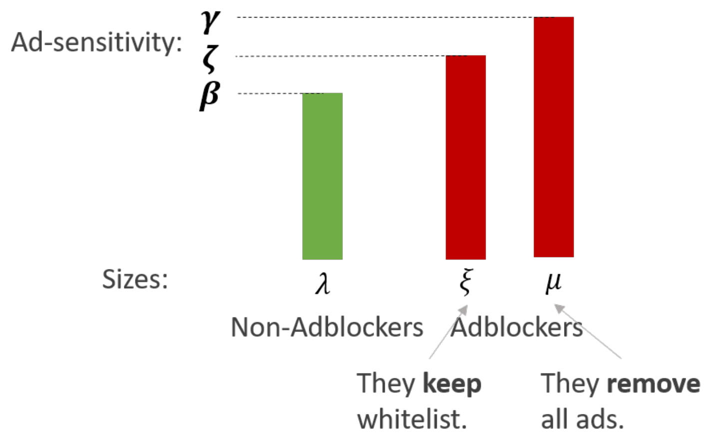


Figure 10: Illustration of the ad sensitivities of the three segments of users in the model with the Whitelist strategy.

the option to disable the feature and remove all ads. We again consider three segments of users, but this time refining the segment of adblock users; our model supposes one segment of non-adblock users of mass $\lambda$ with ad sensitivity $\beta$ and two segments of adblock users. The first segment of adblock users are those who are fine with the whitelisting program and keep the default whitelist of "acceptable" ads. That segment is of mass $\xi$ with ad sensitivity $\zeta$. The second segment of adblock users are those who are against all ads, remove the default whitelist, and as a result block all ads. That segment is of mass $\mu$ with ad sensitivity $\gamma$. We do not assume any relationship between $\beta$, $\zeta$, and $\gamma$, but as we show next, the most interesting results occur when $\beta \leq \gamma$ and $\zeta \leq \gamma$.

The next proposition answers the question above by showing that there is an equilibrium where both platforms choose the Whitelist plan and that this equilibrium is sometimes better for platforms compared to the benchmark model with no ad blockers.

**Proposition 4.** *When we add the* Whitelist *plan to platforms' strategy space, there is an equilibrium where both platforms choose the* Whitelist *option. In this equilibrium, platforms are sometimes better off than they would be if ad blockers did not exist.*

To understand the intuition behind the proposition, consider the case where adblock users are more ad-sensitive than non-adblock users and that those adblock users who remove all ads are even more ad-sensitive than those who keep the ad blocker's whitelist, i.e. $\beta \leq \zeta \leq \gamma$ (Figure 10). The main idea is that the Whitelist option can help platforms separate the two types of adblock users.

A platform with the Ban plan chooses some advertising intensity $a > 0$ and shows ads to all three segments of users (Figure 10). With the Allow plan, they choose some advertising intensity $a' > a$ and show ads only to the first segment of users. As we have seen in the basic model, sometimes Allow is better because of the high $a'$ and sometimes Ban is better because the platforms get ad-revenue from more users. With the Whitelist plan, the platform chooses some advertising intensity $a''$ with $a < a'' < a'$ and they show ads to the first two segments of users, the non-adblockers and the adblocker users who keep the whitelist. What happens is that this middle ground between Ban and Allow sometimes provides more revenue than the other two, i.e. showing ads to exactly two segments with medium ad intensity is better than showing ads to all three segments with low ad intensity or to just one segment with high ad intensity.

The conditions for which Whitelist is the best option for platforms are the following. First, we want a sufficiently small fee $f$, otherwise Whitelist will become a bad option because it is expensive. Second, we want the ad sensitivity of those who see ads in the Whitelist plan to be low to make Whitelist better than Fee, i.e. we want low $\beta$ and $\zeta$. Third, we want those who see ads in Ban but not in Whitelist to have comparatively higher ad sensitivity, i.e. we want high $\frac{\gamma}{\beta}$ and $\frac{\gamma}{\zeta}$. Finally, to make Whitelist better than Allow, we want the ad intensity of those who see ads in Whitelist and not in Allow to have similar ad intensity to those who see ads in both, otherwise Allow that separates them would be better. In other words, we also want low $\frac{\zeta}{\beta}$.

After we analyze all possible pair of strategies for platforms, we get the payoff matrix in Table 4. In this game, there are four symmetric equilibria, one for each strategy. In Figures 11, 12, and 13, we see the equilibria regions for different parameter values. As before, to make plots a bit simpler, when there are more than one equilibria we list only the best one for platforms. The regions where each equilibrium is unique are subregions of those labeled in the plots.

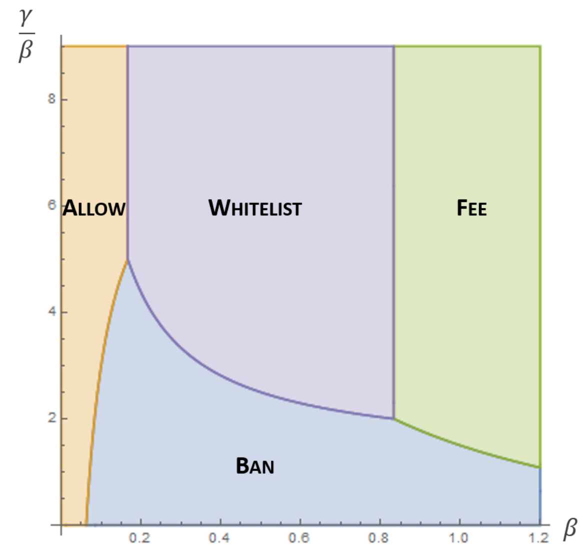


Figure 11: Equilibria regions of the model with the WHITELIST strategy for $f = 0$, $\lambda = \mu = \xi = 1$, and $\zeta = \frac{1}{2}$. When there are more than one equilibria, only the best one for platforms is listed.

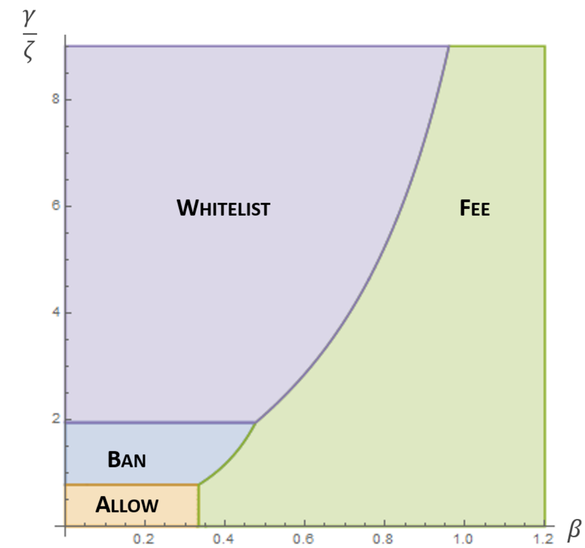


Figure 12: Equilibria regions of the model with the WHITELIST strategy for $f = 0$, $\lambda = \mu = \xi = 1$, and $\frac{\gamma}{\beta} = \frac{7}{2}$. When there are more than one equilibria, only the best one for platforms is listed.

In Figure 11, we see that the WHITELIST plan is preferred by platforms when $\frac{\gamma}{\beta}$ is high and $\beta$ is low. When we compare the WHITELIST plan with the ALLOW plan, WHITELIST is better for low $\frac{\zeta}{\beta}$. In this particular plot $\zeta$ is fixed, so low $\frac{\zeta}{\beta}$ means high $\beta$. Therefore, there is a lower and an upper bound for $\beta$ to make WHITELIST the best option.

In Figure 12, we see that the WHITELIST plan is preferred when $\frac{\gamma}{\zeta}$ is high and $\beta$ is low. To understand why the BAN and the ALLOW regions are in the order they are, let's assume that $\beta$ is fixed. Since in that plot $\frac{\gamma}{\beta}$ is also fixed, that means $\gamma$ is fixed. BAN is better than ALLOW when $\frac{\zeta}{\beta}$ is low, which means when $\zeta$ is low, which means when $\frac{\gamma}{\zeta}$ is high.

In Figure 13, we see that the WHITELIST plan is preferred for medium values of $\frac{\zeta}{\beta}$ and low $\beta$. We know that WHITELIST is better than ALLOW for lower values of $\frac{\zeta}{\beta}$. For the comparison between WHITELIST and BAN, let's again assume that $\beta$ is fixed. Higher $\frac{\zeta}{\beta}$ means higher $\zeta$ and since $\frac{\gamma}{\zeta}$ for that plot is fixed, that means higher $\gamma$. But $\gamma$ is the ad

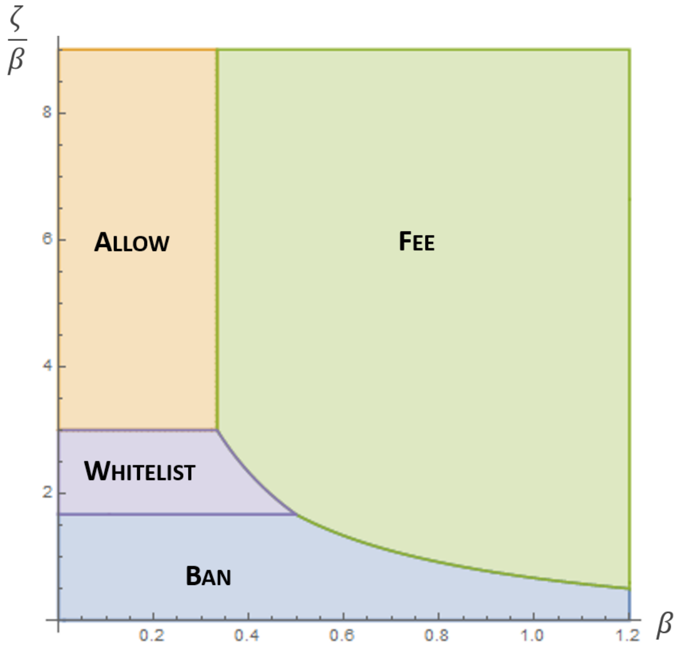


Figure 13: Equilibria regions of the model with the WHITELIST strategy for $f = 0$, $\lambda = \mu = \xi = 1$, and $\frac{\gamma}{\zeta} = 2$. When there are more than one equilibria, only the best one for platforms is listed.

sensitivity of those who see ads in the BAN plan and do not see ads in the WHITELIST plan. Therefore, higher $\gamma$ makes WHITELIST the better option.

In April of 2017, there were surprising reports that Google is planning to create their own built-in ad blocker for the Chrome browser.[47] This ad blocker will remove only "unacceptable" ads from web pages. In other words, Google wants to implement a similar program like the "Acceptable Ads initiative" by Adblock Plus. This is further evidence that Google realizes the benefits of an ad blocker with a whitelisting feature, even though Google itself depends heavily on advertising. Thus, instead of letting third parties implement such a feature and take part of their ad revenue, Google might prefer to do it on its own and thus exercise more control of the ad-blocker market.

[47] https://www.wsj.com/articles/google-plans-ad-blocking-feature-in-popular-chrome-browser-1492643233 and https://www.theverge.com/2017/4/19/15365572/google-ad-blocking-feature-chrome-browser (accessed May 2017)

# 6 Quality of Content and Content Creators

An important feature of many internet platforms that affects users decision of which platform to join is the quality of content. Some platforms generate their own content, while others depend on third parties to generate content for them.

Youtube is an example of a platform that does not generate its own content. Instead it depends on content creators to create and upload videos on the website that other users watch. For a very long time Youtube was dependent solely on advertising as its main source of revenue. However, recently it started offering subscription plans to its users (named Youtube Red) for an ad-free version of Youtube with some additional exclusive content. Any revenue Youtube gets from advertising and from subscriptions is shared with the content creators. Youtube gets 45% of the revenue, while content creators get the remaining 55%.[48] We examine the question of how the quality of content is affected by the advent of ad blockers under a revenue share model, like the one Youtube implemented. To do that, we extend the basic model by adding content creators.

We assume that each platform has its own content creators. Content creators in platform $i \in \{1, 2\}$ have as decision variable the quality of content $q_i$ and they incur some cost $c_i \cdot q_i^2$ to generate content of this q1uality[49]. User utility is the same as in the basic model with an additional quality-based utility term of $r \cdot q_i$ for platform $i$, i.e. higher quality of content in a platform means higher utility for users in that platform. Each platform has also a fixed fraction $f_i$ that determines how they split the revenue with the content creators. The profit for content creators in platform $i$ is $\pi_i = f_i \cdot (\text{total revenue}) - c_i \cdot q_i^2$, while the profit for platform $i$ is $r_i = (1 - f_i) \cdot (\text{total revenue})$. Finally, the timeline of the game is the same as before with the addition that in the second step content creators also decide the value of $q_i$ to maximize their profit, before users choose between the platforms.

We can show that all the results of the basic model are robust under this extension with

[48] https://support.google.com/youtube/answer/6204741 (accessed May 2017)

[49] The convex cost function is a natural choice for increasing quality which has diminishing returns to effort by the creator

content creators. More specifically, there is an equilibrium where platforms allow ad blockers and all platforms, content creators, and users are better off compared to a world without ad blockers. The fact that content creators can be better off when ad blockers are allowed causes an increase in the quality of content. This is the main result in the next proposition.

**Proposition 5.** *When ad blockers are allowed by platforms, the quality of content is higher for sufficiently high $\frac{\gamma}{\beta}$ and sufficiently low $\beta$. This is an additional benefit for users when ad blockers are allowed, whose welfare can increase even more than the increase with ad blockers in the basic model without content creators.*

Indeed, for the case of symmetric platforms, total user welfare is the same in this extension and in the basic model when platforms BAN ad blockers or when they use a FEE. However, when platforms ALLOW ad blockers, user welfare is higher in this extension than in the basic model. This is because when platforms BAN ad blockers or use a FEE, all the extra value that is generated by the quality of content goes to the platforms and the content creators in the form of increased ad intensity or price. However, when platforms ALLOW ad blockers, the higher quality of content allows this extra value to be shared with users who benefit even more with ad blockers.

# 7 Conclusion

## 7.1 Managerial Implications

Our analysis leads to several managerial implications. It can provide websites with some general guidelines regarding the plan they should choose based on how heterogeneous their visitors are in their ad sensitivity. In Figure 14, we exhibit a decision diagram summarizing our findings.

The decision flowchart contains four questions in increasing order of refinement. If the users are generally very ad-sensitive, then the platform cannot expect to receive a lot of ad

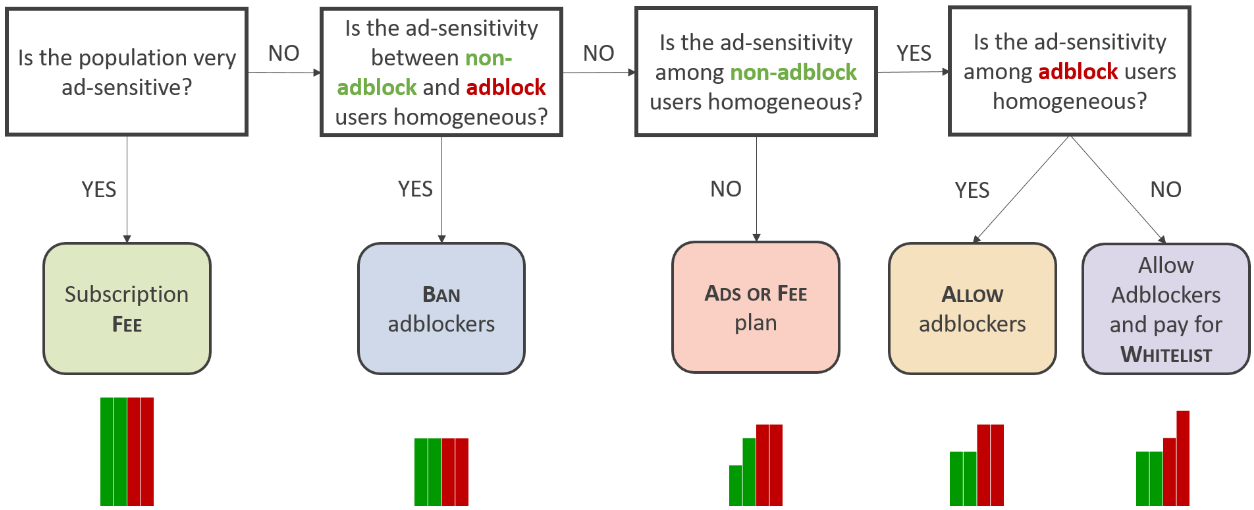


Figure 14: Flowchart for platforms to decide which strategy to follow based on the heterogeneity in the ad sensitivity of their user base.

revenue from them, so it is better to choose a subscription based plan with a fee (Fee). Otherwise, the platform can benefit from serving ads to the users. If the ad sensitivities of non-adblock and adblock users are similar (or if non-adblock users are more ad-sensitive), then ad blockers cannot help the platform and it is better to ban them with an adblock wall (Ban). If, on the other hand, adblock users are more ad-sensitive than non-adblock users, then the platform would be better off with a plan that filters out the very ad-sensitive adblock users. The third question is about the ad sensitivity of non-adblock users. If it is very heterogeneous, then a plan that offers options to the users like the Ads or Fee plan can help the platform filter out the very ad-sensitive non-adblock users. If non-adblock users have homogeneous ad sensitivity and adblock users are more ad-sensitive than non-adblock users, then allowing ad blockers can be beneficial. The heterogeneity of adblock users plays a role here. If adblock users are homogeneous then just allowing ad blockers can be enough (Allow), but if they are very heterogeneous then a whitelist option on top of allowing ad blockers can be the better plan (Whitelist), since it filters out only the very ad-sensitive part of adblock users and keeps the rest, even if that means the platform has to pay a fee to the ad blocker for whitelisting its ads.

The way these findings can be used is the following. First, a platform can run a few tests with varying types of adblock walls or messages to the users (as many web platforms already do) in order to estimate the ad sensitivities of the various user segments. Then it can use the insights from our analysis to decide the ideal plans to offer.

## 7.2 Summary

Ad blockers initiated an existential crisis in the world of online platforms subsisting on advertising. While most speculations point to a grim outlook for advertisers and platforms as a result of ad blockers, our results offer an alternative view that might offer a glimmer of hope for the whole ecosystem, by arguing that ad blockers could actually be beneficial overall.

We suggest several ways in which ad blocking can be beneficial. First, they can make the market more efficient by filtering out ad-sensitive users for more intense or targeted ad serving on the rest. Second, ad-sensitive users can benefit because they can remove ads that annoy them from web sites. Third, ad blockers can also help regulate the ad industry through a whitelisting program of acceptable ads. Finally, a more efficient market can also result in an increase in content quality of web sites, which is an additional benefit for users.

A few years ago, when ad blockers started rising, publishers and advertisers were terrified of their implications for the future of the online ad industry. However, today we see that many of them choose a more friendly approach towards ad blockers. News like the recent plan of Google to create its own ad blocker in its Chrome browser,[50] shows that the industry has started realizing the potential benefits of ad blocking and decided to make it an ally instead of an enemy. As in many existential crises, the result could be rewarding.

[50] https://www.engadget.com/2017/06/01/google-chrome-ad-blocking-baked-in-2018/ (accessed June 2017)

# References

S. P. Anderson and J. S. Gans. Platform siphoning: Ad-avoidance and media content. *American Economic Journal: Microeconomics*, 3(4):1–34, 2011. 10

M. Armstrong, J. Vickers, and J. Zhou. Consumer protection and the incentive to become informed. *Journal of the European Economic Association*, 7(2-3):399–410, 2009. 12

C.-H. Cho and H. J. Cheon. Why do people avoid advertising on the internet? *Journal of advertising*, 33(4):89–97, 2004. 10

M. Clancey. The television audience examined. *Journal of advertising Research*, 34(4):S1–S1, 1994. 10

J. Falkinger. A welfare analysis of" junk" information and spam filters. Technical report, Working Paper, Socioeconomic Institute, University of Zurich, 2008. 12

K.-Y. Goh, K.-L. Hui, and I. P. Png. Privacy and marketing externalities: Evidence from do not call. *Management Science*, 61(12):2982–3000, 2015. 12

D. G. Goldstein, S. Suri, R. P. McAfee, M. Ekstrand-Abueg, and F. Diaz. The economic and cognitive costs of annoying display advertisements. *Journal of Marketing Research*, 51(6):742–752, 2014. 12

I.-H. Hann, K.-L. Hui, S.-Y. T. Lee, and I. P. Png. Consumer privacy and marketing avoidance: A static model. *Management Science*, 54(6):1094–1103, 2008. 11

S. Jain. Digital piracy: A competitive analysis. *Marketing Science*, 27(4):610–626, 2008. 13

J. P. Johnson. Targeted advertising and advertising avoidance. *The RAND Journal of Economics*, 44(1):128–144, 2013. 11

W. Li and Z. Huang. The research of influence factors of online behavioral advertising avoidance. *American Journal of Industrial and Business Management*, 6(09):947, 2016. 10

PageFair. The state of the blocked web. *Global Adblock Report*, February 2017. 3, 6, 7

PageFair and Adobe. The cost of ad blocking. *Ad Blocking Report*, 2015. 4, 7

M. Peitz and T. M. Valletti. Content and advertising in the media: Pay-tv versus free-to-air. *international Journal of industrial organization*, 26(4):949–965, 2008. 12

A. Prasad, V. Mahajan, and B. Bronnenberg. Advertising versus pay-per-view in electronic media. *International Journal of Research in Marketing*, 20(1):13–30, 2003. 12

Z. Seyedghorban, H. Tahernejad, and M. J. Matanda. Reinquiry into advertising avoidance on the internet: A conceptual replication and extension. *Journal of Advertising*, 45(1): 120–129, 2016. 10

G. Shaffer and Z. J. Zhang. Competitive coupon targeting. *Marketing Science*, 14(4):395–416, 1995. 13

P. S. Speck and M. T. Elliott. Predictors of advertising avoidance in print and broadcast media. *Journal of Advertising*, 26(3):61–76, 1997. 10

T. Stühmeier and T. Wenzel. Getting beer during commercials: Adverse effects of ad-avoidance. *Information Economics and Policy*, 23(1):98–106, 2011. 12

J. Tåg. Paying to remove advertisements. *Information Economics and Policy*, 21(4):245–252, 2009. 12

N. Vratonjic, M. H. Manshaei, J. Grossklags, and J.-P. Hubaux. Ad-blocking games: Monetizing online content under the threat of ad avoidance. In *The Economics of Information Security and Privacy*, pages 49–73. Springer, 2013. 12

K. C. Wilbur. A two-sided, empirical model of television advertising and viewing markets. *Marketing science*, 27(3):356–378, 2008. 12

# A Appendix

## A.1 Analyses and Proofs

### Proof of Proposition 1

*Proof.* We consider first the scenario where ad blockers do not exist (benchmark model). This is when platforms have only two available strategies: the ADS strategy where everyone who access the websites has to see ads, and the FEE strategy where users have to pay a fee to access the site.

In this scenario, we start by considering four possible cases, one for each combination of plans chosen by the two platforms. For each one of these cases, we will find how the users react and then which of those cases end up in an equilibrium.

**1. Both platforms use ADS.** The indifferent user among those without ad blockers is the one at position $x_N$ that is the solution to the equation $m + 1 - x_N - \beta a_1 = m + x_N - \beta a_2$, i.e. $x_N = \frac{1+\beta(a_2-a_1)}{2}$.

The indifferent user among those with ad blockers (when they are available) is the one at position $x_A$ that is the solution to the equation $m + 1 - x_A - \gamma a_1 = m + x_A - \gamma a_2$, i.e. $x_A = \frac{1+\gamma(a_2-a_1)}{2}$.

Therefore, the expected market share of platform 1 is $z_1 = \lambda x_N + \mu x_A$, while the expected market share of platform 2 is $z_2 = \lambda(1 - x_N) + \mu(1 - x_A)$. The profit for platform 1 is then $z_1 a_1$ and the profit for platform 2 is $z_2 a_2$. Thus, to find the advertising intensities $a_1$, $a_2$ in the equilibrium, we need to solve the system $\frac{\partial(z_1 a_1)}{\partial a_1} = \frac{\partial(z_2 a_2)}{\partial a_2} = 0$. The solution is $a_1 = a_2 = \frac{\lambda+\mu}{\beta\lambda+\gamma\mu}$. From this, we get that the profit for both platforms is equal to $\frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}$.

**2. Both platforms have a subscription FEE.** In this case, both types of users have similar payoff function, thus the indifferent user for both types is the one at position $x$ that is the solution to the equation $m + 1 - x - p_1 = m + x - p_2$, i.e. $x = \frac{1+p_2-p_1}{2}$.

Therefore, the expected market share of platform 1 is $z_1 = (\lambda + \mu)x$, while the expected market share of platform 2 is $z_2 = (\lambda + \mu)(1 - x)$.

The profit for platform 1 is then $z_1 p_1$ and the profit for platform 2 is $z_2 p_2$. Thus, to find the prices $p_1$, $p_2$ in the equilibrium, we need to solve the system $\frac{\partial(z_1 p_1)}{\partial p_1} = \frac{\partial(z_2 p_2)}{\partial p_2} = 0$. The solution is $p_1 = p_2 = 1$. From this, we get that the profit for both platforms is equal to $\frac{\lambda+\mu}{2}$.

**3. First platform uses ADS, while the second uses a FEE.** The indifferent user among non-adblock users is the one at position $x_N$ that is the solution to the equation $m + 1 - x_N - \beta a_1 = m + x_N - p_2$, i.e. $x_N = \frac{1+p_2-\beta a_1}{2}$.

The indifferent user among adblock users is the one at position $x_A$ that is the solution to the equation $m + 1 - x_A - \gamma a_1 = m + x_A - p_2$, i.e. $x_A = \frac{1+p_2-\gamma a_1}{2}$.

The expected market share of platform 1 is $z_1 = \lambda x_N + \mu x_A$, while the expected market share of platform 2 is $z_2 = \lambda(1 - x_N) + \mu(1 - x_A)$. The profit for platform 1 is then $z_1 a_1$ and the profit for platform 2 is $z_2 p_2$. Thus, to find the advertising intensity $a_1$ and the price $p_2$ in the equilibrium, we need to solve the system $\frac{\partial(z_1 a_1)}{\partial a_1} = \frac{\partial(z_2 p_2)}{\partial p_2} = 0$. The solution is $a_1 = \frac{\lambda+\mu}{\beta\lambda+\gamma\mu}$ and $p_2 = 1$.[51] From this, we get that the profit for platform 1 is $\frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}$, while the profit for platform 2 is $\frac{\lambda+\mu}{2}$.

**4. First platform uses a FEE, while the second uses ADS.** This case is similar to the previous case. The profit for platform 1 is $\frac{\lambda+\mu}{2}$, while the profit for platform 2 is $\frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}$.

The following payoff matrix summarizes the four cases above.

| | | Platform 2: ADS | Platform 2: FEE |
|---|---|---|---|
| Platform 1 | ADS | $\frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}, \frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}$ | $\frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}, \frac{\lambda+\mu}{2}$ |
| | FEE | $\frac{\lambda+\mu}{2}, \frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}$ | $\frac{\lambda+\mu}{2}, \frac{\lambda+\mu}{2}$ |

We observe that

[51] Note that the indifferent user for those who do not use ad blockers is the one at position $x_N = \frac{\beta\lambda-\beta\mu+2\gamma\mu}{2(\beta\lambda+\gamma\mu)}$, which is always at most 1, but we also need this to be non-negative. Therefore, we need that $\beta\lambda + 2\gamma\mu \geq \beta\mu$. Similarly, for the indifferent user for those with ad blockers, we need the inequality $2\beta\lambda + \gamma\mu \geq \gamma\lambda$. Due to symmetry, we get the same conditions from the fourth case of the proof as well.

- (Ban, Ban) is an equilibrium iff $\lambda + \mu \geq \beta\lambda + \gamma\mu$.

- (Fee, Fee) is an equilibrium iff $\lambda + \mu \leq \beta\lambda + \gamma\mu$.

- (Ban, Fee) and (Fee, Ban) are equilibria iff $\lambda + \mu = \beta\lambda + \gamma\mu$.

Now we consider the scenario of the main model, where ad blockers are introduced and the second type of users can use them if they are allowed. The Ban strategy of the main model is similar to the Ads strategy of the benchmark, since every user has to see ads in both of them. Therefore, for the analysis of the main model we can use the four cases we considered in the benchmark and add to them five more cases for the strategy profiles that include the Allow strategy.

**5. Both platforms Allow ad blockers.** The indifferent user among those who do not use ad blockers is the one at position $x_N$ that is the solution to the equation $m+1-x_N-\beta a_1 = m + x_N - \beta a_2$, i.e. $x_N = \frac{1+\beta(a_2-a_1)}{2}$.

The indifferent user among those who use ad blockers is the one at position $x_A$ that is the solution to the equation $m + 1 - x_A = m + x_A$, since now this type of users can use ad blockers to avoid ads. It is $x_A = \frac{1}{2}$.

The expected market share of platform 1 is $z_1 = \lambda x_N$, while the expected market share of platform 2 is $z_2 = \lambda(1 - x_N)$. The profit for platform 1 is then $z_1 a_1$ and the profit for platform 2 is $z_2 a_2$. Thus, to find the advertising intensities $a_1$, $a_2$ in the equilibrium, we need to solve the system $\frac{\partial(z_1 a_1)}{\partial a_1} = \frac{\partial(z_2 a_2)}{\partial a_2} = 0$. The solution is $a_1 = a_2 = \frac{1}{\beta}$. From this, we get that the profit for both platforms is equal to $\frac{\lambda}{2\beta}$.

**6. First platform Allows ad blockers, while the second uses Ban.** The indifferent user among those who do not use ad blockers is the one at position $x_N$ that is the solution to the equation $m + 1 - x_N - \beta a_1 = m + x_N - \beta a_2$, i.e. $x_N = \frac{1+\beta(a_2-a_1)}{2}$.

The indifferent user among those with ad blockers is the one at position $x_A$ that is the solution to the equation $m + 1 - x_A = m + x_A - \gamma a_2$. It is $x_A = \frac{1+\gamma a_2}{2}$.

The expected market share of platform 1 is $z_1 = \lambda x_N$, while the expected market share of platform 2 is $z_2 = \lambda(1-x_N)+\mu(1-x_A)$. The profit for platform 1 is then $z_1a_1$ and the profit for platform 2 is $z_2a_2$. Thus, to find the advertising intensities $a_1$, $a_2$ in the equilibrium, we need to solve the system $\frac{\partial(z_1a_1)}{\partial a_1} = \frac{\partial(z_2a_2)}{\partial a_2} = 0$. The solution is $a_1 = \frac{3\beta\lambda+\beta\mu+2\gamma\mu}{\beta(3\beta\lambda+4\gamma\mu)}$ and $a_2 = \frac{3\lambda+2\mu}{3\beta\lambda+4\gamma\mu}$.[52] From this, we get that the profit for platform 1 is equal to $\frac{\lambda(3\beta\lambda+\beta\mu+2\gamma\mu)^2}{2\beta(3\beta\lambda+4\gamma\mu)^2}$, while the profit for platform 2 is $\frac{(3\lambda+2\mu)^2(\beta\lambda+\gamma\mu)}{2(3\beta\lambda+4\gamma\mu)^2}$.

**7. First platform ALLOWS ad blockers, while the second uses FEE.** The indifferent user among non-adblockers is the one at position $x_N$ that is the solution to the equation $m+1-x_N-\beta a_1 = m+x_N-p_2$, i.e. $x_N = \frac{1+p_2-\beta a_1}{2}$.

The indifferent user among those who use ad blockers is the one at position $x_A$ that is the solution to the equation $m+1-x_A = m+x_A-p_2$. It is $x_A = \frac{1+p_2}{2}$.

The expected market share of platform 1 is $z_1 = \lambda x_N$, while the expected market share of platform 2 is $z_2 = \lambda(1-x_N)+\mu(1-x_A)$. The profit for platform 1 is $z_1a_1$ and the profit for platform 2 is $z_2p_2$. Thus, to find the advertising intensity $a_1$ and the price $p_2$ in the equilibrium, we need to solve the system $\frac{\partial(z_1a_1)}{\partial a_1} = \frac{\partial(z_2p_2)}{\partial p_2} = 0$. The solution is $a_1 = \frac{3(\lambda+\mu)}{\beta(3\lambda+4\mu)}$ and $p_2 = \frac{3\lambda+2\mu}{3\lambda+4\mu}$.[53] From this, we get that the profit for platform 1 is equal to $\frac{9\lambda(\lambda+\mu)^2}{2\beta(3\lambda+4\mu)^2}$, while the profit for platform 2 is $\frac{(\lambda+\mu)(3\lambda+2\mu)^2}{2(3\lambda+4\mu)^2}$.

**8. First platform BANS ad blockers, while the second ALLOWS them.** This is similar to case 6. The profit for platform 1 is equal to $\frac{(3\lambda+2\mu)^2(\beta\lambda+\gamma\mu)}{2(3\beta\lambda+4\gamma\mu)^2}$, while the profit for platform 2 is $\frac{\lambda(3\beta\lambda+\beta\mu+2\gamma\mu)^2}{2\beta(3\beta\lambda+4\gamma\mu)^2}$.

**9. First platform uses a FEE, while the second ALLOWS ad blockers.** This is similar to case 7. The profit for platform 1 is equal to $\frac{(\lambda+\mu)(3\lambda+2\mu)^2}{2(3\lambda+4\mu)^2}$, while the profit for platform 2 is $\frac{9\lambda(\lambda+\mu)^2}{2\beta(3\lambda+4\mu)^2}$.

Summarizing all of the above, we get the following payoff matrix for the two platforms.

[52] Note that the indifferent user for those who do not use ad blockers is the one at position $x_N = \frac{3\beta\lambda+\beta\mu+2\gamma\mu}{6\beta\lambda+8\gamma\mu}$, which is always non-negative, but we also need this to be at most 1. Therefore, we need that $3\beta\lambda+6\gamma\mu \geq \beta\mu$. Similarly, for the indifferent user for those who use ad blockers, we need the inequality $3\beta\lambda+2\gamma\mu \geq 3\gamma\lambda$. We get the same conditions for the symmetric case 8.

[53] The indifferent user for those who do not use ad blockers is the one at position $x_N = \frac{3(\lambda+\mu)}{\beta(6\lambda+8\mu)}$, which is always non-negative and at most 1. Therefore, we do not need any extra inequality here. Similarly, for the indifferent user for those who use ad blockers, we do not need any extra condition either. The same is true for the symmetric case 9.

| | Ban | Allow | Fee |
|---|---|---|---|
| Ban | $\frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}, \frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}$ | $\frac{(3\lambda+2\mu)^2(\beta\lambda+\gamma\mu)}{2(3\beta\lambda+4\gamma\mu)^2}, \frac{\lambda(3\beta\lambda+\beta\mu+2\gamma\mu)^2}{2\beta(3\beta\lambda+4\gamma\mu)^2}$ | $\frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}, \frac{\lambda+\mu}{2}$ |
| Allow | $\frac{\lambda(3\beta\lambda+\beta\mu+2\gamma\mu)^2}{2\beta(3\beta\lambda+4\gamma\mu)^2}, \frac{(3\lambda+2\mu)^2(\beta\lambda+\gamma\mu)}{2(3\beta\lambda+4\gamma\mu)^2}$ | $\frac{\lambda}{2\beta}, \frac{\lambda}{2\beta}$ | $\frac{9\lambda(\lambda+\mu)^2}{2\beta(3\lambda+4\mu)^2}, \frac{(\lambda+\mu)(3\lambda+2\mu)^2}{2(3\lambda+4\mu)^2}$ |
| Fee | $\frac{\lambda+\mu}{2}, \frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)}$ | $\frac{(\lambda+\mu)(3\lambda+2\mu)^2}{2(3\lambda+4\mu)^2}, \frac{9\lambda(\lambda+\mu)^2}{2\beta(3\lambda+4\mu)^2}$ | $\frac{\lambda+\mu}{2}, \frac{\lambda+\mu}{2}$ |

We observe that (Allow, Allow) is an equilibrium iff the following two conditions hold.

$$\frac{\lambda}{2\beta} \geq \frac{(\lambda+\mu)(3\lambda+2\mu)^2}{2(3\lambda+4\mu)^2} \qquad \text{and} \qquad \frac{\lambda}{2\beta} \geq \frac{(3\lambda+2\mu)^2(\beta\lambda+\gamma\mu)}{2(3\beta\lambda+4\gamma\mu)^2}$$

These two conditions are equivalent to

$$\beta \leq \frac{\lambda(3\lambda+2\mu)^2}{(\lambda+\mu)(3\lambda+2\mu)^2} \qquad \text{and} \qquad \frac{\lambda+\mu\cdot\frac{\gamma}{\beta}}{\left(3\lambda+4\mu\cdot\frac{\gamma}{\beta}\right)^2} \leq \frac{\lambda}{(3\lambda+2\mu)^2}.$$

The function $g(x)=\frac{\lambda+\mu\cdot x}{(3\lambda+4\mu\cdot x)^2}$ is decreasing, therefore (Allow, Allow) is an equilibrium for low enough $\beta$ and high enough $\frac{\gamma}{\beta}$.

Moreover, if

$$\frac{\lambda}{2\beta} \geq \frac{(\lambda+\mu)^2}{2(\beta\lambda+\gamma\mu)} \qquad \text{and} \qquad \frac{\lambda}{2\beta} \geq \frac{\lambda+\mu}{2},$$

then the profits of the two platforms in the (Allow, Allow) equilibrium are larger than their profits in the (Ban, Ban) and (Fee, Fee) equilibria. These conditions are equivalent to $\frac{\gamma}{\beta} \geq 2+\frac{\mu}{\lambda}$ and $\beta \leq \frac{\lambda}{\lambda+\mu}$, so again when $\beta$ is low enough and $\frac{\gamma}{\beta}$ is high enough. □

**Proof of Proposition 2**

*Proof.* When both platforms choose Allow, the user utility is

$$\begin{aligned} & \lambda\left(\int_0^{\frac{1}{2}}\left(m+1-x-\beta\cdot\frac{1}{\beta}\right)dx+\int_{\frac{1}{2}}^{1}\left(m+x-\beta\cdot\frac{1}{\beta}\right)dx\right) \\ & \quad +\mu\left(\int_0^{\frac{1}{2}}(m+1-x)\,dx+\int_{\frac{1}{2}}^{1}(m+x)\,dx\right) \\ = \quad & \lambda\left(m-\frac{1}{4}\right)+\mu\left(m+\frac{3}{4}\right). \end{aligned}$$

When both platforms choose Ban, the user utility is

$$\begin{aligned}
&\lambda\left(\int_0^{\frac{1}{2}}\left(m+1-x-\beta\cdot\frac{\lambda+\mu}{\beta\lambda+\gamma\mu}\right)dx+\int_{\frac{1}{2}}^1\left(m+x-\beta\cdot\frac{\lambda+\mu}{\beta\lambda+\gamma\mu}\right)dx\right)\\
&\quad+\mu\left(\int_0^{\frac{1}{2}}\left(m+1-x-\gamma\cdot\frac{\lambda+\mu}{\beta\lambda+\gamma\mu}\right)dx+\int_{\frac{1}{2}}^1\left(m+x-\gamma\cdot\frac{\lambda+\mu}{\beta\lambda+\gamma\mu}\right)dx\right)\\
=\;&\lambda\left(m+\frac{3}{4}-\frac{\beta(\lambda+\mu)}{\beta\lambda+\gamma\mu}\right)+\mu\left(m+\frac{3}{4}-\frac{\gamma(\lambda+\mu)}{\beta\lambda+\gamma\mu}\right)\\
=\;&(\lambda+\mu)\left(m-\frac{1}{4}\right).
\end{aligned}$$

When both platforms choose Fee, the user utility is

$$\begin{aligned}
&\lambda\left(\int_0^{\frac{1}{2}}(m+1-x-1)\,dx+\int_{\frac{1}{2}}^1(m+x-1)\,dx\right)\\
&\quad+\mu\left(\int_0^{\frac{1}{2}}(m+1-x-1)\,dx+\int_{\frac{1}{2}}^1(m+x-1)\,dx\right)\\
=\;&\lambda\left(m-\frac{1}{4}\right)+\mu\left(m-\frac{1}{4}\right)\\
=\;&(\lambda+\mu)\left(m-\frac{1}{4}\right).
\end{aligned}$$

Note that the total user utility is the same when both platforms choose Ban or both platforms choose Fee, and it is higher when both platforms choose Allow.

Moreover, the utility of users without ad blockers is the same when both platforms choose Allow or both platforms choose Fee, while the utility of users with ad blockers is always higher when both platforms choose Allow. This implies that in the regions where platforms were using Fee in the benchmark but Allow in the main model, no user is worse off with Allow. □

**Proof of Proposition 3**

*Proof.* This proof requires to consider 16 cases, one for each strategy profile, similar to the cases of the proof of Proposition 1 but now with three segments of users. Since the proof is very repetitive, we illustrate here only one of the cases and then we provide the payoff matrix we obtain after the full analysis.

**Both platforms use the Ads or Fee plan.** This case has several subcases based on what option (between ads or fee) each segment of users picks. Since $\beta \leq \eta \leq \gamma$, there are four subcases for platform 1:

- $p_1 < \beta a_1 \leq \eta a_1 \leq \gamma a_1$
- $\beta a_1 \leq p_1 \leq \eta a_1 \leq \gamma a_1$
- $\beta a_1 \leq \eta a_1 < p_1 \leq \gamma a_1$
- $\beta a_1 \leq \eta a_1 \leq \gamma a_1 < p_1$

In the first subcase, every user in platform 1 prefers to pay the fee, therefore this subcase is as if platform 1 had chosen the Fee plan, and we can ignore it here.[54] Similarly, the fourth subcase is as if platform 1 had chosen the Ban plan, and we can ignore it too. This leaves us with two subcases for platform 1 and two similar subcases for platform 1. Therefore, there are four possible strategy profiles we need to analyze. For brevity, we show only the two symmetric ones here.

**1. $\beta a_1 \leq p_1 \leq \eta a_1 \leq \gamma a_1$ and $\beta a_2 \leq p_2 \leq \eta a_2 \leq \gamma a_2$.** The indifferent user among the first segment of non-adblockers is the one at position $x_N$ that is the solution to the equation $m + 1 - x_N - \beta a_1 = m + x_N - \beta a_2$, i.e. $x_N = \frac{1+\beta a_2 - \beta a_1}{2}$.

The indifferent user among the second segment of non-adblockers is the one at position $x_{N,2}$ that is the solution to the equation $m + 1 - x_{N,2} - p_1 = m + x_{N,2} - p_2$, since those non-adblock users pay the fee. It is $x_{N,2} = \frac{1+p_2-p_1}{2}$.

The indifferent user among adblock users is the one at position $x_A$ that is the solution to the equation $m + 1 - x_A - p_1 = m + x_A - p_2$. It is $x_A = \frac{1+p_2-p_1}{2}$.

[54] Note that the Ads or Fee plan is more general than the Fee and the Ban plan, as the platform can always make ad intensity or price equal to $+\infty$, forcing all of its users to either pay the fee or see ads respectively. To avoid confusion throughout the paper, when we say that a platform uses the Ads or Fee plan, we actually mean that some of its users see ads and some of its users decide to pay the fee. When we say that a platform uses the Fee plan, we actually mean that it either uses the Ads or Fee plan with ad intensity equal to $+\infty$ or it uses the actual Fee plan with no option for ads. Similarly for the Ban strategy.

The expected mass of users in platform 1 who see ads is $z_{1,a} = \lambda x_N$, while the expected mass of users in platform 1 who pay the fee is $z_{1,p} = \nu x_{N,2} + \mu x_A$. Similarly, the expected mass of users in platform 2 who see ads is $z_{2,a} = \lambda(1 - x_N)$, while the expected mass of users in platform 2 who pay the fee is $z_{2,p} = \nu(1 - x_{N,2}) + \mu(1 - x_A)$.

The profit for platform 1 is $z_{1,a}a_1 + z_{1,p}p_1$ and the profit for platform 2 is $z_{2,a}a_2 + z_{2,p}p_2$. Thus, to find the advertising intensities $a_1$, $a_2$ and the prices $p_1$, $p_2$ in the equilibrium, we need to solve the system $\frac{\partial(z_{1,a}a_1+z_{1,p}p_1)}{\partial a_1} = \frac{\partial(z_{1,a}a_1+z_{1,p}p_1)}{\partial p_1} = \frac{\partial(z_{2,a}a_2+z_{2,p}p_2)}{\partial a_2} = \frac{\partial(z_{2,a}a_2+z_{2,p}p_2)}{\partial p_2} = 0$. The solution is $a_1 = a_2 = \frac{1}{\beta}$ and $p_1 = p_2 = 1$. From this, we get that the profit for both platforms is equal to $\frac{\lambda+\beta(\mu+\nu)}{2\beta}$.

Note that the solution we found satisfy the inequalities of this subcase. Therefore, this subcase gives us an equilibrium.

**2.** $\beta a_1 \leq \eta a_1 < p_1 \leq \gamma a_1$ **and** $\beta a_2 \leq \eta a_2 < p_2 \leq \gamma a_2$**.** The indifferent user among the first segment of non-adblock users is the one at position $x_N$ that is the solution to the equation $m + 1 - x_N - \beta a_1 = m + x_N - \beta a_2$, i.e. $x_N = \frac{1+\beta a_2-\beta a_1}{2}$.

The indifferent user among the second segment of non-adblock users is now the one at position $x_{N,2}$ that is the solution to the equation $m + 1 - x_{N,2} - \eta a_1 = m + x_{N,2} - \eta a_2$, since in these subcase those non-adblock users see ads. It is $x_{N,2} = \frac{1+\eta a_2-\eta a_1}{2}$.

The indifferent user among adblock users is the one at position $x_A$ that is the solution to the equation $m + 1 - x_A - p_1 = m + x_A - p_2$, i.e. $x_A = \frac{1+p_2-p_1}{2}$.

The expected mass of users in platform 1 who see ads is $z_{1,a} = \lambda x_N + \nu x_{N,2}$, while the expected mass of users in platform 1 who pay the fee is $z_{1,p} = \mu x_A$. Similarly, the expected mass of users in platform 2 who see ads is $z_{2,a} = \lambda(1 - x_N) + \nu(1 - x_{N,2})$, while the expected mass of users in platform 2 who pay the fee is $z_{2,p} = \mu(1 - x_A)$.

The profit for platform 1 is $z_{1,a}a_1 + z_{1,p}p_1$ and the profit for platform 2 is $z_{2,a}a_2 + z_{2,p}p_2$. Thus, to find the advertising intensities $a_1$, $a_2$ and the prices $p_1$, $p_2$ in the equilibrium, we need to solve the system $\frac{\partial(z_{1,a}a_1+z_{1,p}p_1)}{\partial a_1} = \frac{\partial(z_{1,a}a_1+z_{1,p}p_1)}{\partial p_1} = \frac{\partial(z_{2,a}a_2+z_{2,p}p_2)}{\partial a_2} = \frac{\partial(z_{2,a}a_2+z_{2,p}p_2)}{\partial p_2} = 0$. The solution is $a_1 = a_2 = \frac{\lambda+\nu}{\beta\lambda+\eta\nu}$ and $p_1 = p_2 = 1$. From this, we get that the profit for both platforms is equal to $\frac{\lambda^2+\beta\lambda\mu+2\lambda\nu+\eta\mu\nu+\nu^2}{2(\beta\lambda+\eta\nu)}$.

Note however, that the solution we found this time does not satisfy the inequalities of this subcase, because $\eta a_1 = \frac{\eta\lambda+\eta\nu}{\beta\lambda+\eta\nu} \geq \frac{\beta\lambda+\eta\nu}{\beta\lambda+\eta\nu} = 1 = p_1$. Therefore, this subcase does not give an equilibrium.

After we analyze all possible cases and subcases, we obtain the payoff matrix in Table 3. From that matrix, we can also obtain the conditions under which both platforms choose Allow as their equilibrium strategy.

An example where (Allow, Allow) is the unique equilibrium is for $\lambda = \mu = \nu = 1$, $\beta = \frac{1}{4}$, $\eta = \frac{3}{10}$, and $\gamma = 2$. In that case, the payoff matrix becomes

| | Ban | Allow | Fee | Ads or Fee |
|---|---|---|---|---|
| Ban | $1.8, 1.8$ | $0.88, 1.4$ | $1.8, 1.5$ | $1.8, 2.2$ |
| Allow | $1.4, 0.88$ | $3.6, 3.6$ | $2.9, 0.96$ | $3.1, 2.2$ |
| Fee | $1.5, 1.8$ | $0.96, 2.9$ | $1.5, 1.5$ | $1.5, 3$ |
| Ads or Fee | $2.2, 1.8$ | $2.2, 3.1$ | $3, 1.5$ | $3, 3$ |

□

**Proof of Proposition 4**

*Proof.* As in the proof of Proposition 3, this proof requires to consider all the 16 possible strategy combinations for the platforms. For brevity we show only one in detail here and then we provide the payoff matrix with the result of all cases.

**Both platforms use the Whitelist plan.** The indifferent user among the non-adblock users is the one at position $x_N$ that is the solution to the equation $m + 1 - x_N - \beta a_1 = m + x_N - \beta a_2$, i.e. $x_N = \frac{1+\beta a_2 - \beta a_1}{2}$.

The indifferent user among the first segment of adblock users, who keep the whitelist, is the one at position $x_{A,2}$ that is the solution to the equation $m+1-x_{A,2}-\zeta a_1 = m+x_{A,2}-\zeta a_2$, since those adblock users see ads. It is $x_{A,2} = \frac{1+\zeta a_2 - \zeta a_1}{2}$.

The indifferent user among the second segment of adblock users, who remove all ads, is the one at position $x_A$ that is the solution to the equation $m+1-x_A = m+x_A$, i.e. $x_A = \frac{1}{2}$.

The expected mass of users in platform 1 who see ads is $z_{1,a} = \lambda x_N + \xi x_{A,2}$. Similarly, the expected mass of users in platform 2 who see ads is $z_{2,a} = \lambda(1 - x_N) + \xi(1 - x_{A,2})$.

The profit for platform 1 is $z_{1,a}a_1 - f$ and the profit for platform 2 is $z_{2,a}a_2 - f$, since they also have to pay the fee $f$ to the ad-blocker company. Thus, to find the advertising intensities $a_1$, $a_2$ in the equilibrium, we need to solve the system $\frac{\partial(z_{1,a}a_1-f)}{\partial a_1} = \frac{\partial(z_{2,a}a_2-f)}{\partial a_2} = 0$. The solution is $a_1 = a_2 = \frac{\lambda+\xi}{\beta\lambda+\zeta\xi}$. From this, we get that the profit for both platforms is equal to $\frac{(\lambda+\xi)^2}{2(\beta\lambda+\zeta\xi)} - f$.

In Table 4, we can see the payoff matrix of the full game. An example where (Whitelist, Whitelist) is the unique equilibrium of the game is $\lambda = \mu = \nu = 1$, $\beta = \zeta = \frac{1}{10}$, and $\gamma = \frac{6}{5}$. In that case, the payoff matrix becomes

| | Ban | Allow | Fee | Whitelist |
|---|---|---|---|---|
| Ban | $3.21, 3.21$ | $1.13, 1.59$ | $3.21, 1.5$ | $1.54, 3.3$ |
| Allow | $1.59, 1.13$ | $5, 5$ | $3.35, 0.61$ | $3.67, 5.1$ |
| Fee | $1.5, 3.21$ | $0.61, 3.35$ | $1.5, 1.5$ | $0.96, 8.1$ |
| Whitelist | $3.3, 1.54$ | $5.1, 3.67$ | $8.1, 0.96$ | $10, 10$ |

□

**Proof of Proposition 5**

*Proof.* This proof is similar to the proof of Proposition 1 with the additional step in every case of the decision about qualities by content creators. To avoid repetition, we analyze one case here and then we provide the payoff matrix of the full game.

**Both platforms Allow ad blockers.** The indifferent user among the non-adblock users is the one at position $x_N$ that is the solution to the equation $m + 1 - x_N - \beta a_1 + rq_1 = m + x_N - \beta a_2 + rq_2$, i.e. $x_N = \frac{1+\beta(a_2-a_1)-r(q_2-q_1)}{2}$.

The indifferent user among those who use ad blockers is the one at position $x_A$ that is the solution to the equation $m + 1 - x_A + rq_1 = m + x_A + rq_2$, since now this type of users can use ad blockers to avoid ads. It is $x_A = \frac{1-r(q_2-q_1)}{2}$.

The expected mass of users who see ads in platform 1 is $z_1 = \lambda x_N$, while the expected mass of users who see ads in platform 2 is $z_2 = \lambda(1 - x_N)$.

The profit for the content creators of platform 1 is $f_1 z_1 a_1 - c_1 q_1^2$, while the profit for the content creators of platform 2 is $f_2 z_2 a_2 - c_2 q_2^2$.[55] To find the qualities $q_1$, $q_2$, we need to solve the system $\frac{\partial(f_1 z_1 a_1 - c_1 q_1^2)}{\partial q_1} = \frac{\partial(f_2 z_2 a_2 - c_2 q_2^2)}{\partial q_2} = 0$. This gives the solution $q_1 = \frac{a_1 f_1 \lambda r}{4c_1}$ and $q_2 = \frac{a_2 f_2 \lambda r}{4c_2}$ as a function of the ad intensities $a_1$ and $a_2$.

The profit for platform 1 is $(1 - f_1) z_1 a_1$ and the profit for platform 2 is $(1 - f_2) z_2 a_2$. Thus, to find the ad intensities $a_1$, $a_2$ in the equilibrium, we need to solve the system $\frac{\partial((1-f_1) z_1 a_1)}{\partial a_1} = \frac{\partial((1-f_2) z_2 a_2)}{\partial a_2} = 0$. The solution is $a_1 = \frac{4c_1}{4\beta c_1 - f_1 \lambda r^2}$ and $a_2 = \frac{4c_2}{4\beta c_2 - f_2 \lambda r^2}$. From this, we get that the profit for platform 1 is equal to $\frac{2c_1(1-f_1)\lambda}{4\beta c_1 - f_1 \lambda r^2}$ and the profit for platform 2 is $\frac{2c_2(1-f_2)\lambda}{4\beta c_2 - f_2 \lambda r^2}$. Moreover, the qualities are $q_1 = \frac{f_1 \lambda r}{4\beta c_1 - f_1 \lambda r^2}$ and $q_2 = \frac{f_2 \lambda r}{4\beta c_2 - f_2 \lambda r^2}$.

The user welfare of non-adblock users is

$$\begin{aligned} & \lambda\left(\int_0^{\frac{1}{2}} \left(m + 1 - x - \beta \cdot \frac{4c_1}{4\beta c_1 - f_1 \lambda r^2} + r \cdot \frac{f_1 \lambda r}{4\beta c_1 - f_1 \lambda r^2}\right) dx \right. \\ & \qquad \left. + \int_{\frac{1}{2}}^1 \left(m + x - \beta \cdot \frac{4c_2}{4\beta c_2 - f_2 \lambda r^2} + r \cdot \frac{f_2 \lambda r}{4\beta c_2 - f_2 \lambda r^2}\right) dx\right) \\ = \quad & \lambda\left(m - \frac{1}{4}\right). \end{aligned}$$

The user welfare of adblock users is

$$\begin{aligned} & \mu\left(\int_0^{x_A} \left(m + 1 - x + r \cdot \frac{f_1 \lambda r}{4\beta c_1 - f_1 \lambda r^2}\right) dx \right. \\ & \qquad \left. + \int_{1-x_A}^1 \left(m + x + r \cdot \frac{f_2 \lambda r}{4\beta c_2 - f_2 \lambda r^2}\right) dx\right), \end{aligned}$$

where $x_A = \frac{1}{2} + \frac{2\beta c_1}{4\beta c_1 - f_1 \lambda r^2} - \frac{2\beta c_2}{4\beta c_2 - f_2 \lambda r^2}$. For symmetric platforms, i.e. when $f_1 = f_2 = \hat{f}$ and

[55] For simplicity in this analysis and to avoid corner solutions we assume that the cost parameters $c_1$ and $c_2$ are sufficiently large.

$c_1 = c_2 = \hat{c}$, the user welfare of adblock users is

$$\mu \left( m + \frac{3}{4} + \frac{\hat{f}\lambda r^2}{4\beta\hat{c} - \hat{f}\lambda r^2} \right) \geq \mu \left( m + \frac{3}{4} \right),$$

larger than it was in the main model.

Table 5 contains the payoff matrix of the game. The quality in the (Ban, Ban) equilibrium for platform 1 is $q_{1,\text{Ban}} = \frac{f_1(\lambda+\mu)^2 r}{4\beta c_1 \lambda + 4\gamma c_1 \mu - f_1(\lambda+\mu)^2 r^2}$. This is less than or equal to $q_{1,\text{Allow}} = \frac{f_1 \lambda r}{4\beta c_1 - f_1 \lambda r^2}$ when $\frac{\gamma}{\beta} \geq 2 + \frac{\mu}{\lambda}$, i.e. for sufficiently high $\frac{\gamma}{\beta}$. Similarly, $q_{2,\text{Ban}} \leq q_{2,\text{Allow}}$ when $\frac{\gamma}{\beta} \geq 2 + \frac{\mu}{\lambda}$.

The quality in the (Fee, Fee) equilibrium for platform 1 is $q_{1,\text{Fee}} = \frac{f_1(\lambda+\mu)r}{4c_1 - f_1(\lambda+\mu)r^2}$. This is less than or equal to $q_{1,\text{Allow}} = \frac{f_1 \lambda r}{4\beta c_1 - f_1 \lambda r^2}$ when $\beta \leq \frac{\lambda}{\lambda+\mu}$, i.e. for sufficiently low $\beta$. Similarly, $q_{2,\text{Fee}} \leq q_{2,\text{Allow}}$ when $\beta \leq \frac{\lambda}{\lambda+\mu}$.

For the case of symmetric platforms, the total user welfare in the (Ban, Ban) and in the (Fee, Fee) equilibria is $(\lambda+\mu)\left(m - \frac{1}{4}\right)$, i.e. the same as in the main model. However, in the (Allow, Allow) equilibrium, the total user welfare is $\lambda\left(m - \frac{1}{4}\right) + \mu\left(m + \frac{3}{4} + \frac{\hat{f}\lambda r^2}{4\beta\hat{c} - \hat{f}\lambda r^2}\right) \geq \lambda\left(m - \frac{1}{4}\right) + \mu\left(m + \frac{3}{4}\right)$, larger than in the main model. □

## A.2 Payoff matrices

| | Ban | Allow | Fee | Ads or Fee |
|---|---|---|---|---|
| Ban | $\frac{(\lambda+\mu+\nu)^2}{2(\beta\lambda+\gamma\mu+\eta\nu)}, \frac{(\lambda+\mu+\nu)^2}{2(\beta\lambda+\gamma\mu+\eta\nu)}$ | $\frac{(3\lambda+2\mu+3\nu)^2(\beta\lambda+\gamma\mu+\eta\nu)}{2(3\beta\lambda+4\gamma\mu+3\eta\nu)^2}, C$ | $\frac{(\lambda+\mu+\nu)^2}{2(\beta\lambda+\gamma\mu+\eta\nu)}, \frac{1}{2}(\lambda+\mu+\nu)$ | $\frac{(\lambda+\mu+\nu)^2}{2(\beta\lambda+\gamma\mu+\eta\nu)}, A$ |
| Allow | $C, \frac{(3\lambda+2\mu+3\nu)^2(\beta\lambda+\gamma\mu+\eta\nu)}{2(3\beta\lambda+4\gamma\mu+3\eta\nu)^2}$ | $\frac{(\lambda+\nu)^2}{2(\beta\lambda+\eta\nu)}, \frac{(\lambda+\nu)^2}{2(\beta\lambda+\eta\nu)}$ | $\frac{9(\lambda+\nu)^2(\lambda+\mu+\nu)^2}{2(3\lambda+4\mu+3\nu)^2(\beta\lambda+\eta\nu)}, \frac{(\lambda+\mu+\nu)(3\lambda+2\mu+3\nu)^2}{2(3\lambda+4\mu+3\nu)^2}$ | $\frac{9(\lambda+\nu)^2(\mu+\nu)^2(\beta\lambda+\eta\nu)}{2(3\beta\lambda(\mu+\nu)+\eta\nu(4\mu+3\nu))^2}, B$ |
| Fee | $\frac{1}{2}(\lambda+\mu+\nu), \frac{(\lambda+\mu+\nu)^2}{2(\beta\lambda+\gamma\mu+\eta\nu)}$ | $\frac{(\lambda+\mu+\nu)(3\lambda+2\mu+3\nu)^2}{2(3\lambda+4\mu+3\nu)^2}, \frac{9(\lambda+\nu)^2(\lambda+\mu+\nu)^2}{2(3\lambda+4\mu+3\nu)^2(\beta\lambda+\eta\nu)}$ | $\frac{1}{2}(\lambda+\mu+\nu), \frac{1}{2}(\lambda+\mu+\nu)$ | $\frac{1}{2}(\lambda+\mu+\nu), \frac{\lambda+\beta(\mu+\nu)}{2\beta}$ |
| Ads or Fee | $A, \frac{(\lambda+\mu+\nu)^2}{2(\beta\lambda+\gamma\mu+\eta\nu)}$ | $B, \frac{9(\lambda+\nu)^2(\mu+\nu)^2(\beta\lambda+\eta\nu)}{2(3\beta\lambda(\mu+\nu)+\eta\nu(4\mu+3\nu))^2}$ | $\frac{\lambda+\beta(\mu+\nu)}{2\beta}, \frac{1}{2}(\lambda+\mu+\nu)$ | $\frac{\lambda+\beta(\mu+\nu)}{2\beta}, \frac{\lambda+\beta(\mu+\nu)}{2\beta}$ |

Table 3: Payoff matrix in the model with the Ads or Fee plan.

$$A = \frac{\lambda^2(\mu+\nu)^2\beta^3+\lambda(\mu+\nu)\Big(4\lambda^2+2((\gamma+2)\mu+(\eta+2)\nu)\lambda+(\mu+\nu)(4\gamma\mu+\mu+4\eta\nu+\nu)\Big)\beta^2+(\gamma\mu+\eta\nu)\Big(((\gamma+4)\mu+(\eta+4)\nu)\lambda^2+2(\mu+\nu)(2\gamma\mu+\mu+2\eta\nu+\nu)\lambda+4(\mu+\nu)^2(\gamma\mu+\eta\nu)\Big)\beta+\lambda(\mu+\nu)(\gamma\mu+\eta\nu)^2}{8\beta(\mu+\nu)(\beta\lambda+\gamma\mu+\eta\nu)^2}$$

$$B = \frac{9\beta^3\lambda^2(\mu+\nu)^3+3\beta^2\lambda\Big(12\lambda^2+6(\eta+2)\nu\lambda+\nu(8\eta\mu+12\eta\nu+3\nu)\Big)(\mu+\nu)^2+\beta\eta\nu\Big((48\mu+9(\eta+4)\nu)\lambda^2+6\nu(4(\eta+1)\mu+6\eta\nu+3\nu)\lambda+4\eta\nu(2\mu+3\nu)^2\Big)(\mu+\nu)+\eta^2\lambda\nu^2(4\mu+3\nu)^2}{8\beta(3\beta\lambda(\mu+\nu)+\eta\nu(4\mu+3\nu))^2}$$

$$C = \frac{(2\gamma\mu(\lambda+\nu)+\beta\lambda(3\lambda+\mu+3\nu)+\eta\nu(3\lambda+\mu+3\nu))^2}{2(\beta\lambda+\eta\nu)(3\beta\lambda+4\gamma\mu+3\eta\nu)^2}$$

| | Ban | Allow | Fee | Whitelist |
|---|---|---|---|---|
| Ban | $\frac{(\lambda+\mu+\xi)^2}{2(\beta\lambda+\gamma\mu+\zeta\xi)}, \frac{(\lambda+\mu+\xi)^2}{2(\beta\lambda+\gamma\mu+\zeta\xi)}$ | $\frac{(\beta\lambda+\gamma\mu+\zeta\xi)(3\lambda+2(\mu+\xi))^2}{2(3\beta\lambda+4\gamma\mu+4\zeta\xi)^2}, E$ | $\frac{(\lambda+\mu+\xi)^2}{2(\beta\lambda+\gamma\mu+\zeta\xi)}, \frac{1}{2}(\lambda+\mu+\xi)$ | $\frac{(3\lambda+2\mu+3\xi)^2(\beta\lambda+\gamma\mu+\zeta\xi)}{2(3\beta\lambda+4\gamma\mu+3\zeta\xi)^2}, D$ |
| Allow | $E, \frac{(\beta\lambda+\gamma\mu+\zeta\xi)(3\lambda+2(\mu+\xi))^2}{2(3\beta\lambda+4\gamma\mu+4\zeta\xi)^2}$ | $\frac{\lambda}{2\beta}, \frac{\lambda}{2\beta}$ | $\frac{9\lambda(\lambda+\mu+\xi)^2}{2\beta(3\lambda+4(\mu+\xi))^2}, \frac{(\lambda+\mu+\xi)(3\lambda+2(\mu+\xi))^2}{2(3\lambda+4(\mu+\xi))^2}$ | $\frac{\lambda(2\zeta\xi+\beta(3\lambda+\xi))^2}{2\beta(3\beta\lambda+4\zeta\xi)^2}, \frac{(3\lambda+2\xi)^2(\beta\lambda+\zeta\xi)}{2(3\beta\lambda+4\zeta\xi)^2}-f$ |
| Fee | $\frac{1}{2}(\lambda+\mu+\xi), \frac{(\lambda+\mu+\xi)^2}{2(\beta\lambda+\gamma\mu+\zeta\xi)}$ | $\frac{(\lambda+\mu+\xi)(3\lambda+2(\mu+\xi))^2}{2(3\lambda+4(\mu+\xi))^2}, \frac{9\lambda(\lambda+\mu+\xi)^2}{2\beta(3\lambda+4(\mu+\xi))^2}$ | $\frac{1}{2}(\lambda+\mu+\xi), \frac{1}{2}(\lambda+\mu+\xi)$ | $\frac{(\lambda+\mu+\xi)(3\lambda+2\mu+3\xi)^2}{2(3\lambda+4\mu+3\xi)^2}, F$ |
| Whitelist | $D, \frac{(3\lambda+2\mu+3\xi)^2(\beta\lambda+\gamma\mu+\zeta\xi)}{2(3\beta\lambda+4\gamma\mu+3\zeta\xi)^2}$ | $\frac{(3\lambda+2\xi)^2(\beta\lambda+\zeta\xi)}{2(3\beta\lambda+4\zeta\xi)^2}-f, \frac{\lambda(2\zeta\xi+\beta(3\lambda+\xi))^2}{2\beta(3\beta\lambda+4\zeta\xi)^2}$ | $F, \frac{(\lambda+\mu+\xi)(3\lambda+2\mu+3\xi)^2}{2(3\lambda+4\mu+3\xi)^2}$ | $\frac{(\lambda+\xi)^2}{2(\beta\lambda+\zeta\xi)}-f, \frac{(\lambda+\xi)^2}{2(\beta\lambda+\zeta\xi)}-f$ |

Table 4: Payoff matrix in the model with the Whitelist plan.

$$D = \frac{(2\gamma\mu(\lambda+\xi)+\beta\lambda(3\lambda+\mu+3\xi)+\zeta\xi(3\lambda+\mu+3\xi))^2}{2(\beta\lambda+\zeta\xi)(3\beta\lambda+4\gamma\mu+3\zeta\xi)^2}-f$$

$$E = \frac{\lambda(\beta(3\lambda+\mu+\xi)+2(\gamma\mu+\zeta\xi))^2}{2\beta(3\beta\lambda+4\gamma\mu+4\zeta\xi)^2}$$

$$F = \frac{9(\lambda+\xi)^2(\lambda+\mu+\xi)^2}{2(3\lambda+4\mu+3\xi)^2(\beta\lambda+\zeta\xi)}-f$$

| | Ban | Allow | Fee |
|---|---|---|---|
| Ban | $-\frac{2c_1(f_1-1)(\lambda+\mu)^2}{4c_1(\beta\lambda+\gamma\mu)-f_1r^2(\lambda+\mu)^2}, -\frac{2c_2(f_2-1)(\lambda+\mu)^2}{4c_2(\beta\lambda+\gamma\mu)-f_2r^2(\lambda+\mu)^2}$ | $I, J$ | $-\frac{2c_1(f_1-1)(\lambda+\mu)^2}{4c_1(\beta\lambda+\gamma\mu)-f_1r^2(\lambda+\mu)^2}, -\frac{2c_2(f_2-1)(\lambda+\mu)}{4c_2-f_2r^2(\lambda+\mu)}$ |
| Allow | $G, H$ | $\frac{2c_1(f_1-1)\lambda}{f_1r^2\lambda-4c_1\beta}, \frac{2c_2(f_2-1)\lambda}{f_2r^2\lambda-4c_2\beta}$ | $-\frac{18c_1(f_1-1)\lambda\left(4c_1\beta-f_1r^2\lambda\right)(\lambda+\mu)^2}{(3f_1r^2\lambda(\lambda+\mu)-4c_1\beta(3\lambda+4\mu))^2}, L$ |
| Fee | $-\frac{2c_1(f_1-1)(\lambda+\mu)}{4c_1-f_1r^2(\lambda+\mu)}, -\frac{2c_2(f_2-1)(\lambda+\mu)^2}{4c_2(\beta\lambda+\gamma\mu)-f_2r^2(\lambda+\mu)^2}$ | $K, -\frac{18c_2(f_2-1)\lambda\left(4c_2\beta-f_2r^2\lambda\right)(\lambda+\mu)^2}{(3f_2r^2\lambda(\lambda+\mu)-4c_2\beta(3\lambda+4\mu))^2}$ | $-\frac{2c_1(f_1-1)(\lambda+\mu)}{4c_1-f_1r^2(\lambda+\mu)}, -\frac{2c_2(f_2-1)(\lambda+\mu)}{4c_2-f_2r^2(\lambda+\mu)}$ |

Table 5: Payoff matrix in the model with the content creators.

$$G = -\frac{2c_1(f_1-1)\lambda\left(4c_1\beta-f_1r^2\lambda\right)\left(-3f_2r^2(\lambda+\mu)^2+8c_2\gamma\mu+4c_2\beta(3\lambda+\mu)\right)^2}{(3f_1f_2\lambda(\lambda+\mu)^2r^4-4(c_1f_2\beta(\lambda+\mu)(3\lambda+4\mu)+c_2f_1\lambda(3\beta\lambda-\beta\mu+4\gamma\mu))r^2+16c_1c_2\beta(3\beta\lambda+4\gamma\mu))^2}$$

$$H = -\frac{2c_2(f_2-1)\left(3f_1r^2\lambda(\lambda+\mu)-4c_1\beta(3\lambda+2\mu)\right)^2\left(4c_2(\beta\lambda+\gamma\mu)-f_2r^2(\lambda+\mu)^2\right)}{(f_1\lambda(3f_2r^2(\lambda+\mu)^2+4c_2(-3\beta\lambda+\beta\mu-4\gamma\mu))r^2+4c_1\beta(4c_2(3\beta\lambda+4\gamma\mu)-f_2r^2(\lambda+\mu)(3\lambda+4\mu)))^2}$$

$$I = -\frac{2c_1(f_1-1)\left(3f_2r^2\lambda(\lambda+\mu)-4c_2\beta(3\lambda+2\mu)\right)^2\left(4c_1(\beta\lambda+\gamma\mu)-f_1r^2(\lambda+\mu)^2\right)}{(f_1(\lambda+\mu)(3f_2r^2\lambda(\lambda+\mu)-4c_2\beta(3\lambda+4\mu))r^2+4c_1(f_2\lambda(-3\beta\lambda+\beta\mu-4\gamma\mu)r^2+4c_2\beta(3\beta\lambda+4\gamma\mu)))^2}$$

$$J = -\frac{2c_2(f_2-1)\lambda\left(4c_2\beta-f_2r^2\lambda\right)\left(3f_1r^2(\lambda+\mu)^2-4c_1(2\gamma\mu+\beta(3\lambda+\mu))\right)^2}{(f_1(\lambda+\mu)(3f_2r^2\lambda(\lambda+\mu)-4c_2\beta(3\lambda+4\mu))r^2+4c_1(f_2\lambda(-3\beta\lambda+\beta\mu-4\gamma\mu)r^2+4c_2\beta(3\beta\lambda+4\gamma\mu)))^2}$$

$$K = -\frac{2c_1(f_1-1)(\lambda+\mu)\left(3f_2r^2\lambda(\lambda+\mu)-4c_2\beta(3\lambda+2\mu)\right)^2}{(4c_1-f_1r^2(\lambda+\mu))(3f_2r^2\lambda(\lambda+\mu)-4c_2\beta(3\lambda+4\mu))^2}$$

$$L = -\frac{2c_2(f_2-1)(\lambda+\mu)\left(3f_1r^2\lambda(\lambda+\mu)-4c_1\beta(3\lambda+2\mu)\right)^2}{(4c_2-f_2r^2(\lambda+\mu))(3f_1r^2\lambda(\lambda+\mu)-4c_1\beta(3\lambda+4\mu))^2}$$