Allow or Block: Optimal Strategies against Ad-blockers in Competitive Markets

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Abstract

The main income streams of many publishers (of online content such as websites) are advertising (ad) revenues from their websites. However, users mostly find the ads annoying especially when they are not relevant for them. Also, many users are concerned with potential privacy and security issues if they see customized and/or harmful ads. The resulting irritation motivates users to look for ways how to avoid the ads. One of the most common and efficient options are ad-blockers. Thus, an increasing number of people use ad-blockers recently which becomes a threat to the main revenue stream of publishers. In order to deal with this challenge some publishers offer an ad-free (premium) version of their websites to customers who pay a subscription fee. Others ask the users to turn off their ad-blocker. In this case, the users either turn off the ad-blocker or leave the website. In this article, we consider a market with two sides: (a) the publisher whose main income are the ads and (b) the user who may want to use the ad-blocker to avoid the ads. The purpose of this article is to develop a modeling approach to explore the best strategy for publishers in monopoly and duopoly markets. The publisher could choose among three strategies: (1) show the content to everyone, (2) show the content only to those who turn the ad-blockers off, and (3) show the content to users who pay a subscription fee. Furthermore, we are interested in finding the optimal content quality the publisher generates and the optimal subscription fee if the premium model is optimal.

Keywords: ad-blocking, competitive markets, game theory

1 Introduction

The Internet has changed the advertisement world among many others. Since the first online advertisement on hotwired.com in 1993 (Pujol et al. 2015), the share of the Internet has increased dramatically taking the first place among the advertisement platforms. 40% of the total ad spending is expected to be online in 2018 (Molla 2018). Likewise, the Internet is the biggest platform for the advertisers, the main income of many websites comes from the advertisements (ads) they show on the website (Manjoo 2015). In spite of the fact that the ads are the main income of the websites, many users don't want to see them and are seeking ways to avoid online ads. However, users mostly find the ads annoying especially when they are not relevant for them (Baek and Morimoto 2012). Also, many users are concerned with potential privacy and security issues if they see customized and/or harmful ads (e.g. Storey et al. 2017). The irritation motivates the users to look for ways to block the ads (Kim and Sundar 2010). One of the most common and efficient ways the users apply against this problem is ad-blockers. Ad-blocker is an Internet extension which blocks the ads the users don't want to see. They are easy to install, anonymous, and free.

The ads could be in three formats: standard (traditional ad units), articles (sponsored articles), and native (ads matching the website's format) (Cummings 2016). Ad-blockers are not successful to block all these ad types although they can block the ads mostly. Cummings (2016) tested 39 of the biggest websites with ad-blocker on and off. Half of the websites did not show any ads with the ad-blocker on. 18 websites showed at least some ads but never standard ads. Finally, ad-blocker did not block the article ads.

Recently, an increasing number of people who are majorly between the ages of 18-34 use ad-blockers (Richman 2016). The ad-blocker industry grew by 41% from 2014 to 2015 globally. They blocked $21.8 billion global ad revenue in 2015 (Cortland 2017). This is a big obstacle for websites. They must have taken a precaution against it. This is how anti-ad-blockers existed. Around 30% of Alexa Top 10k websites use anti-ad-blockers to detect whether an ad-blocker is currently active (Zhu et al. 2018). However, anti-ad-blockers are not efficient and can be avoided in 82.2% of the cases (Zhu et al. 2018). As an answer, the ad publishers become more aggressive in their advertising behavior. It can be foreseen that the fight between the publishers and ad-blockers will continue.

Ad-blockers can be non-profit or profit-oriented like advertisers and publishers (Greenberg 2016). Non-profit ad-blockers block the ads that the user does not want to see. They have

no income other than the donations. Some profit-oriented ad-blockers are free to the users; however, they sell customer information to the companies. Some other profit-oriented ad-blockers‘ main income is coming from the ”whitelisted“ websites. Whitelisted advertisers and publishers can show their ads online as long as they abide by user-generated criteria to be whitelisted. Ad-blockers disallow ads unless the publishers pay for them to be whitelisted. For example, Adblock Plus takes 30% of the ad revenue by the big publishers (Castillo 2016), while it is free to be whitelisted for the small publishers as long as they fulfill three main criteria: the ads should not occupy the whole screen, they should be identifiable as ads, and they should not disturb the reading flow.

Getting whitelisted is a way against the harm by the ad-blockers. However, there are other strategies for the publishers to follow as well. Some publishers apply to freemium models while some of them such as Facebook change the ads in a way, which makes them harder to be detected by ad-blockers. Some other publishers such as Wired and The Guardian offer an ad-free (premium) version of the websites to the customers who pay or donate to the website (Saeed 2019). The premium accounts can compensate for the revenue loss due to blocked ads (entrepreneur). However, this method is effective only for powerful, international websites and small websites with a focused market (Ingram 2015).

Another strategy the publishers pursue against ad-blockers is to ask the users to turn off the ad-blocker. In this case, the users either turn off the ad-blocker or leave the website. However, the results of this strategy could be severe. Some big newspapers‘ websites such as Bild and Forbes fell drastically globally after they applied to this strategy (Anderson 2016). Still, it should be kept in mind that the remaining users are fully monetized although the number of users falls.

In this paper, we focus on the strategies that the publishers follow against ad-blockers. We start the model by defining the user's utility function. Then, we present the publishers' strategies and analyze them. Accordingly, we aim to reach the optimal content quality, subscription fee (when it is the optimal strategy), and the optimal strategy. To our best knowledge, our paper is the first analyzing the ad-blockers in a duopoly market.

The rest of the paper is organized as follows. We focus on the related literature in Section 2. We present the market structure in Section 3. Then, we analyze the publisher model in Section 4. Lastly, we present the general discussion and conclude the paper in Section 5.

2 Literature Review

There is a vast body of literature on advertisement avoidance (ad-avoidance). Researchers have been working on the topic for a long time. However, most studies focus on classic media types like TV ads rather than advertising on the internet. An early study on ad-avoidance conducted by Speck and Elliot (1997) shows that ad-avoidance is more relevant to television and magazine comparing with other communication channels (such as radio and newspapers). However, this study was conducted before the Internet was widely used. The phenomenon existed even before users started applying technology to avoid ads. TV viewers avoid the ads by either leaving the room or changing the channel (Abernethy, 1991c) or simply ignore them (Knobloch-Westerwick and Meng 2009) causing the ads being less effective. In parallel with an increasing number of technological options, there have been new ways to avoid ads such as video recorders, spam filters, pop-up blockers, anonymous browsing, and other devices and techniques for the users to protect their privacy (Hann et al. 2008). Ad-averse users are the ones who use the ad-avoidance technologies the most (Anderson and Gans 2011).

As mentioned earlier, ad-blockers have been one of the most popular ways to avoid online ads. However, online ad-avoidance existed before the ad-blockers were launched. The internet users can avoid online ads in three ways: (1) cognitive avoidance (intentionally ignoring the ads), (2) effective avoidance (negative feelings towards the ads), and (3) behavioral avoidance (actions to avoid from ad-exposure such as scrolling down the webpage) (Cho and Cheon 2013). Some researchers focused on online media firms before ad-blockers were launched. Prasad et al. (2003) analyzed the case that the users could subscribe to see less or no ads when the publisher generate ad as well as subscription income. They show that the optimal strategy is offering options to the consumers instead of forcing them to follow a certain strategy. Tag (2007), in a similar setup, shows that advertisement quantity increases when the publisher offers a subscription option.

Although ad-blockers have attracted the attention of the computer science community recently (e.g. Storey et al. 2017, Walls et al. 2015), in marketing the research about ad-blockers is rather scarce. The current literature focuses mostly on factors that drive users to use ad-blockers and its effects on publishers.

Miroglio et al. (2018) ran a field experiment on the Firefox browser to see the ad-blocker effect on users‘ web engagement. The results show that ad-blocker users spend more time in the browser and view more pages although there is no significant change in the

search numbers. Although users employing ad-blockers spend more time on the internet, ad-blockers have a negative effect on the websites worsening their traffic rank especially if the initial rank of the website is low (Shiller, Waldvogel, and Ryan 2018). The same paper also states that ad-blockers are threatening the ad-supported web because they reduce the publisher revenues.

However, ad-blockers aren't necessarily harmful to the platforms all the times. Despotakis et al. (2017) show that allowing users to apply ad-blockers could actually be beneficial because the platform could differentiate the users based on their ad-viewing disutility. They can focus on the non-ad-blocker users to reach higher return rates as well as they could increase the number of ads to non-ad-blocker users. However, although the publishers increase their profits by targeted ads, users may not like them all the time, especially if targeting isn't very precise. If users feel interfered or interrupted, they avoid the ads even more. This leads to higher ad-blocking rates (Johnson 2013, Edwards et al. 2002, Anderson and Gans 2011).

Lastly, Gritckevich, Katona, and Sarvary (2018) develop an analytical model focusing on the publishers, ad-blockers, and consumers. Although this paper is conceptually the closest one to our paper, we examine the ad-blocker paper differently in two ways. Firstly, we try to find the optimal strategies that the publishers should follow. Secondly, we focus on this problem in monopolistic and duopolistic markets. To best of our knowledge, we are the first ones approaching this issue in a duopolistic market.

3 Publishers

3.1 Model Setup

Consider a multi-sided market with two sides: users and publishers.

Users maximize their utility from consuming unique content and decide how much content to consume from each publisher. Their utility increases in the amount of unique content consumed, and incur some disutility if the content consumed across different outlets are overlapping, or formally, if they are substitutes. They also incur a disutility if the content they consume is interrupted by ads and if they have to pay a price to access the content.

Publishers are content providers- they produce and distribute content online. They earn

revenues from advertising or subscription fees. Publishers are profit maximizers.

In this eco-system, we introduce the possibility of users' adoption of an ad-blocker. Ad-blockers can be independent tools or can be partly integrated into the browser. Users can can install an ad-blocker when they are willing to avoid the ads. When a user installs an ad-blocking tool, publishers cannot serve her an ad impression, and cannot earn advertising revenues from her. Take, for instance, a user who uses Chrome to access the New York Times using an ad-blocker. This user will not be served an ad by the New York Times.

We capture consumers' sensitivity towards ad content with by assuming that the preferences are heterogeneous. Specifically, let's assume that an exogenously set proportion of users have a sufficiently high disutility from seeing ads that they choose to use an ad-blocker software to avoid seeing any ads. Since advertising is the main revenue source for publishers, they can follow different strategies to reduce the profit harm coming from the users who block ads. Each publisher chooses its content quality v_i that will be shown to the x_i users and subscription fee p_i that will be charged on those who subscribe ($x_{subs,i}$) while deciding on its optimal strategy. We constraint v_i and p_i to take only positive values ($v_i > 0$ and $p_i > 0$). The publisher can have two types of revenue based on the strategy it follows: (1) advertising revenue and (2) subscription revenue. Advertising revenue $\pi_{ad,i}$ comes from the users who see the ads that $\pi_{ad,i} = x_{ad,i} yq$ where $x_{ad,i}$ is the number of customers who see the ads, y [1] [2] is the number of ads shown on the web page, and q is the ad revenue each ad each customer that yq yields the ad revenue each customer. Subscription revenue $\pi_{sub,i}$ comes from the users who subscribe to avoid the ads that $\pi_{sub,i} = x_{subs,i} p_i$ where p_i yields the subscription fee. The publisher has to consider the cost of producing content while deciding on its strategy.

Publisher's Cost:

We follow Liu et al. (2004) deciding on the relationship between publisher cost and content quality. The amount the publisher spends to improve the content is the main spending. The higher a publisher spends on the content, the higher quality it gets. However, higher spending doesn't bring higher content quality equally. When the amount the publisher spends increases, the speed of the content quality increase decreases. So, we

[1] The number of ads shown on the web page is exogenous. See Godes et al. (2009) for a model with endogenous number of ads. They endogenize the number of ads while they exogenize the content quality.

[2] The number of ads is equal for the firms since they are identical.

assume a quadratic function to explain the relationship between the amount the publisher spends and the content quality. There is an exogenous parameter c in the cost function. Although there is a fixed cost of the publisher (such as physical spending), we normalize it to 0[3]. In this case, the content spending of Publisher i is given by cv_i^2 where c is the cost constant and v_i is the content quality of Publisher i.

In our setup, firstly, the user maximizes his/her utility by consuming content. There are different user segments with utilities accordingly. Then, the publisher finds out its demand of each user segment after the amount of content that would maximize the user's utility. The publisher decides on its content quality (v_i) and subscription fee (p_i) to maximize its profit for each strategy. Finally, the publisher finds its optimal profit for each strategy it could follow and decides which one to follow. Below, we present the user segments and describe the utility of users followed by publisher strategies. Then, we analyze the model in monopolistic and duopolistic markets.

3.2 The User Segments

There are two user segments conditional on their ad-blocker usage: (a) the users who do not use an ad-blocker [4] and (b) the users who use an ad-blocker (they avoid seeing ads). There are two user subsegments among those who use an ad-blocker conditional on their disutility of seeing ads: (1) the users with low ad disutility (Low Type), and (2) the users with high ad disutility (High Type). We assume that a user is high type with a probability of α while s/he is low type with a probability of $1 - \alpha$. Only the users who use an ad-blocker are in our interest.

Both types of users have the disutility of seeing ads and of spending money. We assume that while the users are homogeneous in terms of the disutility of spending money, they are heterogeneous in terms of the disutility of seeing ads. There are low and high types of users. Low type has the ad seeing disutility of d while high type disutility is $(d + \delta)$. High type disutility is bigger than low type disutility ($\delta > 0$).

The users make decisions based on the publishers' offers. If the publisher does not offer subscription, the users either turn off the ad-blocker or leave. In this case, if they turn off the ad-blocker, they have the utility of consuming the content and the disutility of

[3] Fixed cost has no impact on the equilibrium. We normalize it to 0 without the loss of generality

[4] This segment has no impact on the equilibrium because they already see the ads. We normalize the ad income coming from this segment to 0 without loss of generality.

substitutable contents as well as seeing the ads. If the publisher offers subscription, the user either subscribes or turns off the ad-blocker, or leave. In case they subscribe, they have the utility of consuming the content and the disutility of substitutable contents as well as paying the subscription fee (p). If they turn off the ad-blocker (instead of subscription due to the subscription fee),they have the utility of substitutable contents as well as seeing the ads. If they leave, their utility is 0. In case the publisher offers subscription, we assume that the user follows a decision path. The user firstly decides on the subscription offer: s/he either subscribes or does not subscribe. When the user does not subscribe, s/he either turns off the ad-blocker or leaves.

3.3 The Utility of Users

We set our model up based on the work of Singh and Vives (1984) and Godes, Ofek, and Sarvary (2009). The user maximizes his/her utility:

$$U(x_1, \ldots., x_N) = \sum_{i=1}^{N} x_i v_i - D(x_1, \ldots., x_N) \tag{1}$$

$$D(x_1, \ldots., x_N) = x_i dy + x_i p_i + \frac{1}{2}(\sum_{i=1}^{N} x_i^2 + 2\phi \sum_{i \neq i'} x_i x_{i'}) \tag{2}$$

where $i = 1, \ldots.., N$ are the publishers, x_i is the amount of content i a user consumes, and v_i is the content value that a user places on content i. We measure the value of the content with content quality. The user has the utility of seeing the content which is equal to the sum of the multiplication of each content and its value. We assume that the utility function is strictly concave.The users have a disutility $D(x_1, \ldots., x_N)$ of seeing the ads, spending the subscription fee, and consuming more content of each publisher (captured by x_i^2) and substitute contents offered by different publishers (captured by $x_i x_{i'}$). d is the disutility of seeing the ads (d and $d + \delta$ accordingly) and y is the number of ads. $x_i dy$ is equal to the total disutility of seeing ads. p_i is the subscription fee. Hence, $x_i p_i$ is the total disutility of subscribing. The disutility coming from the substitutable contents exists only in non-monopolistic markets and the reason it exists is that the user sees repetitive contents. ϕ captures the degree of substitutability ($0 < \phi < 1$) among content. A small value of ϕ indicates that the substitutability of the content provided by different publishers is low, indicating that the content of each publisher is differentiated. A high value, on the other hand, indicates the content provided by the publishers are

close substitutes, where $\phi = 1$ indicates perfect substitution rate. We assume that the content of publishers are never perfect substitutes ($\phi < 1$).

3.4 The Publisher Strategies

The publishers compete in content provision. Producing better (which, we will refer to as "quality") content has a potential of an increase in demand, accordingly advertising and subscription revenues. At the same time, higher quantities of content is costly to produce. Hence, the producer must follow a certain strategy to maximize its total revenue. There are strategies that the publishers follow against the ad-blockers although some of them give content access to all users. Some publishers do not show their content unless the user turns off the ad-blocker (such as suddeutsche.de) while some others offer an ad-free version of the website (by subscribing such as bild.de). Other strategies to follow are asking for a donation (such as theguardian.com) and presenting the ads as real content (such as buzzfeed). In our model, we focus on the first three strategies. In this environment, publishers maximize revenue by choosing the optimal content quality and the subscription fee. We present the decisions the publishers make in these three strategies below:

Strategy 1: Free access for all (S1). Under this strategy, the publishers compete in the content provision. They allow all users to access their content independent of the user's ad-blocker usage (they give access to those who even have an ad-blocker installed). Thus the only source of revenue for the publishers is advertising revenue obtained from the users who do not have an ad-blocker installed. In our model, we do not focus on this strategy because the publishers have an advertising revenue of these users no matter which strategy it follows. Since a publisher that follows this strategy does not have a subscription revenue or an advertising revenue from those who have an ad-blocker installed, this strategy is dominated.

Strategy 2: Turn off the ad-blocker or leave (S2): in this strategy, each publisher maximizes its advertising revenue by providing content to those who see ads. The publishers decide on the optimal content quality ($v > 0$) simultaneously. Higher content quality increases the user's utility, accordingly brings more users. The publishers that follow this strategy do not offer a subscription option to the users. They do not show their content to ad-blocker users. Those who use an ad-blocker have two options: (1) turning off the ad-blocker and (2) leaving the website. When the user turns off the ad-blocker, s/he has to see the ads to consume the content. This means the only revenue of

the publishers that follow this strategy comes from advertising. Publisher i's total profit $\pi^P_{i,S2}$ in Strategy 2 is equal to its advertising revenue ($\pi^P_{i,ad,S2}$): $\pi^P_{i,S2}=\pi^P_{i,ad,S2}$.

Strategy 3: Subscribe or turn off the ad-blocker or leave (S3): in this strategy, each publisher maximizes its revenue obtained by advertising and subscription by providing content to the users. The publishers decide on the optimal content quality ($v > 0$) and the optimal subscription fee ($p > 0$) simultaneously. The publishers that follow this strategy do not show their content to ad-blocker users. There are two ways for an ad-blocker user to see the content: (1) turning off the ad-blocker or (2) subscribing the website. If the publisher follows this strategy, the user has to see the ads or pay a subscription fee for an ad-free version of the website to consume the content. Otherwise, the user leaves. Publisher i's total profit $\pi^P_{i,S3}$ in Strategy 3 is the sum of its advertising revenue $\pi^P_{i,ad,S3}$ and subscription revenue $\pi^P_{i,subs,S3}$: $\pi^P_{i,S3}=\pi^P_{i,subs,S3}+\pi^P_{i,ad,S3}$.

Strategy 1 is divided from Strategies 2 and 3 in a certain way: giving content access to those who use an ad-blocker. While a publisher who follows Strategy 1 gives access to the users who use an ad-blocker, a publisher who follows Strategy 2 or Strategy 3 actively blocks them. The main difference between Strategy 2 and Strategy 3 is offering subscription to the users.

We consider an online market where the publisher(s) could be in monopolistic or duopolistic markets. We will first analyze the monopolistic case and then, move on to the duopolistic case and explore the impact of competition. For each market, we firstly derive the demand under each strategy the publisher could follow then, analyze these strategies by deriving the optimal content quality, the subscription fee, and total revenue. Finally, we show which strategy a publisher follows under certain circumstances.

4 Analysis

4.1 Monopoly

4.1.1 User Demand under Each Strategy

When a publisher follows Strategy 2, a low type user who consumes x_i amount of Publisher i's content by seeing the ads has the utility

$$U(x) = xv - xdy - \frac{1}{2}x_2 \tag{3}$$

and a high type user who consumes the content has the utility

$$U(x) = xv - x(d+\delta)y - \frac{1}{2}x_2 \tag{4}$$

where v is the content value and d is the disutility of seeing ads for the low type users and $d+\delta$ is the disutility of seeing ads for the high type users ($\delta > 0$). y is the number of ads they see. The disutility of subscribing does not exist here because the publisher does not offer subscription. The x value that maximizes the utility function in a monopoly market (x^M) for the low type users is given by

$$x^M = v - dy, \tag{5}$$

for the high type users is given by

$$x^M = v - (d+\delta)y \tag{6}$$

Now, we focus on the case that the publisher follows Strategy 3. When a user (low or high type) subscribe the website, s/he has the utility

$$U(x) = xv - xp - \frac{1}{2}x^2 \tag{7}$$

where p is the subscription fee and v is the content value. The disutility of seeing ads does not exist here because the users subscribe and they have access to the ad-free version of the website. The x value that maximizes the utility function of a user who subscribe in a monopoly market (x^M) for low and high types of users is given by

$$x^M = v - p \tag{8}$$

Rest of the users will either turn off the ad-blocker or leave. The number of users who turn off the ad-blocker will be equal to the difference between the number of users when the publisher does not offer subscription and the number of customers who subscribe when the publisher offers subscription. The number of low type users who turn off the ad-blocker instead of subscribing when the publisher follows Strategy 3 is given by

$$x^M = p - dy, \tag{9}$$

and the number of high type users who turn off the ad-blocker instead of subscribing when the publisher follows Strategy 3 is given by

$$x^M = p - (d + \delta)y, \tag{10}$$

4.1.2 The Publisher's Strategy

The monopolist publisher chooses the strategy in the existence of ad-blocker to maximize its profit. The publisher's profit is the sum of its profit from advertising fees (π^M_{ad}) when it follows Strategy 2 and the sum of its advertising revenue (π^M_{ad}) and subscription revenue (π^M_{subs}) when it follows Strategy 3 ($\pi^M_{ad} + \pi^M_{subs}$). We present the monopolist publisher's optimal income below when it follows the strategies presented above as well as its optimal content quality and subscription fee (in Strategy 3). We normalize the advertisement income from non-ad-blocker users to 0. y is the number of ads that a user sees and q is the ad income per ad per customer. We assume that q and y are exogenous variables.

Strategy 1:

In this strategy, the publisher allows everyone to access its content for free. There is no profit coming from the ad-blocker users. The number of low type users $(1 - \alpha)v$ and the number of high users αv. Hence, the total number of users is v. However, these users don't bring any income since they don't see any ads and they don't pay for subscription. Hence, the total income of the publisher that follows Strategy 1 (π^M_{S1}) is 0. Because this strategy is never optimal, we don't focus on it in the following steps.

Strategy 2:

In this strategy, the publisher has only advertising income from the users who turn off the ad-blocker. Both user types either turn off the ad-blocker and see the content or they leave. The publisher has an ad income coming from the users who turn off the ad-blocker. In this strategy, the number of low type users is $(1-\alpha)(v-dy)$ and the number of high type users is $\alpha(v-(d+\delta)y)$. Total number of users is $v-(d+\alpha\delta)y$.The ad income coming from each user is the multiplication of the number of ads (y) and the ad-income each ad each user (q). The profit of the publisher is the difference between the ad income and content spending. The total profit ($\pi^M_{i,S2}$) is given by

$$\pi^M_{S2} = \pi^M_{S2,ad} - cv_i^2 = (v-(d+\alpha\delta)y)yq - cv^2$$

where $\mathrm{v}^{M*}_{S2} = \frac{qy}{2c}$.

Proposition 1. *Under Strategy 2, there exists a unique equilibrium. In equilibrium, a monopolist publisher sets its content quality at* $v^{M*}_{S2} = \frac{qy}{2c}$ *and gets a profit of*

$$\pi^{M*}_{S2} = \frac{(q-4c(d+\alpha\delta))qy^2}{4c}.$$

An immediate result is that when producing content is costly, the publisher decreases its content quality and accordingly, the revenue decreases.

We focus on the case that v and π take only positive values. Hence, we include the condition that $c < \frac{q}{4(d+\alpha\delta)}$. It can be easily seen that the optimal content quality ($v*$) increases with q and y while it decreases with c. When the publisher's content producing cost constant (c) is high, the optimal revenue (π) decreases because of two reasons: (1) higher cost constant (c) decreases the optimal content quality (accordingly the number of users who turn off the ad-blocker) and (2) it increases the content producing expenses. Likewise, higher user disutility of seeing ads as well as higher proportion of high type users decrease the optimal revenue. In this strategy, the publisher does not offer subscription. Its revenue depends on only advertising. When the users' disutility of seeing the ads is high, they tend to leave the website instead of turning the ad-blocker off to access the content. Ad amount (y) and ad income each user each ad (q) play a different role. When the publisher's content producing cost constant is low, these parameters increase the optimal revenue. However, when the cost constant is high, they decrease the revenue. We can here conclude that when producing content is cheaper, although the publisher loses some of its users, its revenue increases by higher amount of ads and ad price.

Strategy 3:

In this strategy, the publisher offers two options to the users: (1) turning the ad-blocker off and see the ads and (2) subscribing. Its total income is the summation of its income from subscription fees and advertising. The users either pay for subscription fee for an ad-free version or turn off the ad-blocker or leave. As in Strategy 2, the disutility of seeing the ads for user types are d and $(d+\delta)$ respectively. The number of users who subscribe for an ad-free version is $(1-\alpha)(v-p)$ and $\alpha(v-p)$ for low and high types respectively. Hence, the total number of users who subscribe is equal to $v-p$. The rest of the users either turn off the ad-blocker or leave. The number of users who turn off the ad-blocker is $(1-\alpha)(p-dy)$ and $\alpha(p-(d+\delta)y)$ for low and high types respectively. In this strategy, the publisher has to decide on the optimal subscription fee ($p*$) and the optimal content quality ($v*$) to get the optimal profit (π_{S3}^{M*}). The total revenue (π_{S3}^{M}) is given by

$$\pi_{S3}^{M} = \pi_{S3,subs}^{M} + \pi_{S3,ad}^{M} - cv_i^2 = (v-p)p + (p-(d+\alpha\delta)y)yq - cv^2$$

where $p_{S3}^{M*} = \frac{2cyq}{4c-1}$ and $v_{S3}^{M*} = \frac{yq}{4c-1}$.

Proposition 2. *Under Strategy 3, there exists a unique equilibrium. In equilibrium, a monopolist publisher sets its subscription fee at* $p_{S3}^{M*} = \frac{2cyq}{4c-1}$ *and content quality at* $v_{S3}^{M*} = \frac{yq}{4c-1}$ *and gets a profit of*

$$\pi_{S3}^{M*} = \frac{((1-4c)(d+\alpha\delta)+cq)qy^2}{4c-1}.$$

We have the following main results:
(i). When producing content is costly, the publisher offers only one option to the users because high content production cost lowers the content quality as well as the subscription fee, accordingly the revenue.
(ii). Having users with high ad avoidance forces the publisher to offer subscription option.

We focus on the case that v, p, and π take only positive values. Hence, we include the condition that $c < \frac{d+\alpha\delta}{4(d+\alpha\delta)-q}$. Accordingly, when the publisher's cost constant increases, the optimal subscription fee (p) and content quality (v) decrease. We see here that no matter which strategy the publisher follows, higher cost constant decreases the content quality. Hence, the optimal profit (π) decreases.

We compare the optimal profit of a monopolistic publisher to find out under which range it should follow Strategy 2 (π_{S2}^{M*}) and Strategy 3 (π_{S3}^{M*}). If $c > \frac{1}{2}$, the monopolist publisher follows Strategy 3 ($\pi_{S3}^{M*} > \pi_{S2}^{M*}$). Hence, the publisher offers subscription when

$\frac{1}{2} < c < \frac{d+\alpha\delta}{4(d+\alpha\delta)-q}$ and it does not offer subscription when $c < \frac{1}{2}$. This result proves that when the publisher's cost constant (c) is high, it offers subscription option to the users. In this range, the optimal subscription fee as well as the optimal content quality are low. Low subscription fee increases the number of users who subscribe while low content quality decreases the number of users who turn off the ad-blocker to access the content. In this case, the publisher avoids offering only one option to the users. Instead, it offers two options including the subscription option which creates a higher revenue to the publisher. Strategy 3 more profitable. Similarly, when the proportion of users with high ad-seeing disutility (α) increases, the publisher tends to follows Strategy 3. This means that forcing the users with high ad avoidance to see the ads instead of subscribing harms the publisher's revenue. The publisher does not offer subscription (follows Strategy 2) when producing content is cheaper and the users' ad avoidance is low.

4.2 Duopoly

4.2.1 User Demand under Each Strategy

When a duopolistic publisher follows Strategy 2, a low type user who consumes x_i amount of Publisher i's content by seeing the ads has the utility

$$U(x_1, x_2) = x_1 v_1 + x_2 v_2 - (x_1 + x_2)dy - \frac{1}{2}(x_1^2 + x_2^2 + 2\phi x_1 x_2) \tag{11}$$

and a high type user who consumes x_i amount of Publisher i's content by seeing the ads has the utility

$$U(x_1, x_2) = x_1 v_1 + x_2 v_2 - (x_1 + x_2)(d+\delta)y - \frac{1}{2}(x_1^2 + x_2^2 + 2\phi x_1 x_2) \tag{12}$$

where v is the content value, d and $(d+\delta)$ are the disutility of seeing each ad for low and high types of users respectively ($\delta > 0$). y is the number of ads they see. The disutility of subscribing does not exist here because the publisher does not offer it. The x value that maximizes the utility function in a duopolistic market (x^D) for a low type user is given by

$$x_i^D = \frac{1}{(1-\phi^2)}(v_i - \phi v_{i'} + (\phi - 1)dy), \quad i = 1, 2. \tag{13}$$

for high type users is given by

$$x_i^D = \frac{1}{(1-\phi^2)}(v_i - \phi v_{i'} + (\phi - 1)(d+\delta)y), \quad i = 1, 2. \tag{14}$$

When a duopolistic publisher follows Strategy 3, both types of users who consume x_i amount of Publisher i's content by seeing the ads have the utility

$$U(x_1, x_2) = x_1 v_1 + x_2 v_2 - (x_1 p_1 + x_2 p_2) - \frac{1}{2}(x_1^2 + x_2^2 + 2\phi x_1 x_2) \tag{15}$$

where p is the subscription fee and v is the content value. The disutility of seeing ads does not exist here because the users subscribe. The x value that maximizes the utility function in a duopolistic market (x^D) is given by

$$x_i^D = \frac{1}{(1-\phi^2)}(v_i - p_i - \phi(v_{i'} - p_{i'})), \quad i = 1, 2. \tag{16}$$

Rest of the users will either turn off the ad-blocker or leave. The number of users who turn off the ad-blocker will be equal to the difference between the number of users in case the publisher does not offer subscription and the number of customers who subscribe when the publisher offers subscription. The number of low type users who turn off the ad-blocker when the publisher follows Strategy 3 is given by

$$x_i^D = \frac{1}{1-\phi^2}(p_i - \phi p_{i'} + (\phi - 1)dy), \quad i = 1, 2. \tag{17}$$

and the number of high type users who turn off the ad-blocker when the publisher follows Strategy 3 is given by

$$x_i^D = \frac{1}{1-\phi^2}(p_i - \phi p_{i'} + (\phi - 1)(d + \delta)y), \quad i = 1, 2. \tag{18}$$

4.2.2 The Publisher's Strategy

In a duopoly, each publisher follows the strategy that maximizes its income in the existence of ad-blockers simultaneously. Because Strategy 1 is never optimal, we ignore it in the duopoly case as well. We normalize the advertisement income from non-ad-blocker users to 0 for both publishers. As in the monopoly case, Publisher i's income is equal to the ad income if it follows Strategy 2 and the sum of its income from the ads ($\pi^D_{i,S3,ad}$) and subscriptions ($\pi^D_{i,S3,subs}$), if it follows Strategy 3. The profits of Publisher i in Strategy 2 and Strategy 3 (respectively $\pi^D_{i,S2}$ and $\pi^D_{i,S3}$) are given by

$$\pi^D_{i,S2} = \pi^D_{i,S2,ad} - cv_i^2$$

$$\pi^D_{i,S3} = \pi^D_{i,S3,ad} + \pi^D_{i,S3,subs} - cv_i^2$$

We present the publishers' incomes in an equilibrium when they follow Strategy 2 and Strategy 3.

Strategy 2

In this strategy, each publisher decides on its content quality (v) that maximizes its profit. The number of low type users is $\frac{1-\alpha}{(1-\phi^2)}(v_i - \phi v_{i'} + (\phi-1)dy)$ and the number of high type users is $\frac{\alpha}{(1-\phi^2)}(v_i - \phi v_{i'} + (\phi-1)(d+\delta)y)$. Total number of users is

$$\frac{1}{(1-\phi^2)}((v_i - \phi v_{i'}) + (\phi-1)(d+\alpha\delta)y).$$

The total income $\pi^D_{i,S2}$ is given by

$$\pi^D_{i,S2} = \pi^D_{i,S2,ad} - cv_i^2 = \frac{1}{(1-\phi^2)}((v_i - \phi v_{i'}) + (\phi-1)(d+\alpha\delta)y)yq - cv_i^2 \qquad (19)$$

where $v^{D*}_{1,S2} = v^{D*}_{2,S2} = \frac{yq}{2c(1-\phi^2)}$.

Proposition 3. *Under Strategy 2, there exists a unique equilibrium. In equilibrium, a duopolist publisher sets its content quality at* $v^{D*}_{1,S2} = v^{D*}_{2,S2} = \frac{yq}{2c(1-\phi^2)}$ *and gets a profit of*

$\pi^{D*}_{i,S2} = \frac{(q(1-2\phi)-4c(1-\phi^2)(1+\phi)(d+\alpha\delta))qy^2}{4c(1-\phi^2)^2}$

Immediate results show that
(i). When the publisher's product is more common, it increases the quality. However, it could still be non-profitable.
(ii). Competition increases the content quality in Strategy 2.

We focus on the case that v and π take only positive values. Hence, we include the condition that $c < \frac{q(2\phi-1)}{4(d+\alpha\delta)(\phi-1)(\phi+1)^2}$. When we take the derivative of the optimal content quality based on the substitutability, we get $\frac{\partial v^{D*}_{S2}}{\partial\phi} = \frac{qy\phi}{c(\phi^2-1)^2}$. This value is always positive showing that when the substitutability increases, the optimal content quality increases, too. It means that the publisher that has a more common content produces higher quality content. When we take the derivative of the optimal content quality based on the publisher's cost constant, we get $\frac{\partial v^{D*}_{S2}}{\partial c} = \frac{qy}{2c^2(\phi^2-1)}$. This value is always negative showing that when content production is costly, the optimal content quality decreases. Lastly, higher q and y values increase the content quality meaning that when the publisher earns more form advertising, it increases the content quality.

How the publisher's optimal profit in Strategy 2 in duopoly (π^{D*}_{S3}) changes based on the substitutability (ϕ) is seen in Figure 1. The graph and the derivative of the optimal profit based on the substitutability[5] show us that when the substitutability of the content

[5] $\frac{\partial\pi^{D*}_{S2}}{\partial\phi} = \frac{-2c(d+\alpha\delta)(\phi-1)(\phi+1)^3+q\phi(3\phi-2(1+y^2))+q}{2c(\phi^2-1)^3}$

is low (in other words, the content is uncommon), the optimal profit value is positive. However, this value decreases when the publisher starts producing a common content. It is important to note that higher c values makes Strategy 2 non-profitable even in the case that the content is not substitutable. This means that the publisher prefers not to produce content when it is costly to produce it. Lastly, the optimal profit value decreases by higher d and δ although the effect is not strong. When the publisher has ad-averse users, its profit decreases. However, q and y increases the profit.

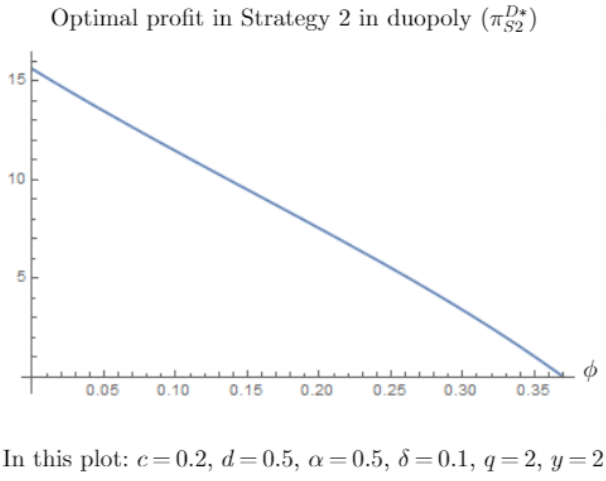

Fig. 1: Publisher's optimal profit in Strategy 2 in duopoly

When we compare Proposition 1 and Proposition 3, we see that $v_{S2}^{D*} > v_{S2}^{M*}$. This shows us that when there is competition in the market (in other words when there are more firms) the optimal content quality increases when the firm(s) follow Strategy 2. Hence, competition increases the content quality in Strategy 2.

Strategy 3

In this strategy, each publisher decides on its subscription fee (p) and content value (v) that maximizes its profit. The users either subscribe, or turn off the ad-blocker, or leave. The number of low type users who subscribe is $\frac{1-\alpha}{(1-\phi^2)}(v_i - p_i + \phi(v_{i'} - p_{i'}))$ and the number of high type users who subscribe is $\frac{\alpha}{(1-\phi^2)}(v_i - p_i + \phi(v_{i'} - p_{i'}))$. Further, the number of low type users who turn off the ad-blocker is $\frac{1-\alpha}{1-\phi^2}(p_i - \phi p_{i'} + (\phi - 1)dy)$ and the number of high type users who turn off the ad-blocker is $\frac{\alpha}{1-\phi^2}(p_i - \phi p_{i'} + (\phi - 1)(d + \delta)y)$. The

total income $\pi^D_{i,S3}$ is given by

$$\begin{aligned}\pi^D_{i,S3} &= \pi^D_{i,S3,subs} + \pi^D_{i,S3.ad} - cv_i^2 \\ &= \frac{1}{(1-\phi^2)}(v_i - p_i - \phi(v_{i'} - p_{i'}))p_i + \frac{1}{(1-\phi^2)}(p_i - \phi p_{i'} + (\phi-1)(d+\alpha\delta)y)yq - cv_i^2\end{aligned} \tag{20}$$

where

$\mathrm{p}^{D*}_{1,S3} = p^{D*}_{2,S3} = \frac{2qyc(1+\phi)}{1+2c(1+\phi)(2\phi^2+\phi-2)}$ and $v^{D*}_{1,S3} = v^{D*}_{2,S3} = \frac{qy}{(1-\phi)(1+2c(1+\phi)(2\phi^2+\phi-2))}$.

Proposition 4. *Under Strategy 3, there exists a unique equilibrium. In equilibrium, a duopolist publisher sets its subscription fee and content quality at their optimal values presented above and gets a profit of*

$$\pi^{D*}_{S3} = qy^2\left(\frac{cq(4c(2\phi-1)(\phi^2-1)^2+2\phi^2-6\phi+3)}{(\phi-1)^2(c(4\phi^3+6\phi^2-2\phi-4)+1)^2} - \frac{d+\alpha\delta}{\phi+1}\right)$$

The immediate results are
(i). Having a common content decreases the publisher's revenue in this strategy.
(ii). Competition increases the content quality unless the publisher has a more special content and producing it is costly.
(iii). Competition decreases the subscription fee unless the publisher has a more special content and producing it is less costly.
(iv). When the publisher has a more common content, it offers more options (turn off the ad-blocker and subscription) to the users.

We focus on the case that v, p, and π take only positive values. Hence, we include the condition that $\frac{2qyc(1+\phi)}{1+2c(1+\phi)(2\phi^2+\phi-2)} > 0$, $\frac{qy}{(1-\phi)(1+2c(1+\phi)(2\phi^2+\phi-2))} > 0$, and $qy^2\left(\frac{cq(4c(2\phi-1)(\phi^2-1)^2+2\phi^2-6\phi+3)}{(\phi-1)^2(c(4\phi^3+6\phi^2-2\phi-4)+1)^2} - \frac{d+\alpha\delta}{\phi+1}\right) > 0$. When the publisher's cost constant of producing content (c) is low, the optimal content quality increases with substitutability. However, this changes for higher cost constant values. In this range, higher substitutability causes lower content quality. Finally, producing content becomes non-profitable for high cost constant values independent of substitutability. This means that when producing content is not costly to the publisher, it produces higher quality content if its content is common while it produces lower quality content if its content is uncommon. However, when producing content is costly, the publisher's behavior would be the opposite. Another point is on the optimal subscription fee. When we take the derivative of the optimal subscription fee based on the substitutability, we get $\frac{\partial p^{D*}_{S3}}{\partial\phi} = -\frac{2c(-1+2c(1+\phi)^2(1+4\phi))qy}{(1+2c(1+\phi)(2\phi^2+\phi-2))^2}$. This result proves that higher substitutability firstly increases the optimal subscription fee (p^{D*}_{S3}).

It takes its highest value when $\phi = -\frac{(2\sqrt{2}\sqrt{c^4(c+2)}-c^2(c+4))^{1/3}+c(3+\frac{c}{(2\sqrt{2}\sqrt{c^4(c+2)}-c^2(c+4))^{1/3}})}{4c}$. After this value, the optimal subscription fee decreases with substitutability. It shows that when the content is highly uncommon or common, the publisher decreases the subscription fee.

Publisher's optimal profit in Strategy 3 in duopoly (π_{S3}^{D*}) is a power function of ϕ. How it changes based on the substitutability (ϕ) is seen in Figure 2. The graph and the derivative of the optimal profit based on the substitutability[6] show that when the substitutability of the content increases, the optimal profit value firstly increases, then decreases and becomes non-profitable when the substitutability of the content high. It means that if the publisher's content gets more common, the publisher loses revenue. Finally, when the publisher's content is too common, it becomes non-profitable and the publisher does not produce content. d, α, and δ decrease the profit while q and y increases it. When the users are more ad-averse, the publisher loses revenue while higher ad income increases it. Lastly, we focus on the publisher's cost constant (c). When the content is more uncommon, higher cost constant decreases the optimal revenue and makes the content non-profitable. However, when the content is more common, higher cost constant increases the revenue.

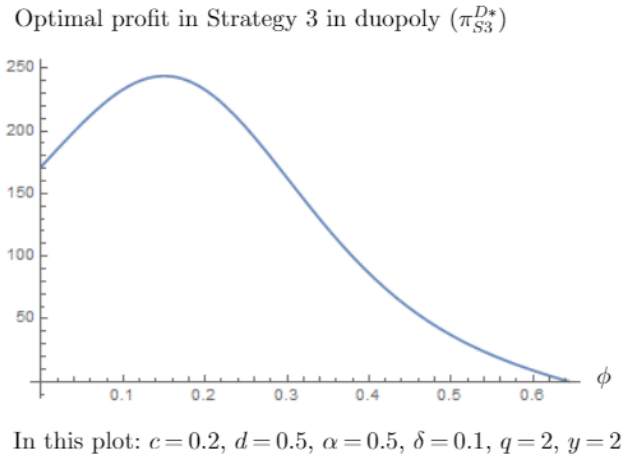

Fig. 2: Publisher's optimal profit in Strategy 3 in duopoly

When we compare Proposition 2 and Proposition 4, we can see how competition changes the optimal subscription fee (p_{S3}^*) and content quality (v_{S3}^*) in Strategy 3. The comparison shows us that when the publisher's cost constant (c) is small, the optimal content quality in duopoly (v_{S3}^{D*}) is higher than the optimal content quality in monopoly (v_{S3}^{M*}). However, the results change when the publisher's cost constant (c) is large. In this case,

6 $\frac{\partial \pi_{S3}^{D*}}{\partial \phi} = qy^2\left(\frac{d+\alpha\delta}{(1+\phi)^2} - \frac{2qc(-\phi+2c(3+(\phi-4)\phi(5+\phi(6\phi^2-2\phi-7))+4c(\phi-1)^3(\phi+1)(1+\phi(6\phi^3+9\phi^2+\phi-4))))}{(\phi-1+2c(1+\phi^2(2\phi^2+\phi-4)))^3}\right)$

the optimal content quality in duopoly (v_{S3}^{D*}) is higher than the optimal content quality in monopoly (v_{S3}^{M*}) when the content substitutability (ϕ) is large while the optimal content quality in duopoly (v_{S3}^{D*}) is lower than the optimal content quality in monopoly (v_{S3}^{M*}) when the content substitutability (ϕ) is low. This result implies that competition increases the content quality unless the publisher's cost constant (c) is large and the content substitutability (ϕ) is low at the same time. Hence, when the publisher's product is uncommon and producing it is not costly, the publisher produces a lower quality content when it is in competition with another publisher. In the same case, when the publisher does not offer subscription, competition increases the content quality. We conclude that the only case that competition decreases the content quality is when the publisher offers subscription and its product is uncommon and cheaper to produce.

Competition has a different effect on the optimal subscription fee (p_{S3}^{*}). The comparison shows us that when the publisher's cost constant (c) is very small, the optimal subscription fee in duopoly (p_{S3}^{D*}) is higher than the optimal subscription fee in monopoly (p_{S3}^{M*}). However, the results change when the publisher's cost constant (c) gets larger. In this case, the optimal subscription fee in monopoly (p_{S3}^{M*}) is smaller than the optimal subscription fee in duopoly (p_{S3}^{D*}) when the content substitutability (ϕ) is very large. The optimal subscription fee in monopoly (p_{S3}^{M*}) is greater than the optimal subscription fee in duopoly (p_{S3}^{D*}) when the content substitutability (ϕ) is low. This result implies that competition decreases the subscription fee unless the publisher's cost constant (c) is very small or the publisher's cost constant (c) and the content substitutability (ϕ) are big at the same time. This implies that competition increases the subscription fee if producing content is not costly. Similarly, competition increases the subscription fee if producing it is costly but it is common. However, competition decreases the subscription fee other than these very special cases.

Regarding the publisher's optimal strategy in a duopolistic market, we compare the publisher's optimal profit in case it follows Strategy 2 (π_{S2}^{D*}) and Strategy 3 (π_{S3}^{D*}). The publisher has a complicated decision to make. Hence, we explain the results over 3 graphs. They show which strategy is more profitable based on the content producing constant. The first graph is the case when $\phi = 0.3$, the second graph is the case when $\phi = 0.6$, and the last graph is the case when $\phi = 0.8$. The publisher decides on the optimal strategy to follow by looking at the difference difference between its optimal profit when it follows Strategy 2 and Strategy 3 (π_{S2}^{D*}-π_{S3}^{D*}). Figure 3 shows the results. We conclude that when the content substitutability is small, the duopolistic firm follows Strategy 2. When the content substitutability gets higher, the case that the publisher follows Strategy 3 in-

creases. Finally, when the substitutability is high, the publisher follows Strategy 3. This proves that when the publisher has an uncommon content, it does not offer subscription to the users. In this case, the users have to turn off the ad-blockers or leave. However, when the content specialty decreases, the publisher gets closer to offering multiple options to the users to be chosen. Firstly, the cost constant of content production determines the strategy. If producing content is costly, the publisher still does not offer subscription. However, if producing content is not costly, then, the publisher offers subscription option. It is important to note that when the cost constant is small, content quality increases with substitutability when the publisher offers subscription.

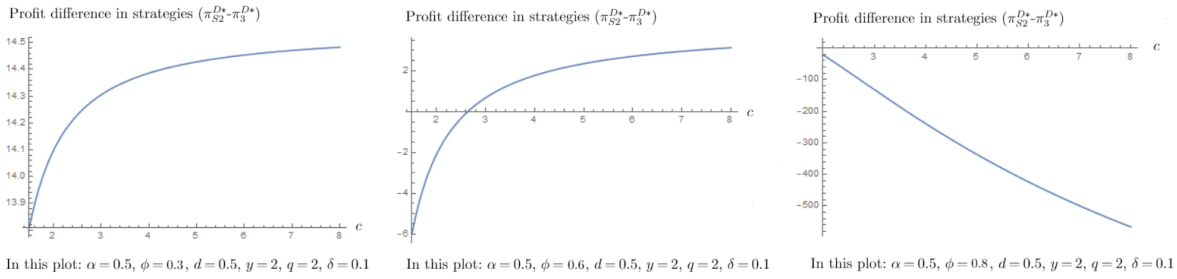

Fig. 3: Optimal strategy to follow in duopolistic markets

5 General Discussion

In this paper, we have developed an analytical model to evaluate the strategies that the publishers follow against ad-blockers. In many cases, the publishers' main income is ads. However, the users have the disutility of seeing ads. This is why they download ad-blockers to avoid them. This could turn to a big problem for the Internet community because this means a shortage for the publisher income and this could cause the content quality to decrease or even stop. This is why the publishers take precautions against ad-blockers. The most common ones are as follows. The publishers could simply ask the users to turn off the ad-blockers. In this case, either the users turn off the ad-blocker or they don't get access to the website. When the publisher follows this strategy, they could have the income, although they lose some of the users. Another strategy is the subscription model. In this strategy, the users either pay a subscription fee to access the ad-free website or they leave. In this case, the publisher has the income of a subscription fee and ad from the non-ad-blocker users.

In our model, we started with defining the market followed by the user segments. The users have a utility of seeing the content although they have the disutility of seeing the

same or similar content more than once. We define two types of users: (1) those who have lower disutility of seeing the ads and (2) those who have higher disutility of seeing the ads. The users either pay a subscription fee to get access to the ad-free version of the website if the publisher offers it or turn off the ad-blockers or leave. If the publisher does not offer a subscription option, they either turn off the ad-blockers or leave. Following, we analyzed the model for monopoly and duopoly markets. In this analysis, we aimed to reach the optimal content quality and the optimal subscription fee (when the publisher follows Strategy 3) and accordingly the optimal profit. Firstly, we found out the user demand under each strategy the publisher follows in monopoly and duopoly markets. Then, we concluded with the optimal values under each strategy and which strategy the publisher follows. Finally, we showed that when producing content is costly, the publisher produces a content with a lower quality in a monopoly market. This decreases the publisher's revenue. In this range, the publisher does not offer subscription option to the users. However, when producing content is less costly or when the users are highly ad-averse, the publisher offers subscription. After analyzing the duopoly market, we have showed that competition increases the content quality when the publisher follows Strategy 2; however, this effect changes when the publisher follows Strategy 3 and its content is uncommon and costly at the same time. A similar effect exists for the subscription fee. Competition decreases it unless the publisher has an uncommon content which is less costly. Having a common content decreases the publisher's revenue. In this case, the publisher offers more options to the users.

Although ad-blockers is an important topic for today's Internet world, the researchers have recently started working on them. To our best knowledge, there are only a limited number of papers focusing on this topic specifically and only few of them use an analytical model. Among those, again to our best knowledge, our paper is the first one analyzing the subscription model as well as including a duopoly market and show how competition changes the publishers‘ act.

The biggest simplification of our model is limiting the publisher choice down to three. However, the publishers could follow some other strategies such as presenting the ads as if they are the real content or invest in anti-ad-blocker software. Another simplification we made is taking the ad price as an exogenous variable. Since ad-blockers decrease the number of users, the advertisement companies may want to decrease the ad prices. However, making it an endogenous variable would make the model overcomplicated.

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