Strategic Implications of Ad-Blockers and Limited Ad-Blocking

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Abstract

Ad-blockers enable consumers block ads on websites. While ad-blockers began as user-oriented initiatives promising to block all ads, many now allow websites to display a limited amount of ads. We examine whether, when and how, a user-oriented ad-blocker that maximizes the welfare of its ad-averse users, may nevertheless employ *limited ad-blocking (*LAB). Accounting for consumers' ad-blocker adoption and website publisher's content quality decisions, we show that LAB can benefit ad-blocker users by incentivizing content provision, but may do so only if consumers' ad-blocker adoption cost is sufficiently high. Moreover, incentivizing content provision may require that LAB not only improves publisher's ability to monetize high-quality content but also constrains its ability to monetize low-quality content; essentially discouraging ad-blocker users from visiting low-quality websites by not blocking all ads. Despite the debate and controversy surrounding ad-blockers and LAB, we find that they may in fact facilitate "a better world for all": LAB may emerge as a means to discriminate ad intensity across consumers, resulting in higher ad revenue, content quality, consumer surplus and even publisher profit under a user-oriented ad-blocker than in its absence. Interestingly, raising ad-blocker adoption cost can benefit ad-blocker users, leading a user-oriented ad-blocker to charge users a fee.

Keywords: Ad-blockers, Limited Ad-blocking, Online Advertising, Game Theory

1 Introduction

More and more consumers today use ad-blocking software that can block a website from displaying advertisements (ads) when browsing the website. In 2018, almost 25% of U.S. consumers were estimated to be using ad-blockers across various devices (Statista 2019). Examples of firms supplying ad-blocking software include AdBlock, AdBlock Plus, AdGuard, and uBlock, to name a few. Ad-blockers began primarily as user-oriented not-for-profit initiatives, in response to consumer concerns over the proliferation of online ads, with the express goal of providing users an ad-free browsing experience (Malloy et al. 2016). However, many ad-blockers have since shifted to allowing a limited amount of ads to be displayed to their users, with the ad-blocker deciding the format and extent of ads that are allowed (e.g., Marshall 2015, Maheshwari 2016). This partial blocking of ads, which we refer to as *limited ad-blocking* (LAB), has led to consumer complaints and criticism as to whether ad-blockers have abandoned their original goal of protecting and furthering user interests (e.g., Germ 2016, Fivefilters 2017). At the same time, website owners or publishers too have been wary about the rise and impact of ad-blockers. For example, U.S. publishers are estimated to have lost $5.8 billion in ad revenues from blocked ad impressions in 2014 (Pagefair 2015). Thus, ad-blockers have emerged as a force to be reckoned with and there is much debate and controversy regarding their strategies. In this paper, we examine whether, when and how a *user-oriented* ad-blocker (whose objective is to maximize the total welfare of its users) may nevertheless allow some display of ads through LAB, and the resulting impact on consumers, publishers, website content quality and ad revenues.

Many websites are premised on the idea of offering content for free by capturing and monetizing consumers' attention through online ads. In effect, exposure to online ads is the price a consumer pays for the content. In turn, the ad revenue is important to sustain publisher investments in content (Bhat 2015). Content provision is costly since publishers must recruit or compensate content producers. If consumers are able to avoid ads, then it diminishes publishers' return on content provision. Therefore, ad-blocking not only poses a threat to publisher ad revenue, but also to the provision of online content. Moreover, ad-supported content constitutes a substantial portion of consumers' media consumption; upwards of 85% according to Nielsen data (Nielsen 2018). Given the prevalence and importance of ad-supported content for publishers and consumers, it is vital to understand the impact of ad-blockers in this context.

The market need for ad-blockers can be traced to consumers finding online ads distracting, intrusive or outright annoying (e.g., Interactive Advertising Bureau 2016). Publishers' quest to monetize consumer attention has led to a proliferation of online ads not only in their numbers but also in their formats, some of which can be quite disruptive of consumers' browsing experience; for example, animated ads, excessively colorful ads, over-sized ads, pop-up ads, native ads and so on. Moreover, the increase in ad intensity has caused websites to become slower to load or refresh. Consumers have also been concerned about their online privacy and security as ad networks may track their browsing behaviors and also expose them to malware and viruses. Consequently, many consumers find online ads to be problematic and have sought to block them with ad-blockers. At the same time, not all consumers have uniformly adopted ad-blockers. A recent study finds that a fifth of the consumers aware of ad-blockers have adopted the software, with ad-blocker users disliking ads more than non-users due to differences in their browsing tastes and propensities, and concerns about privacy, security and internet bandwidth (Interactive Advertising Bureau 2017). Moreover, a third of non-users report that they are likely to adopt an ad-blocker if there is an increase in disruptive ad formats and intensity, while users report that they are likely to become non-users if websites switch to fewer and less intrusive ad formats (Interactive Advertising Bureau 2016, 2019).

Ad-blocker firms began as user-oriented not-for-profit initiatives in response to consumer concerns with online ads, with the primary goal of creating a better online experience for their users (Malloy et al. 2016). For example, AdBlocker Ultimate's website states: "*Ad-blocker Ultimate is an open source and non-profit project, driven by the idea of making the Internet a better and safer place*".[1] Similarly, "*UBlock Origin's stated purpose is to give users the means to enforce their own (content-filtering) choices*".[2] Thus, the stated objective of ad-blockers has been to improve the welfare of their users. Accordingly, most ad-blockers initially blocked all ads and adopted the business model of making their software available free of charge.[3]

Yet, many ad-blockers no longer block all ads (e.g., Marshall 2015, Maheshwari 2016). Instead, they allow website publishers to display a limited amount of ads to ad-blocker users through LAB. Specifically, the ad-blocker allows ads that conform to certain restrictions or standards (e.g., non-animated, only a certain amount, limited size and placement positions, clearly and explicitly demarcated from main content, not obscuring content). These restrictions, which are set forth by the ad-blocker, effectively limit the ad intensity that publishers can display to ad-blocker users. The ad-blocker software detects the presence of conforming and non-conforming ads on a website, and only allows the former to be displayed to its users. Whereas, ad-blocker non-users see all ads on the website. Consequently, under LAB, ad-blocker users are exposed to ads, albeit fewer and of lower intensity than ad-blocker non-users (Walls et al. 2015, Malloy et al. 2016). Leading examples of LAB standards are the *Acceptable Ads* standard and *Better Ads* standard.[4] Ad-blockers that employ LAB include AdBlock, AdBlock Plus, Crystal and UBlock.

[1] See https://adblockultimate.net/why-us.html.
[2] See https://en.wikipedia.org/wiki/UBlock_Origin.
[3] They may accept voluntary donations to support software development. Other examples of free ad-blockers include AdBlock and AdBlock Plus.
[4] See, for example, https://acceptableads.com/ and https://www.betterads.org/standards/.

Ad-blockers and LAB have led to much debate and criticism from consumers and publishers alike. On the one hand, ad-blocker users complain about having to see ads on websites due to LAB.[5] They accuse ad-blockers of abandoning the goal of protecting and furthering user welfare, and instead shifting to serve publishers by enabling them to display ads to ad-blocker users. On the other hand, even with LAB, publishers have been concerned about the impact of ad-blockers on their ability to monetize content. In fact, the Interactive Advertising Bureau, a leading trade organization for online ads, considers ad-blockers a serious threat to online business models and has called for their boycott (e.g., Shields 2016). Indeed, some publishers have required ad-blocker users to disable the ad-blocker when browsing their website (e.g., Slater-Robins 2015, Wolde 2015). Others, however, have allowed the use of ad-blockers and actively participate in the ad-blocker's LAB, conforming to their restrictions and standards (Walls et al. 2015, Malloy et al. 2016). Ad-blockers themselves contend that LAB is necessary to help sustain online business models and ultimately benefits both ad-blocker users and publishers (O'Reilly 2015, Lazauskas 2016).

The above observations raise questions about the impact of ad-blocker and LAB on publishers, online content, and consumers. How does the advent of a user-oriented ad-blocker impact ad-supported content? Does the recent shift towards LAB necessarily mean that ad-blockers have abandoned their original goal of creating a better online experience for their users? Or, can user-oriented ad-blockers also have an incentive to implement LAB? Does a user-oriented ad-blocker only benefit ad-blocker users? Or, as claimed by some, can it "make the world a better place" for all? These are some of the questions that we wish to study.

To shed light on these issues, we conduct a model-based examination of ad-blocker strategies and their impact. We explicitly model the ad-blocker as a strategic player that maximizes total user welfare (i.e., the surplus of its user base) by deciding the extent to which it blocks ads. We analyze a setting where the publisher decides content quality and ad intensity on its website, consumers differ in their need to adopt the ad-blocker, and the ad-blocker user base is determined endogenously by publisher and ad-blocker strategies.

We find that, compared to a benchmark scenario without the ad-blocker, an ad-blocker that blocks all ads benefits its users; however, it also reduces a publisher's *return on content quality*, i.e., the publisher's incremental ad revenue from investing in high-quality content. In particular, the ad-blocker limits publisher revenue even from ad-blocker non-users, by forcing the publisher to lower its website ad intensity to keep non-users from adopting the ad-blocker. In fact, in the presence of the ad-blocker, the publisher may not invest in high content quality even if the cost of doing so is arbitrarily small.

Consistent with conventional wisdom, LAB improves publisher revenue (relative to blocking all ads). However, it may not always increase the publisher's return on content quality. More specifically, we find that LAB can increase a publisher's return on content quality in two distinct ways: (i) increasing the

[5] See for example "How Adblock Plus Decided To Become Another Sleazy Ad Company" (Germ 2016) and "There are no acceptable ads" (Fivefilters 2017).

publisher's ability to monetize high-quality content by displaying ads to ad-blocker users, and (ii) limiting the publisher's ability to monetize low-quality content by allowing display of sufficient amount of ads so as to discourage ad-blocker users from visiting a low-quality website. Consequently, even a user-oriented ad-blocker may introduce LAB to induce publishers to provide better content. However, LAB may be able to improve user welfare only if consumers' ad-blocker adoption cost is not too low. Furthermore, LAB may be effective in incentivizing high content quality only if it allows sufficient ad intensity so as to curtail traffic to a low-quality website. In this sense, users may perceive (and complain) that LAB allows "too many ads", but it may nevertheless increase their surplus by improving content quality. Interestingly, we also find that more users may adopt the ad-blocker when it employs LAB than when it does not.

Moreover, we find that even the publisher can benefit from the presence of a user-oriented ad-blocker. The ad-blocker essentially induces consumers to sort themselves based on their aversion to ads. Consequently, although LAB constrains the publisher's website ad intensity, it may nevertheless emerge as a means to sufficiently discriminate ad intensity across consumers. As a result, a user-oriented ad-blocker's LAB may lead to a win-win for all: the publisher, ad-blocker users and non-users may all be better off, and website ad revenue and content quality may both be higher, than in the absence of the ad-blocker. We also find that a user-oriented ad-blocker may charge its users a fee; such a fee may effectively shift the burden of incentivizing higher content quality from ad-blocker users to non-users.

Overall, our findings suggest that even a user-oriented ad-blocker may introduce LAB and benefit publishers. Our results may explain why ad-blockers remain popular amongst consumers despite LAB, and why some publishers actively participate in LAB rather than discourage the use of ad-blockers on their websites by requiring ad-blocker users to disable the ad-blocker.

1.1 Related Research

There is growing interest in the strategic implications of online ad-blocking due to the controversy surrounding this topic. Our work contributes to this discussion by explicitly incorporating the role of the ad-blocker as a strategic user-oriented player, and analyzing the implications of LAB. In ongoing work, Gritckevich, Katona and Sarvary (2018) investigate the role of an ad-blocker, where the ad-blocker either blocks all ads or allows all ads; they do not consider LAB. They consider that the ad-blocker has become a for-profit player, deciding its strategies taking the publisher quality as given. They examine whether the ad-blocker should charge publisher a fee for not blocking ads (i.e., withholding ad-blocking to consumers), or charge consumers a fee for providing ad-blocking. Consistent with fears expressed by some in the publishing and advertising industry, they find that the ad-blocker may extort the publisher with the threat of ad-blocking. Hence, the publisher does not benefit from the presence of the ad-blocker and even users may be hurt. In contrast, we adopt a different perspective to contribute to the ongoing debate about ad-blockers and LAB; we show LAB is not inconsistent with protecting user interests and hence, as ad-blockers have claimed, LAB may indeed be a means to incentivize content provision thereby benefiting users.[6] Importantly, we show how LAB may incentivize content provision by curtailing traffic to low-quality websites, how an ad-blocker with LAB may attract more users, and how the publisher may benefit from and even actively leverage LAB provided by a user-oriented ad-blocker. We further show how charging users a fee may effectively shift the burden of incentivizing content quality to ad-blocker non-users. Later, in Section 8, we discuss how our results are affected if the ad-blocker is also influenced by profit motive.

Other research has examined the implications of the presence of a segment of ad-blocking consumers in the market for publishers without explicitly considering the role of the ad-blocker or LAB. Specifically, Anderson and Gans (2011) examine the content provider's reaction to ad blocking technologies, demonstrating that their adoption increases advertising clutter, may reduce total welfare and content quality, and can lead to more mass-market content. Aseri, Dawande, Janakiraman and Mookherjee (2019) show that when there is a positive network effect amongst website visitors, it can be optimal for the publisher to require only some ad-blocking consumers to disable the ad-blocker. They assume that the publisher can directly discriminate ad-intensities between ad-blocker users and non-users and find that even ad-blocker non-users (who face higher ad intensity) may be better off because of the positive network effect from increased traffic from ad-blocker users. In contrast, we examine the implications when the ad intensity displayed to ad-blocker users is determined by a third-party, namely, the ad-blocker through LAB, as is widely prevalent. We show that LAB can benefit ad-blocker users, non-users and even the publisher through its effect on content quality. Despotakis, Ravi and Srinivasan (2018) examine how ad-blocking affects competition in ad intensities between publishers. They show that by not requiring ad-blocking consumers to disable their ad-blocker, a publisher can effectively commit to not competing for these consumers, which softens competition between publishers if these consumers are also more ad sensitive (ad averse), thereby increasing publisher profit. They do not study LAB or consider the ad-blocker as a separate strategic player.

Researchers have examined the role of ad-avoidance technologies when advertising is informative. Ghosh and Stock (2010) study the effect of DVR penetration on competing advertisers' strategies and profits, when advertising exposure creates consumer awareness of the advertiser. They find that ad-avoidance can soften price competition between advertisers and, interestingly, can benefit advertisers when DVR penetration is above (not below) a threshold. Johnson (2013) further examines ad-avoidance when advertisers can target

[6] For example, AdBlock Plus has stated that publishers cannot pay to stop blocking ads if they do not conform to LAB standards (https://adblockplus.org/en/about). It has also stated that it charges only large publishers a licensing fee to cover its software development and maintenance costs and keep the service free for all other publishers; specifically, publishers that gain 10 million or more ad impressions per month due to LAB pay a fee, and account for 10% of all publishers participating in LAB (O'Reilly 2015). Similarly, competing ad-blocker AdBlock has stated that they are supported only by user donation and do not receive fees from publishers for LAB (Cassidy 2018).

their ads to create consumer awareness. He finds that although firms generally benefit from improved targeting, consumers need not. Chen and Liu (2019) examine the role of ad-blocking when advertising can signal quality. They show that lowering ad-blocking costs can result in fewer consumers blocking ads. This is because the ad platform lowers ad distribution costs, forcing advertisers to spend more on ad production in order to signal their quality, which makes ads less annoying to consumers. Dukes, Liu and Shuai (2019) examine the impact of skippable video ads, when consumers receive incremental information from ads and can dynamically decide whether to skip an ad or engage with the advertiser. They find that skippable ads benefit the publisher by increasing website traffic, and may also improve advertiser conversion rates depending on consumers' prior belief about the advertiser. Moreover, the resulting increase in ad volume may also improve consumers' opportunities to be matched with a relevant advertiser.

2 Model

We analyze the strategic interactions between an ad-blocker, a website publisher and consumers. The publisher offers a website with content of quality $q \in \{q_H, q_L\}$ and ad intensity $a_N \geq 0$, with $q_H > q_L > 0$. We refer to q_H as *high content quality* and to q_L as *low content quality*. The publisher can provide high content quality at a cost $d > 0$. We normalize the cost of providing low content quality to zero. The publisher sets the website ad intensity a_N, for example, by deciding the ad formats, number or frequency of ads to be displayed, and so on. We assume that the publisher earns unit revenue per visitor per unit ad intensity, i.e., the revenue from displaying an ad intensity a to a mass of N consumers is Na.

There is a unit mass of consumers with two segments, namely, a high (H) and a low (L) segment that differ in their tastes for quality and disutility from ads. Let $\beta \in (0,1)$ denote the proportion of type-L consumers. The utility of a type $i \in \{H, L\}$ consumer from visiting the website is $U_i(q, a) = v_i q - \theta_i a$, where q is the website content quality, a is the ad intensity the consumer experiences, v_i is her valuation of content quality and θ_i is her aversion to ads. Her utility from not visiting the website is zero. We assume that type-H consumers are more ad-averse than type-L consumers: $\theta_H > \theta_L > 0$. In our main analysis, we examine the case where both segments value content quality equally, i.e., $v_H = v_L = v > 0$. Later, in Section 6, we examine the analytically more challenging case where type-H consumers also have higher valuation for content quality, i.e., $v_H > v_L > 0$. Our approach allows us to develop the key insights in a straightforward manner and better elucidate the effect of each dimension of consumer heterogeneity.

A consumer can limit the website ad intensity that is displayed to her by adopting the ad-blocker at a cost $c > 0$. The ad-blocker *adoption cost c* captures consumer hassle costs such as the time, effort and technical expertise needed to locate, install and properly configure the ad-block software on their device. Such hassle costs could explain, for example, why not all Internet users have adopted ad-blockers even though most users dislike ads and are aware of ad-blockers (Interactive Advertising Bureau 2017). The adoption cost also captures any fees charged by ad-blockers to their users. Later, in Section 7, we examine the incentives of the ad-blocker to charge a positive fee, effectively increasing c. We refer to consumers adopting the ad-blocker as *ad-blocker users* and those not adopting the ad-blocker as *ad-blocker non-users*. We assume that a consumer may adopt the ad-blocker only if she obtains strictly positive surplus from doing so. We say that the ad-blocker is a *viable option* for a consumer only if she obtains a strictly positive surplus from adopting the ad-blocker. It will be sufficient to focus on $c \in (0, vq_H)$ since the ad-blocker is not a viable option for $c \geq vq_H$ regardless of website or ad-blocker strategies.

Table 1. Summary of Notations and Game Sequence

Notation		**Description**
Exogenous Parameters	θ_i	Type-$i \in \{H, L\}$ consumers' aversion to ads ($\theta_H > \theta_L > 0$)
	v_i	Type-$i \in \{H, L\}$ consumers' valuation for content quality ($v_H = v_L = v$ in main analysis)
	β	Size of type-L segment, $\beta \in (0,1)$
	c	Consumers' ad-blocker adoption cost
	q_L , q_H	Low and high content quality levels ($q_H > q_L > 0$)
	d	Publisher's cost of providing high content quality
Decision Variables	q	Content quality set by publisher, $q \in \{q_L, q_H\}$
	a_N	Website ad intensity set by publisher, experienced by ad-blocker non-users
	a_B	Ad intensity limit set by ad-blocker for ad-blocker users
Other Variables	U_i	Consumer i's utility: $U_i = vq - \theta_i a_N$, if consumer does Not Install ad-blocker and Visit (**NI-V**) $U_i = vq - \theta_i \min\{a_B, a_N\} - c$, if consumer Installs ad-blocker and Visit (**I-V**) $U_i = 0$, if consumer does Not Install and does Not Visit (**NI-NV**)
	$R(q, a_B)$	Publisher ad revenue under optimal website ad intensity
	$\Delta R(a_B)$	Publisher return on content quality ($= R(q_H, a_B) - R(q_L, a_B)$)
Game Sequence	Benchmark (No Ad-blocker)	(1) Publisher sets q and a_N → (2) Consumers decide whether to visit publisher website
	Main	(1) Ad-blocker sets a_B → (2) Publisher sets q and a_N → (3) Consumers decide whether to install ad-blocker and/or visit publisher website

The ad-blocker can block all ads displayed on the website altogether. Or, it may only limit the ad intensity without blocking all ads, by restricting the number, size, position and type of ads that are allowed to be displayed to its users. For example, the ad-blocker may block pop-up ads and animated ads and allow all other ads. Or, it may also block banner ads in certain positions of the page and those that occupy too large a portion of the screen. Let $a_B \geq 0$ denote the *ad intensity limit* that the ad-blocker allows to be displayed to its users. The ad intensity experienced by an ad-blocker user is $min\{a_B, a_N\}$. Thus, if $a_B = 0$, then the ad-blocker blocks all ads and there is no LAB. If $a_B > 0$, then the ad-block allows some ads to be displayed but limits the overall ad intensity to a_B. In this case, we say that the ad-blocker employs LAB with ad intensity limit a_B. The publisher earns revenue from ad-blocker users based only on the actual ad intensity displayed to them. Later, in Section 8, we discuss the implications if the publisher can block ad-blocker users from browsing the website, so as to force them to disable the ad-blocker and not avoid ads.

The objective of the user-oriented ad-blocker is to maximize the total surplus (welfare) of its user base. We assume that the ad-blocker sets the lowest ad intensity limit that maximizes its user base surplus, such that LAB arises in equilibrium only if it strictly improves user base surplus. In particular, the ad-blocker will not offer LAB if it does not attract any users, since user base surplus is zero without users, and user base surplus cannot be lower for $a_B = 0$. Later, in Section 8, we discuss the implications if the ad-blocker is also influenced by profit motive.

The sequence of events is as follows. In Stage 1, the ad-blocker decides the ad intensity limit $a_B \geq 0$ that the website can display to ad-blocker users. In Stage 2, the publisher decides its content quality $q \in \{q_H, q_L\}$ and the ad intensity $a_N \geq 0$. In Stage 3, consumers decide whether to install the ad-blocker, and whether to visit the website. Lastly, publisher revenue is realized given consumer decisions to use the ad-blocker and visit the website. Publisher revenue is $R = N_B a_B + N_N a_N$, where N_B and N_N are, respectively, the number of ad-blocker users and non-users visiting the website; given the two discrete consumer segments, we have $N_A, N_B \in \{0, \beta, 1-\beta, 1\}$ and $N_B + N_A = 1$.

We solve for the subgame-perfect equilibrium of this game. Consumers maximize their utility, the publisher maximizes its profit, and the user-oriented ad-blocker maximizes the total surplus (welfare) of ad-blocker users. Table 1 summarizes the model notations and game sequence.

3 Benchmark Scenario: No Ad-Blocker

We start by examining the benchmark scenario in which the ad-blocker is absent and consumers cannot avoid ads. We solve for the equilibrium by backward induction. In Stage 3, given website content quality $q \in \{q_H, q_L\}$ and ad intensity $a_N \geq 0$, consumers face a choice between: (i) visiting the website to obtain utility $U_i = vq - \theta_i a_N$, and (ii) not visiting the website to obtain zero utility. A type-i consumer will visit the website if and only if $a_N \leq \frac{vq}{\theta_i}$, i.e., if the website ad intensity is below a threshold. This threshold ($\frac{vq}{\theta_i}$) is lower for type-H consumers than for the type-L consumers because type-H consumers are more ad averse ($\theta_H > \theta_L$). In this sense a type-H consumer is less profitable to serve, requiring a lower ad intensity.

In Stage 2, given content quality q, the publisher essentially faces a choice between setting a website ad intensity of: (i) $a_N = \frac{vq}{\theta_H}$ to serve both consumer segments and earn revenue $\frac{vq}{\theta_H}$, and (ii) $a_N = \frac{vq}{\theta_L}$ to serve only type-L consumers and earn revenue $\beta\frac{vq}{\theta_L}$. The publisher will set $a_N = \frac{vq}{\theta_H}$ to serve both segments if and only if $\frac{\theta_L}{\theta_H} \geq \beta$, i.e., type-H consumers are not too ad averse and, hence, sufficiently profitable to serve.

Let $R(q) = \frac{vq}{\theta_L}\max\left\{\frac{\theta_L}{\theta_H}, \beta\right\}$ denote the publisher's resulting revenue under its optimal ad intensity decision given content quality q. The publisher's incentive to invest in high content quality depends on the incremental revenue from providing high (than low) quality content, given by $\Delta R \triangleq R(q_H) - R(q_L)$. We refer to ΔR as the publisher's *return on content quality*. We have $\Delta R = \frac{v(q_H - q_L)}{\theta_L}\max\left\{\frac{\theta_L}{\theta_H}, \beta\right\}$. The publisher will invest in high content quality if and only if $\Delta R \geq d$. The following lemma describes the equilibrium.

Lemma 1. *In the benchmark scenario (without the ad-blocker), given website content quality* $q \in \{q_H, q_L\}$*:*

(i) if $\frac{\theta_L}{\theta_H} \geq \beta$, *then the publisher sets ad intensity* $a_N = \frac{v}{\theta_H}q$ *and all consumers visit the website.*

(ii) if $\frac{\theta_L}{\theta_H} < \beta$ *then the publisher sets ad intensity* $a_N = \frac{v}{\theta_L}q$ *and only type-L consumers visit the website.*

The publisher provides high quality content if and only if $d \leq \frac{v(q_H - q_L)}{\theta_L} max\left\{\frac{\theta_L}{\theta_H}, \beta\right\}$.

4 Ad-Blocker Blocks All Ads (No LAB)

We next examine the implications if an ad-blocker is available to consumers and blocks all ads, i.e., $a_B = 0$ and the ad-blocker does not employ LAB.

4.1 Consumer Ad-blocking Behavior

In Stage 3, consumers face the choice of whether to install the ad-blocker or not. Consumers will install the ad-blocker only if they will visit the website. Hence, they may follow one of three strategies: (i) install ad-blocker and visit the website, denoted as strategy I-V, resulting in utility $U_i(q, 0) = vq - c$; (ii) not install ad-blocker and visit the website, denoted as strategy NI-V, resulting in utility $U_i(q, a_N) = vq - \theta_i a_N$; (iii) not install ad-blocker and not visit the website, denoted as strategy NI-NV, resulting in utility of zero.

We note consumers obtain a positive surplus from adopting the ad-blocker and, hence, the ad-blocker is a viable option for either segment if and only if $vq > c$. In this case, a type-i consumer will visit the website without the ad-blocker if the ad intensity is below a threshold $\frac{c}{\theta_i}$, and visit the website with the ad-blocker otherwise. This threshold ad intensity is lower for type-H consumers than for type-L consumers. In other words, type-H consumers are more prone to adopt the ad-blocker. If the ad-blocker is not a viable option for either segment ($vq \leq c$), then, as in the benchmark scenario, a type-i consumer will visit the website (without the ad-blocker) if $a_N \leq \frac{vq}{\theta_i}$, and not visit the website otherwise.

4.2 Publisher Ad Intensity Decision

The publisher earns revenue only from consumers visiting the website without (installing) the ad-blocker. Consider the publisher's optimal website ad intensity a_N given the website content quality q. If the ad-blocker is not viable ($vq \leq c$), then as in the benchmark scenario, the publisher sets $a_N = \frac{vq}{\theta_H}$ to serve all consumers if $\frac{\theta_L}{\theta_H} \geq \beta$, and $a_N = \frac{vq}{\theta_L}$ to serve only type-L consumers otherwise. Instead, if the ad-blocker is viable ($vq > c$), then the publisher essentially faces a choice between an ad intensity of (i) $a_N = \frac{c}{\theta_H}$ so as to attract both segments to visit without the ad-blocker and earn revenue $\frac{c}{\theta_H}$, and (ii) $a_N = \frac{c}{\theta_L}$ so as to attract only type-L consumers to visit without the ad-blocker (while type-H consumers visit with the ad-blocker) and earn revenue $\beta \frac{c}{\theta_L}$. The former is more profitable if $\frac{\theta_L}{\theta_H} \geq \beta$. The following lemma describes the results.

Lemma 2: *In the presence of an ad-blocker that blocks all ads, given content quality $q \in \{q_H, q_L\}$:*

(i) if $\frac{\theta_L}{\theta_H} \geq \beta$, then the publisher sets ad intensity $a_N = min\{vq, c\}/\theta_H$. All consumers visit the website without an ad-blocker, and the ad-blocker has no users;

(ii) if $\frac{\theta_L}{\theta_H} < \beta$, then the publisher sets ad intensity $a_N = min\{vq, c\}\,/\theta_L$. Type-L consumers visit the website without an ad-blocker. Type-H consumer visit the website with an ad-blocker if $vq > c$ and do not visit the website otherwise.

Lemma 2 establishes that when the ad-blocker is viable ($vq > c$), the publisher cannot monetize website visits to the same extent as in the benchmark scenario even from ad-blocker non-users. The maximum ad intensity that a type-i consumer is willing to tolerate to visit the website without the ad-blocker ($\frac{c}{\theta_i}$) is lower than that in the benchmark scenario ($\frac{vq}{\theta_i}$). Thus, the ad-blocker lowers the maximum ad intensity that a website can display to consumers and the publisher responds by cutting back its website ad intensity. We further find that only type-H consumers may adopt the ad-blocker and do so only if $\frac{\theta_L}{\theta_H} < \beta$, i.e., if they are sufficiently ad-averse that it is unprofitable for the publisher to serve them. Otherwise, the publisher attracts both consumer segments to visit the website without an ad-blocker and the ad-blocker has no users (though the ad-blocker still constrains the publisher's ad intensity and revenue).

4.3 Publisher Website Content Quality Decision

The impact of the ad-blocker on the publisher's return on content quality depends on the ad-blocker adoption cost c as this determines the content quality levels for which the ad-blocker is viable. If $c \in$

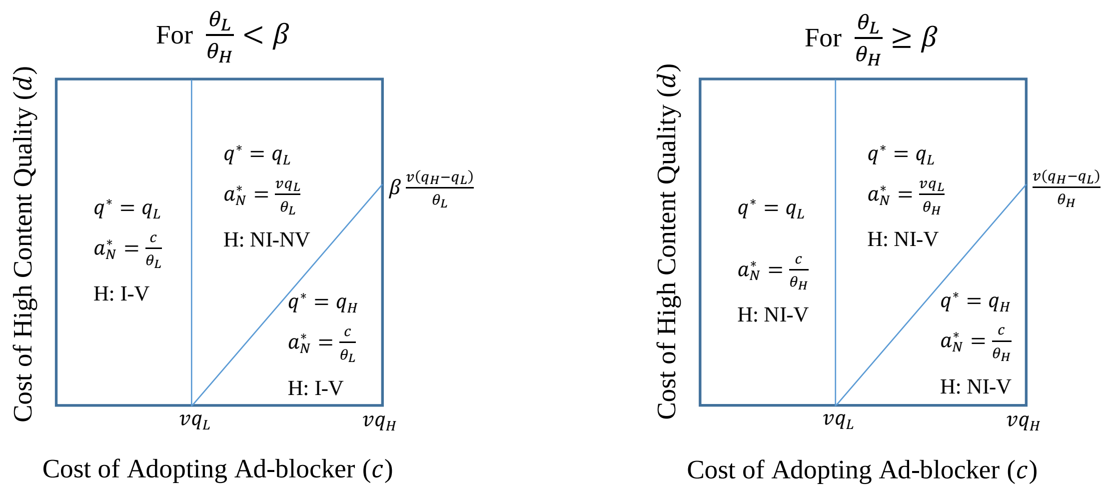
$(0, vq_L)$, then the ad-blocker is viable for either segment under both high and low content quality and, hence, constrains publisher revenue in both cases. In fact, publisher revenue is $R(q) = \frac{c}{\theta_L} max\{\frac{\theta_L}{\theta_H}, \beta\}$ irrespective of the content quality. It follows that the return on content quality is $\Delta R = 0$. Consequently, the publisher will not invest in high quality content even if the cost of doing so (d) is arbitrarily small. Instead, if $c \in [vq_L, vq_H)$, then the ad-blocker is viable for either segment only under high content quality. Accordingly, the ad-blocker constrains the publisher's revenue only under high content quality. We have $R(q_L) = \frac{vq_L}{\theta_L} max\{\frac{\theta_L}{\theta_H}, \beta\}$ and $R(q_H) = \frac{c}{\theta_L} max\{\frac{\theta_L}{\theta_H}, \beta\}$. Therefore, $\Delta R = \frac{c - vq_L}{\theta_L} max\{\frac{\theta_L}{\theta_H}, \beta\}$, which is positive but still less than that in the benchmark scenario. Proposition 1 summarizes our findings.

Proposition 1. *An ad-blocker that fully blocks ads reduces the publisher's website ad intensity (a_B) and return on content quality (ΔR) compared to the benchmark scenario. If the ad-blocker adoption cost is sufficiently low, $c \in (0, vq_L)$, then the publisher will not invest in high content quality even if the cost of doing so is arbitrarily small. If the ad-blocker adoption cost is high, $c \in [vq_L, vq_H)$, then the publisher invests in high content quality if and only if $d \leq \frac{c - vq_L}{\theta_L} max\{\frac{\theta_L}{\theta_H}, \beta\}$.*

Proposition 1 confirms publisher fears regarding the impact of an ad-blocker that block all ads, namely, that it lowers the publisher's ability to monetize website visits and the incentive to invest in high content quality, thereby hurting publisher profit. Importantly, the ad-blocker limits publisher revenue even from ad-blocker non-users. Industry experts have advised publishers to respond to ad-blockers by lowering their website ad intensity, showing fewer ads and using less annoying ad formats, to ensure that more consumers do not adopt ad-blockers (e.g., IAB 2017, 2019). We too find that it is optimal for publishers to lower their ad intensity in order to attract consumers to visit without the ad-blocker. As a result, the ad-blocker lowers the publisher's return on content quality, since it poses a greater constraint on publisher revenue under high content quality than under low content quality. In fact, if the ad-blocker adoption cost is sufficiently low, then the publisher will not invest in content quality even if the cost of doing so is arbitrarily low. More generally, the ad-blocker reduces the scope for the publisher to invest in high content quality. We find that the ad-blocker lowers publisher profit if $c < vq_L$ or $d \leq \frac{v(q_H - q_L)}{\theta_L} max\{\frac{\theta_L}{\theta_H}, \beta\}$; in these instances, the ad-blocker forces the publisher to lower its ad intensity and may also lower the website content quality.

Figure 1 illustrates the equilibrium content quality, website ad intensity and type-H consumer behavior (type-L consumers always visit the website without installing the ad-blocker) as a function of the ad-blocker adoption cost (c) and the cost of high content quality (d). The left and right panels, respectively, correspond to the cases where type-H consumers are sufficiently ad-averse and where they are not. We observe that in the former case ($\frac{\theta_L}{\theta_H} < \beta$), type-H consumers are not served by the publisher in the benchmark scenario and may adopt the ad-blocker when it is available. In the latter case ($\frac{\theta_L}{\theta_H} \geq \beta$), type-H consumers are served by the publisher and do not adopt the ad-blocker when it is available. We also observe that the ad-blocker reduces the scope for the publisher to invest in high content quality compared to the benchmark scenario, i.e., equilibrium website content quality can be low for $d \leq \frac{v(q_H - q_L)}{\theta_L} max\left\{\frac{\theta_L}{\theta_H}, \beta\right\}$.

Figure 1. Equilibrium website content quality (q^*), ad intensity (a_N^*), and type-H behavior (H) when ad-blocker fully blocks ads



Even though the ad-blocker can hurt website content quality, ad-blocker users as well as non-users may be better off. In particular, when the ad-blocker attracts users in equilibrium ($\frac{\theta_L}{\theta_H} < \beta$ and $c < vq_L$), both consumer segments obtain higher surplus than in the benchmark scenario even if the ad-blocker causes the publisher not to invest in high content quality. Ad-blocker users (type-H consumers) are better off because the ad-blocker enables them to visit the website and obtain positive surplus (and they would not have visited the website in the benchmark scenario). Ad-blocker non-users (type-L consumers) are better off because the ad-blocker forces the publisher to lower its ad intensity and not fully extract their surplus.

5 Ad-Blocker Allows Limited Amount of Ads (LAB)

We now examine the implications of the ad-blocker employing LAB, i.e., setting $a_B > 0$ to allow some ads to be displayed. All else equal, setting $a_B > 0$ would make ad-blocker users worse off. However, they may benefit if LAB motivates the publisher to invest in high content quality. We therefore analyze how LAB affects the publisher's return on content quality, and whether and when a user-oriented ad-blocker will implement LAB.

5.1 Consumer Ad-blocking Behavior

If $a_N > a_B$, then a type-i consumer's utility from installing the ad-blocker and visiting the website is given by $U_i^B(q, a_B) = vq - \theta_i a_B - c$. If $a_N \leq a_B$, then consumers face the same ad intensity with or without the ad-blocker, and hence no consumer adopts the ad-blocker. With some abuse of terminology, we will say that the ad-blocker is a viable option for type-i consumers (regardless of whether $a_N > a_B$) if and only if $U_i^B(q, a_B) > 0$, i.e., $vq > c$ and $a_B \in \left[0, \frac{vq-c}{\theta_i}\right)$. It follows that if the ad-blocker is a viable option, then a type-i consumer will visit the website without the ad-blocker if $a_N \leq a_B + \frac{c}{\theta_i}$, and will visit with the ad-blocker otherwise. Whereas, if the ad-blocker is not a viable option, then a type-i consumer will visit the website without the ad-blocker if $a_N \leq \frac{vq}{\theta_i}$, and will not visit the website otherwise.

Thus, LAB makes it relatively more attractive for consumers to visit the website without the ad-blocker. Specifically, when the ad-blocker is viable without LAB ($vq > c$), the threshold website ad intensity up to which consumers will visit the website without the ad-blocker, given by $a_B + \frac{c}{\theta_i}$, is increasing in a_B. We observe that the threshold LAB ad intensity limit up to which the ad-blocker is viable, $a_B = \frac{vq-c}{\theta_i}$, is lower for type-H consumers. Consequently, the ad-blocker will be viable for type-L consumers if it is viable for type-H consumers, but not vice-versa. As we will see, this makes the analysis of publisher decisions more complex than without LAB ($a_B = 0$). At the same time, conditional on the ad-blocker being viable, type-H consumer are more prone to adopt the ad-blocker; the threshold website ad intensity up to which consumers will visit the website without the ad-blocker ($a_N = a_B + \frac{c}{\theta_i}$) is lower for type-H consumers.

5.2 Publisher Ad Intensity Decision

LAB affects the publisher's tradeoff in setting its website ad intensity in two ways. First, as mentioned above, it increases the maximum website ad intensity up to which consumers will visit the website without the ad-blocker. Second, if the website ad intensity causes consumers to adopt the ad-blocker, then the publisher can monetize their website visits. There are three cases to consider. First, if the ad-blocker is viable for both consumer segments ($vq > c$ and $a_B \in \left[0, \frac{vq-c}{\theta_H}\right)$) then the publisher essentially faces a choice between the following two ad intensities: (i) $a_N = a_B + \frac{c}{\theta_H}$ to attract both segments to visit without the ad-blocker and earn revenue of $a_B + \frac{c}{\theta_H}$, (ii) $a_N = a_B + \frac{c}{\theta_L}$ to attract type-L consumers to visit without the ad-blocker and induce type-H consumers to visit with ad-blocker, and earn revenue of $\beta\left(a_B + \frac{c}{\theta_L}\right) + (1-\beta)a_B = a_B + \beta\frac{c}{\theta_L}$. The former is more profitable if $\frac{\theta_L}{\theta_H} \geq \beta$; in other words, if type-H consumers are not too ad averse (and hence not too unprofitable) to serve. Second, if the ad-blocker is viable for type-L consumers but not viable for type-H consumers ($vq > c$ and $a_B \in \left[\frac{vq-c}{\theta_H}, \frac{vq-c}{\theta_L}\right)$), then the publisher essentially faces a choice between the following two ad intensities: (i) $a_N = \frac{vq}{\theta_H}$ to attract both consumer segments to visit without the ad-blocker and earn revenue of $\frac{vq}{\theta_H}$, (ii) $a_N = a_B + \frac{c}{\theta_L}$ to attract only type-L consumers to visit without the ad-blocker and earn revenue of $\beta\left(a_B + \frac{c}{\theta_L}\right)$. The former is more attractive if $c < \frac{vq(1-\beta)\theta_L}{\beta(\theta_H-\theta_L)}$ and $a_B < \frac{vq}{\beta\theta_H} - \frac{c}{\theta_L}$. Intuitively, attracting both consumers segments is more profitable if LAB still sufficiently limits the ad intensity that type-L consumers are willing to tolerate, which is the case if c is sufficiently small and a_B is not too high. Lastly, if the ad-blocker is not viable for either consumer segment ($vq \le c$ or $a_B \ge \frac{vq-c}{\theta_L}$), then the publisher's optimal strategy is as in the benchmark scenario.

Let $R(q, a_B)$ denote the publisher revenue under its optimal ad intensity given content quality q and LAB ad intensity limit a_B. If $vq \le c$, then the ad-blocker is not viable for either consumer segment and thus LAB has no further impact and the outcome is the same as in the benchmark scenario. The following lemma summarizes the publisher's optimal ad intensity and revenue under LAB when instead $vq > c$.

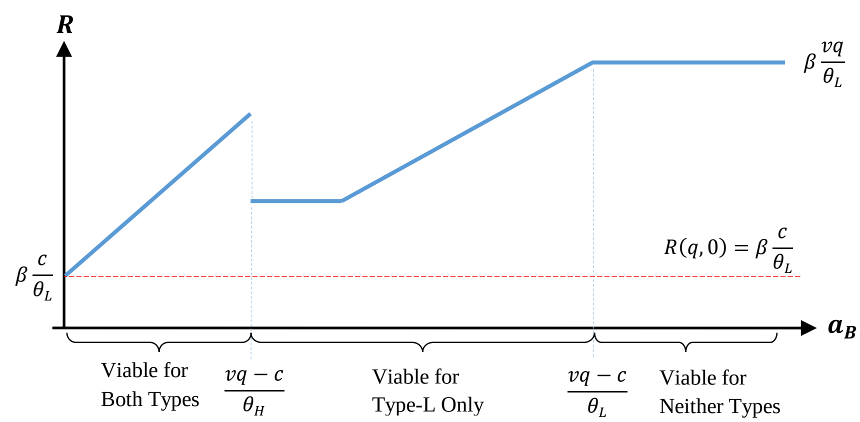
Lemma 3. *If the content quality is $q \in \{q_H, q_L\}$ and the ad-blocker is viable without LAB ($vq > c$), then the publisher's optimal ad intensity, revenue and consumer behaviors under LAB is given in Table 2.*

Table 2: Publisher Optimal Ad Intensity (a_N^*), Revenue (R), and Type-H Behavior Given a_B and q

Case	$a_N^*(q, a_B)$	$R(q, a_B)$	Type-H Behavior	Conditions
1	$\frac{vq}{\theta_L}$	$\beta\frac{vq}{\theta_L}$	NI-NV	$\frac{\theta_L}{\theta_H} < \beta$ & $\frac{vq-c}{\theta_L} \le a_B$
2	$\frac{vq}{\theta_H}$	$\frac{vq}{\theta_H}$	NI-V	$\frac{\theta_L}{\theta_H} < \beta$ & $c < \frac{vq(1-\beta)\theta_L}{\beta(\theta_H-\theta_L)}$ & $\frac{vq-c}{\theta_H} \le a_B < \frac{vq}{\beta\theta_H} - \frac{c}{\theta_L}$
3	$a_B + \frac{c}{\theta_L}$	$\beta\left(a_B + \frac{c}{\theta_L}\right)$	NI-NV	$\frac{\theta_L}{\theta_H} < \beta$ & $max\{\frac{vq-c}{\theta_H}, \frac{vq}{\beta\theta_H} - \frac{c}{\theta_L}\} < a_B < \frac{vq-c}{\theta_L}$
4		$a_B + \beta\frac{c}{\theta_L}$	I-V	$\frac{\theta_L}{\theta_H} < \beta$ & $0 \le a_B < \frac{vq-c}{\theta_H}$
5	$\frac{vq}{\theta_H}$	$\frac{vq}{\theta_H}$	NI-V	$\frac{\theta_L}{\theta_H} \ge \beta$ & $\frac{vq-c}{\theta_H} \le a_B$
6	$a_B + \frac{c}{\theta_H}$	$a_B + \frac{c}{\theta_H}$		$\frac{\theta_L}{\theta_H} \ge \beta$ & $0 \le a_B < \frac{vq-c}{\theta_H}$

Lemma 3 shows that given the publisher's optimal ad strategy, type-L consumers always visit the website without the ad-blocker and only type-H consumers may be ad-blocker users. Specifically, if $\frac{\theta_L}{\theta_H} \ge \beta$, then type-H consumers are sufficiently profitable to serve and the publisher lowers its ad intensity to induce them to visit the website without the ad-blocker (Cases 5 and 6 in Table 2). Instead, if $\frac{\theta_L}{\theta_H} < \beta$, then type-H consumers adopt the ad-blocker provided the ad-blocker blocks sufficient amount of ads, i.e., if $a_B < \frac{vq-c}{\theta_H}$ (Case 4 in Table 2). For $a_B \geq \frac{vq-c}{\theta_H}$, type-H consumers do not adopt the ad-blocker, but may visit the website without the ad-blocker under certain conditions (Case 2 in Table 2); essentially, if the ad-blocker sufficiently constrains the ad intensity the publisher can display to type-L consumers then LAB makes it profitable for the publisher to also serve type-H consumers.

Figure 2. Publisher Revenue under LAB when $\frac{\theta_L}{\theta_H} < \beta$ and $vq > c$



Lemma 3 further establishes two important aspects of LAB. First, compared to blocking all ads, LAB increases publisher revenue, i.e., $R(q, a_B) > R(q, 0)$ for $a_B > 0$. In particular, LAB enables the publisher to not only monetize visits from ad-blocker users (if the ad-blocker attracts users), but also raises the ad intensity displayed to non-users (as they are willing to tolerate a higher website ad intensity). Second, publisher revenue may, however, not be monotonically increasing in the LAB ad intensity limit a_B. Specifically, if $\frac{\theta_L}{\theta_H} < \beta$ then the ad-blocker attracts users for $a_B < \frac{vq-c}{\theta_H}$ but not otherwise. Consequently, publisher revenue is increasing in a_B for $a_B < \frac{vq-c}{\theta_H}$, and then falls at $a_B = \frac{vq-c}{\theta_H}$ since the ad-blocker no longer attracts users. Essentially, if LAB blocks sufficiently few ads, then ad-blocker users are discouraged from visiting the website. Figure 2, which illustrates publisher's revenue as a function of a_B, depicts these two important characteristics. The following corollary describes the impact of LAB on publisher revenue.

Corollary 1: *If the ad-blocker is a viable option for consumers when it does not employ LAB ($vq > c$) then LAB increases publisher revenue. Publisher revenue under LAB is not monotonically increasing in the LAB ad intensity limit.*

5.3 Publisher Website Content Quality Decision

We now examine how LAB affects the publisher's return on content quality. Of particular interest are cases where LAB can emerge in equilibrium, which the ad-blocker attracts users under LAB. From Lemma 3, the ad-blocker can attract users only in Case 4 in Table 2, which requires $\frac{\theta_L}{\theta_H} < \beta$ and $a_B < \frac{vq_H - c}{\theta_H}$, i.e., type-H consumers are sufficiently ad averse and LAB ad intensity is not too high. In this case, if content quality is high, then the ad-blocker is viable for both consumer segments and publisher revenue under its optimal website ad intensity is $R(q_H, a_B) = a_B + \beta \frac{c}{\theta_L}$ (Case 4 in Table 2). If content quality is low, publisher revenue depends on whether the ad-blocker is viable for both, one or none of the segments (different cases in Table 2). We examine each of these cases to obtain the publisher's return on content quality $\Delta R(a_B)$ under LAB. We say that LAB is *effective* in stimulating content quality (relative to the ad-blocker not employing LAB) if $\Delta R(a_B) > \Delta R(0)$. The following lemma describes our results. The proof is deferred to the Appendix.

Lemma 4. *When the ad-blocker attracts users under LAB* ($\frac{\theta_L}{\theta_H} < \beta$ *and* $0 < a_B < \frac{vq_H - c}{\theta_H}$), *the publisher's return on content quality is:*

(i) $\Delta R(a_B) = 0$ *if* $c \in [0, vq_L)$ *and* $a_B \in \left(0, \frac{vq_L - c}{\theta_H}\right)$;

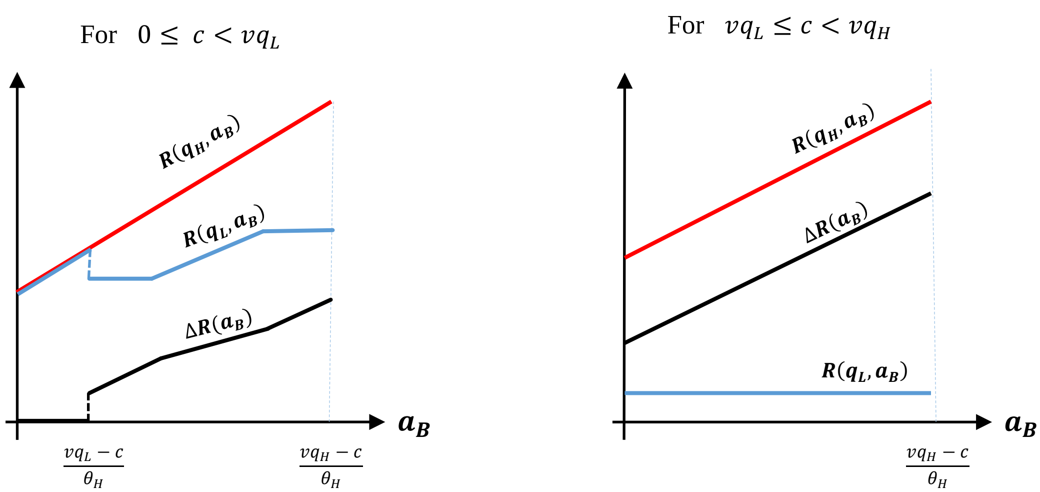
(ii) $\Delta R(a_B) = a_B + \beta \frac{c}{\theta_L} - max\left\{\beta\left(a_B + \frac{c}{\theta_L}\right), \frac{vq_L}{\theta_H}\right\}$ *if* $c \in [0, vq_L)$ and $a_B \in \left[\frac{vq_L - c}{\theta_H}, min\{\frac{vq_L - c}{\theta_L}, \frac{vq_H - c}{\theta_H}\}\right)$;

(iii) $\Delta R(a_B) = a_B + \beta \frac{c}{\theta_L} - \beta \frac{vq_L}{\theta_L}$ *if* $c \in [vq_L, vq_H)$, *or* $c \in [c', vq_L)$ *and* $a_B \in \left[\frac{vq_L - c}{\theta_L}, \frac{vq_H - c}{\theta_H}\right)$, *where* $c' = min\{0, \frac{v(q_L\theta_H - q_H\theta_L)}{\theta_H - \theta_L}\}$.

Lemma 4 shows that even though LAB increases publisher revenue (Corollary 1), it need not be effective in stimulating content quality when ad-blocker adoption cost c is low. Figure 3 illustrates $R(q, a_B)$ and $\Delta R(a_B)$ as a function of a_B for two distinct ranges of c. As depicted by the right panel of Figure 3, LAB is always effective in stimulating content quality when the ad-blocker adoption cost is high ($c \in [vq_L, vq_H)$). In this case, LAB increases publisher revenue under high content quality (positively-sloped line) attracting and monetizing website traffic from ad-blocker users (type-H consumers) and displaying higher ad intensity to ad-blocker non-users (type-L consumers). Said differently, LAB improves the publisher's ability to monetize high content quality. In contrast, LAB has no impact on publisher revenue under low content quality since the ad-blocker is not viable for either segment. Consequently, $\Delta R(a_B) > \Delta R(0)$, and LAB is effective in stimulating content quality. Furthermore, the effectiveness is increasing in the LAB ad intensity limit, i.e., $\Delta R(a_B)$ is strictly increasing in a_B (for $a_B < \frac{vq_H - c}{\theta_H}$).

In contrast, as depicted by the left panel of Figure 3, the ad-blocker may not always be effective when the ad-blocker adoption cost is low ($c \in [0, vq_L)$). In this case, when the LAB ad intensity limit is sufficiently low ($a_B < \frac{vq_L - c}{\theta_H}$), the ad-blocker is viable for both consumer segments under high as well as low content quality. Consequently, LAB increases publisher revenue to an equal extent under high (positively-sloped line $R(q_H)$) as well as low content quality (positively-sloped line $R(q_L)$). As a result, even though LAB increases publisher revenue compared to no LAB, we have $\Delta R(a_B) = \Delta R(0) = 0$. However, if LAB ad intensity limit is sufficiently high ($a_B \geq \frac{vq_L - c}{\theta_H}$), then the ad-blocker is not viable for ad-blocker users under low content quality. As a result, LAB enables the publisher to attract and monetize traffic from ad-blocker users only when providing high content quality and not when providing low content quality. Hence, LAB is effective. In other words, for LAB to be effective we require that it not only enables monetization of high-content quality but also limits monetization of low-content quality, setting a_B sufficiently high so as to curtail ad-blocker user traffic to low-quality websites. Furthermore, $\Delta R(a_B)$ is strictly increasing in a_B.

Figure 3. Publisher Revenue (R) and Return on Content Quality (ΔR) under LAB



Thus, the effectiveness of LAB depends crucially on ad-blocker adoption cost c. In particular, if c is sufficiently low, then LAB may not be effective and the publisher will not invest in high content quality even if the cost of doing so is arbitrarily small. Proposition 2 describes these insights.

Proposition 2. *LAB is not always effective in increasing publisher's return on content quality even if it increases publisher's revenue. Specifically, when the ad-blocker attracts users ($\frac{\theta_L}{\theta_H} < \beta$ and $0 \leq a_B < \frac{vq_H - c}{\theta_H}$), LAB is effective if and only if either ad-blocker adoption cost or the LAB ad intensity limit is sufficiently high ($c \in [vq_L, vq_H)$ or $a_B \geq \frac{vq_L - c}{\theta_H}$). The effectiveness of LAB is increasing in the ad-blocker adoption cost (c) and LAB ad intensity limit (a_B).*

5.4 Ad-blocker LAB Strategy

The user-oriented ad-blocker's objective in employing LAB is to maximize the surplus of its user base. Since only type-H consumers may adopt the ad-blocker in equilibrium, the total surplus of ad-blocker users can be expressed as $S_{ub}(a_B) = (1-\beta)\,max\{0, U_H(q^*(a_B), a_B) - c\}$, where $q^*(a_B) \in \{q_H, q_L\}$ is the publisher's optimal content quality decision. We have $q^*(a_B) = q_H$ if and only if $\Delta R(a_B) - d \geq 0$, where $\Delta R(a_B)$ is given by Lemma 4. We obtain the following necessary conditions for LAB to improve user surplus and thus be employed in equilibrium. First, as noted before, type-H consumers must adopt the ad-blocker, which requires $\frac{\theta_L}{\theta_H} < \beta$ and $a_B < \frac{vq-c}{\theta_H}$. Second, the publisher must invest in high content quality if and only if the ad-blocker adopts LAB. Otherwise, $q^*(a_B) = q^*(0)$ and $S_{ub}(a_B) < S_{ub}(0)$. Therefore, we require that $\Delta R(a_B) \geq d > \Delta R(0)$, such that $q^*(a_B) = q_H$ and $q^*(0) = q_L$. We also note that, given $S_{ub}(a_B) > 0$ and $q^*(a_B) = q_H$, $S_{ub}(a_B)$ is strictly decreasing in a_B. Therefore, the ad-blocker sets the minimum a_B such that the above necessary conditions hold, and its decision can be expressed as follows:

$$\min_{a_B \geq 0} a_B,$$

$$\text{subject to: (1) } \Delta R(a_B) \geq d,$$

$$\text{(2) } \Delta R(0) < d,$$

$$\text{(3) } U_H(q_H, a_B) - c > \max\{0, U_H(q_L, 0) - c\}.$$

Here, constraints (1) and (2) respectively ensure that the publisher invests in high content quality only if the ad-blocker employs LAB and not otherwise ($a_B = 0$). Constraint (3) ensures that type-H consumers (adopting the ad-blocker under LAB) are better off with LAB than without. If constraint (2) does not hold, then the publisher will invest in high content quality even without LAB. Hence, the ad-blocker will not employ LAB. If constraint (1) and (3) do not hold for any $a_B > 0$, then LAB cannot jointly incentivize the publisher to invest in high content quality and also make ad-blocker users better off than without LAB. Hence, the ad-blocker will not employ LAB.

Solving the above optimization problem, we find there are two distinct cases to consider depending on the ad-blocker adoption cost c. If c is high ($c \in [vq_L, vq_H)$), then the ad-blocker can be viable only under high content quality. Hence, ad-blocker user surplus under low content quality is zero. If offering LAB, the ad-blocker sets the minimum a_B necessary to induce the publisher to invest in high content quality (if feasible) while ensuring that type-H consumers adopt the ad-blocker and obtain positive surplus ($a_B < \frac{vq_H-c}{\theta_H}$). In this case, LAB enables the publisher to better capture value from ad-blocker users and non-users when providing high content quality. Moreover, LAB improves ad-blocker user base surplus because type-H consumers will not adopt the ad-blocker (and not visit the website) under low content quality (and the publisher invests in high content quality only with LAB). Since $\Delta R(0) > 0$, the publisher will invest in high content quality without LAB if the cost of high content quality d is sufficiently low. Consequently, we find that the ad-blocker employs LAB if d is neither too high nor too low.

Next, if c is low ($c \in [0, vq_L)$), then the ad-blocker can be viable under low and high content quality. In this case, LAB must not only enable the publisher to better capture value under high content quality, but also limit the publisher's ability to do so under low content quality. In particular, for LAB to be effective, the LAB ad intensity limit must be sufficiently high ($a_B \geq \frac{vq_L - c}{\theta_H}$) to ensure that the ad-blocker is not viable for type-H consumers under low content quality. Intuitively, the ad-blocker uses LAB to limit publisher revenue under low content quality, in effect penalizing a publisher providing low content quality. We find that c may have to be sufficiently high such that the a_B needed to incentivize high content quality is not too high to also improve ad-blocker user base surplus. Proposition 3 describes the equilibrium outcomes.

Proposition 3*. A user-oriented ad-blocker employs LAB (setting $a_B^* > 0$) if and only if $\frac{\theta_L}{\theta_H} < \beta$ and either: (i)* $\max\{0, v(2q_L - q_H)\} < c < vq_L$ *and d is sufficiently low, or (ii) $vq_L < c < vq_H$ and d is neither too high nor too low. The equilibrium LAB ad intensity limit (a_B^*) is weakly decreasing in the ad-blocker adoption cost (c), and is provided in Table 3.*

Table 3. Ad-blocker's Optimal LAB Strategy (a_B^*) when $\frac{\theta_L}{\theta_H} < \beta$

Case	$\boldsymbol{a_B^*}$	**Conditions**	**Type-H Surplus** $U_H = vq_H - \theta_H a_B^* - c$
1	$\frac{vq_L - c}{\theta_H}$	$\max\{\frac{d}{1-\beta}, \frac{vq_L}{\theta_H} - \beta\frac{c}{\theta_L} + d\} < \frac{vq_L - c}{\theta_H} < \frac{vq_H - vq_L}{\theta_H}$	$v(q_H - q_L)$
2	$\frac{vq_L}{\theta_H} - \beta\frac{c}{\theta_L} + d$	$0 < \frac{vq_L - c}{\theta_H} < \frac{vq_L}{\theta_H} - \beta\frac{c}{\theta_L} + d < \min\{\frac{vq_H - vq_L}{\theta_H}, \frac{vq_L}{\beta\theta_H} - \frac{c}{\theta_L}\}$	$v(q_H - q_L) + \frac{\beta\theta_H - \theta_L}{\theta_L}c - \theta_H d$
3	$\frac{d}{1-\beta}$	$\max\{\frac{vq_L - c}{\theta_H}, \frac{vq_L}{\beta\theta_H} - \frac{c}{\theta_L}, 0\} < \frac{d}{1-\beta} < \min\{\frac{vq_H - vq_L}{\theta_H}, \frac{vq_L - c}{\theta_L}\}$	$vq_H - c - \frac{\theta_H}{1-\beta}d$
4	$d + \beta\frac{vq_L - c}{\theta_L}$	$\max\{\frac{vq_L - c}{\theta_L}, 0\} < d + \beta\frac{vq_L - c}{\theta_L} < \min\{\frac{vq_H - vq_L}{\theta_H}, \frac{vq_H - c}{\theta_H}\}$	$vq_H - \frac{\beta\theta_H}{\theta_L}vq_L + \frac{\beta\theta_H - \theta_L}{\theta_L}c - \theta_H d$

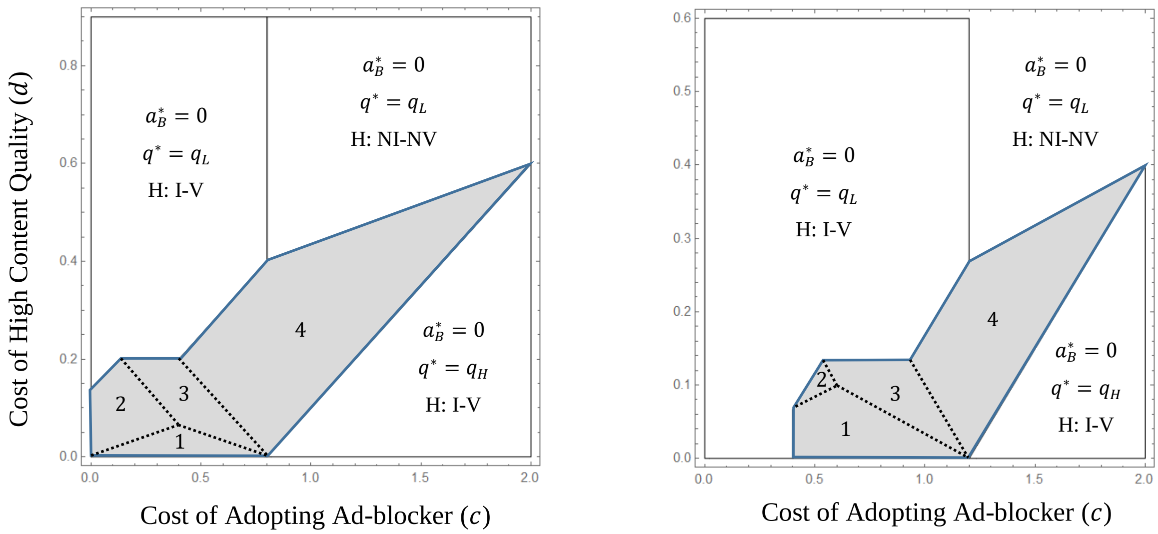
Figure 4 illustrates the ad-blocker's equilibrium LAB strategy as a function of consumers' ad-blocker adoption cost (c) and the content quality cost (d), for specific values of other model parameters. LAB is offered only within the shaded region. The shaded region is further subdivided and numbered, corresponding to the cases for the equilibrium level of a_B^* in Table 3. As noted in Proposition 3, the ad-blocker is more effective in increasing the publisher's incentive to invest in content quality if c is higher. Accordingly, we observe that the maximum d for which LAB is employed is (weakly) increasing in c.

Similarly, if the difference in content quality levels is not sufficiently high ($q_H - q_L < q_L$), then the scope for ad-blocker user base surplus to improve under high content quality is more constrained. Consequently, we find that LAB is used only if c is sufficiently high.

Figure 4. Equilibrium LAB Strategy (a_B^*), Content Quality (q^*) and Type-H Behavior

($\theta_L = 1,\ \theta_H = 3,\ v = 1, \beta = 0.5$)

For $2q_L < q_H$ ($q_L = 0.8, q_H = 2$) | **For $2q_L > q_H$** ($q_L = 1.2, q_H = 2$)



<u>Within the shaded region:</u> Ad-blocker employs LAB ($a_B^* > 0$, $q^* = q_H$, H: I-V), numbers correspond to Cases in Table 3

Consumer advocates have criticized ad-blockers for LAB, accusing ad-blockers of failing to protect user interests as initially promised. By explicitly considering the strategic interaction between the ad-blocker and the publisher, we show that even a user-oriented ad-blocker may nevertheless introduce LAB to incentivize the publisher to provide high content quality, thereby benefiting users. However, LAB may not be able to improve user welfare if the ad-blocker adoption cost c is low. In particular, for $c < vq_L$, the ad-blocker may set the LAB ad intensity sufficiently high that ad-blocker users will not find it attractive to visit low-quality websites. In this sense, ad-blocker users may complain about the LAB blocking "too few ads", but it might be intended to incentivize low-quality websites improve their content quality. Moreover, for $c \geq vq_L$, the ad-blocker is not viable under low content quality, and hence does not attract users without LAB. However, when the ad-blocker employs LAB in equilibrium, the publisher invests in high content quality and, therefore, users obtain positive surplus from adopting the ad-blocker. Thus, an ad-blocker that employs LAB in equilibrium may attract more users than if it did not employ LAB as described in Corollary 2 below. Our result might explain why ad-blockers continue to attract users despite LAB.

Corollary 2: *An ad-blocker attracts more users by employing LAB if and only if the ad-blocker adoption cost* $c \in [vq_L, vq_H)$.

Our results further shed light on the ad-blocker's strategic considerations in determining whether and how to employ LAB. If the ad-blocker adoption cost is high ($c \in [vq_L, vq_H)$), then the ad-blocker uses LAB simply to enable the publisher better extract surplus from website visitors (ad-blocker users as well as non-users) when providing high content quality. In contrast, if the ad-blocker adoption cost is low ($c < vq_L$), then LAB may not be effective even if it increases publisher revenue, since it may increase publisher revenue equally under high and low content quality. To be effective, the ad-blocker designs LAB to also limit the publisher's ability to extract ad-blocker user base surplus when providing low content quality, effectively penalizing the publisher for providing low content quality.

6 Can Publishers Benefit from Ad-blockers?

Our analysis thus far showed how a user-oriented ad-blocker may nevertheless employ LAB. We now examine whether the user-oriented ad-blocker can also benefit the publisher. Publishers have been wary about ad-blockers and some disallow the use of ad-blockers on their website. Other publishers continue to allow the use of ad-blockers and even participate in the ad-blocker's LAB by conforming to its criteria and standards. One reason why publishers continue to allow the use of ad-blockers could be that they want to avoid consumer backlash and alienating consumers (e.g., O'Reilly 2016, Söllner and Dost 2019). We now examine another; namely, that the publisher may be better off when consumers use the ad-blocker.

6.1 Consumers do not Differ in Valuation of Content Quality

In our main analysis (where $v_H = v_L = v$), we showed that LAB can help the publisher better monetize website traffic from ad-blocker users as well as non-users. Moreover, with LAB, consumers are exposed to two levels of ad intensity depending on their ad-blocker usage: ad-blocker non-users (type-L consumers) view a higher ad intensity ($a_N = a_B + \frac{c}{\theta_L}$) than ad-blocker users (type-H consumers). In effect, LAB enables the publisher to discriminate amongst consumers based on their aversion to ads, and display a lower ad intensity to more ad averse consumers.

Nevertheless, we find that equilibrium publisher profit under LAB cannot be higher than in the absence of the ad-blocker. Even though the LAB allows the publisher to discriminate amongst consumers, it still constrains the ad intensity that the publisher can display to type-L consumers by the maximum LAB ad intensity that the type-H consumers are willing to tolerate, namely $a_B = \frac{vq_H - c}{\theta_H}$ (see Figure 2). Specifically, the publisher's ability to discriminate is maximized for $a_B = \left(\frac{vq-c}{\theta_H}\right)^-$ such that the ad-blocker is just viable for type-H consumers. Publisher revenue in this case is $R(q, a_B) = \left(\frac{vq-c}{\theta_H} + \beta\frac{c}{\theta_L}\right)^{-}$, which we find is strictly less than publisher revenue of $R(q, \infty) = \beta\frac{vq}{\theta_L}$ in the absence of an ad-blocker (since $\frac{\theta_L}{\theta_H} < \beta$). Consequently, the publisher does not benefit from the presense of ad-blocker and LAB.

6.2 Consumers Differ in Valuation of Content Quality

The above observations suggest that if the LAB ad intensity that type-H consumers are willing to tolerate is higher, which would be the case if their valuation of content quality is higher, then the publisher would be less constrained in the ad intensity it can display to type-L consumers. Hence, it is possible that the publisher benefits from the ad-blocker. We now investigate this possibility. Let v_i denote the valuation for content quality of segment $i \in \{H, L\}$, where $v_H > v_L$.

We find that, on the one hand, a higher v_H allows the publisher to leverage LAB to a greater extent in monetizing website traffic. In particular, the maximum LAB ad intensity that type-H consumers are willing to tolerate is $a_B = \frac{v_H q_H - c}{\theta_H}$, which is increasing in v_H. Consequently, a higher v_H increases the extent to which the publisher can leverage LAB to discriminate the ad-intensity levels between the two consumer segments based on their ad aversion. On the other hand, a higher v_H also increases the profitability of serving type-H consumers and, hence, affects the publisher's strategy and outcomes in the absence of the ad-blocker. Specifically, in the benchmark scenario, the ad intensity that type-H consumers are willing to tolerate is $a_N = \frac{v_H q_H}{\theta_H}$, which is increasing in v_H. If v_H is sufficiently high (i.e., $\frac{v_H}{\theta_H} > \frac{v_L}{\theta_L}$), then in fact, type-H consumers are the more valuable segment for the publisher, but they are also more prone to adopt the ad-blocker as they are more ad-averse ($\theta_H > \theta_L$). In this case, even though ad-blocker may allow the publisher to vary the ad intensity between the consumer segments, it in fact forces the publisher to display a lower ad intensity to the more valuable segment; hence, LAB does not facilitate (useful) discrimination. These opposing effects imply that if v_H is either too low or too high, then the publisher revenue in presence of ad-blocker is strictly below that in the benchmark scenario, as confirmed by the following lemma.

Lemma 5. *Publisher revenue in presence of ad-blocker is strictly below that in the benchmark scenario without an ad-blocker if either* $\frac{v_H}{v_L} \leq 1$ *or* $\frac{v_H}{v_L} \geq \frac{\theta_H}{\theta_L}$.

Instead, if $\frac{v_H}{v_L} \in (1, \frac{\theta_H}{\theta_L})$, then LAB may emerge as a useful means to discriminate ad intensity across consumers and there is scope for publisher revenue to be higher than in the benchmark scenario even under a user-oriented ad-blocker. Solving for the ad-blocker's equilibrium LAB strategy, we find that this is indeed possible. Note that the publisher can benefit from the ad-blocker only if it employs LAB.

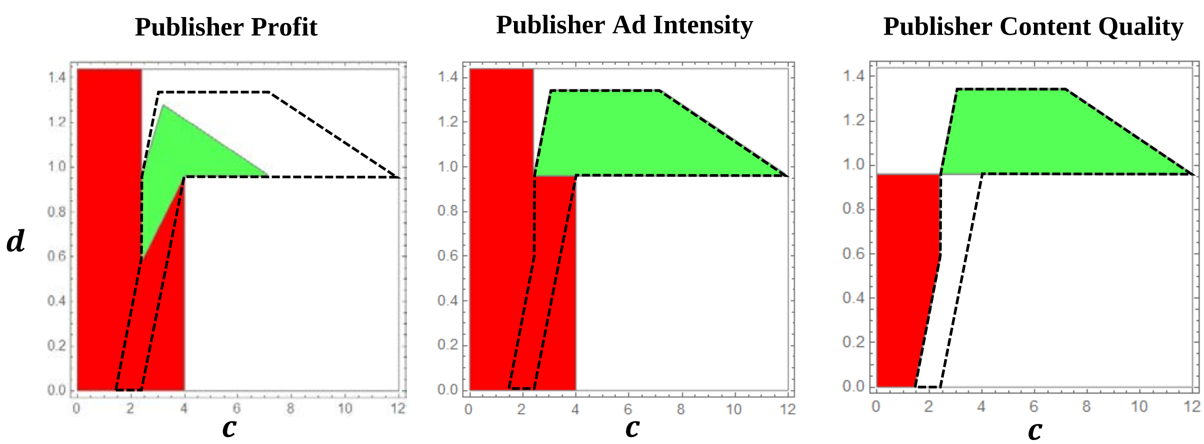
Furthermore, the ad-blocker will employ LAB only if doing so incentivizes the publisher to invest in content quality resulting in higher surplus for its users. Consequently, we require that β is sufficiently large, such that the ad-blocker will attract users in equilibrium. We further require that the LAB ad intensity limit is sufficiently high, such that the publisher can set a sufficiently high ad intensity for ad-blocker non-users. These conditions require that d is neither too low (such that a_B^* is higher) nor too high, and c is neither too low (such that LAB is employed) nor too high (such that the ad-blocker is viable under low content quality). Proposition 4 summarizes our findings.

Proposition 4. *If $\frac{\theta_L}{\theta_H} < \beta$, $\frac{q_H}{q_L}$ is sufficiently small, and $\frac{v_H}{v_L}$, c, d are all neither too high nor too low, then the publisher's profit in presence of a user-oriented ad-blocker is higher than that in the benchmark scenario without the ad-blocker.*

Thus, we find that when the consumers are heterogeneous not only in their aversion to ads but also in their valuation of content quality, then LAB by a user-oriented ad-blocker can also benefit the publisher as LAB emerges as a means for the publisher to discriminate amongst consumers based on their ad-blocker usage. In fact, unlike in the main analysis (where $v_H = v_L$), we find that the ad-blocker may employ LAB even in cases where the publisher serves both consumer segments in the benchmark scenario. In this case, which occurs if $\beta \in \left(\frac{\theta_L}{\theta_H}, \frac{v_H}{v_L}\frac{\theta_L}{\theta_H}\right]$, LAB does not enable the publisher to attract more consumers. Instead, it acts solely as a means for the publisher to discriminate the ad intensity between the consumer segments. In fact, if $c > v_H q_L$ (such that the ad-blocker is not viable for either consumer segment under low content quality) and d is sufficiently high (such that the publisher does not invest in high content quality in the absence of the ad-blocker), then even in the presence of the ad-blocker, the publisher can serve both consumer segments and earn the same profit as in the benchmark scenario. However, LAB provides the publisher a new option: invest in high content quality and raise the ad intensity to drive type-H consumers to adopt the ad-blocker so as to sort themselves based on their aversion to ads, resulting in higher publisher profit than in the benchmark scenario. Consequently, the publisher actively leverages the ad-blocker and LAB to discriminate across consumers. In contrast, if $\frac{v_H}{v_L}\frac{\theta_L}{\theta_H} < \beta$, then LAB enables the publisher to attract type-H consumers who would have not visited the website in the absence of the ad-blocker.

Figure 5 illustrates how equilibrium publisher profit, website content quality, and ad intensity in the presence of the ad-blocker compares with those in the benchmark scenario (as a function of ad-blocker adoption cost c and content quality cost d). The figure shows regions where each outcome is higher, lower or the same as in the benchmark scenario. The region within the dashed line indicates situations where the ad-blocker employs LAB ($a_B^* > 0$) in equilibrium. As shown in the figure, a user-oriented ad-blocker can lead to a "win-win-win": in addition to improving publisher profit relative to the benchmark scenario, the ad-blocker can also lead to higher content quality. Further, this improvement in content quality can result in higher surplus for ad-blocker non-users (type-L consumers) even though the ad intensity may be higher. As a result, in equilibrium, the publisher is better off, website content quality is higher, and even ad-blocker non-users benefit. The following corollary provides sufficient conditions for this to occur.

Figure 5. Effect of Ad-Blocker on Publisher Compared to Benchmark Scenario
$(\theta_L = 1, \theta_H = 5, v_L = 1, v_H = 3, \beta = 0.6, q_L = 2.4, q_H = 4)$



Region with dashed border (----) illustrates LAB ($a_B^* > 0$). The colors illustrate:

More than benchmark | Less than benchmark | Equal to benchmark

Corollary 3. *A user-oriented ad-blocker leads to higher publisher profit, website content quality, ad intensity, ad-blocker user and non-user base surplus compared to the benchmark scenario without the ad-blocker if* $\frac{\theta_L}{\theta_H} < \beta$, $\frac{q_H}{q_L} < \beta\frac{\theta_H}{\theta_L}$, $\frac{q_H}{q_L} < \frac{v_H}{v_L} < \beta\frac{\theta_H}{\theta_L}$, $\max\{2v_H q_L - v_H q_H, \frac{\beta v_L q_H \theta_H - v_H q_L \theta_L}{\beta\theta_H - \theta_L}, \frac{v_L q_L \theta_H - v_H q_L \theta_L}{\theta_H - \theta_L}\} < c < \frac{v_L q_H \theta_H - v_H q_L \theta_L}{\theta_H - \theta_L}$ *and* $\beta\frac{v_L(q_H - q_L)}{\theta_L} < d < \frac{v_H q_L - c}{\theta_H} - \beta\frac{v_L q_L - c}{\theta_L}$.

Our results lend support to the claim by ad-blockers that LAB can benefit the entire online ecosystem. We find that publishers, in addition to ad-blocker users, can benefit from ad-blockers (Proposition 4). Moreover, even ad-blocker non-users can be better off, and website content quality and ad intensity can be higher than without the ad-blocker (Corollary 3). By helping a publisher to better separate and serve customers who differ in their aversion to ads and valuation of content quality, LAB can increase the publisher's discrimination ability while also incentivizing it to improve content quality. Our results might explain why publishers have increasingly embraced LAB. For example, AdBlock Plus has stated that over 40 of top 100 publishers participate in its LAB.[7] Further, some industry experts (e.g., AdRecover, Blockthrough, Pagefair, Uponit) recommend that publishers can best respond to ad-blocking by leveraging LAB to deliver a "lightweight" ad experience with fewer ads to ad-blocker users (Kratky-Katz 2018). Our findings show how this strategy may in fact make publishers better off than in the absence of the ad-blocking.

7 Should a User-Oriented Ad-blocker Charge its Users a Fee?

While many ad-blockers are available for free, others charge users an upfront fee.[8] Charging users a fee provides a source of revenue to support the development of the ad-blocker software. Furthermore, a for-profit ad-blocker may also charge users a fee to generate profits. We now examine whether, even absent these considerations, a user-oriented ad-blocker would have a strategic reason to charge its users a positive fee, thereby increasing consumers' ad-blocker adoption cost. As our analysis thus far has shown, ad-blocker adoption cost plays an important role in the effectiveness of LAB. Thus, we also examine how these two distinct ad-blocker strategies, charging users a fee and employing LAB, may be used in conjunction.

Specifically, we consider that the ad-blocker adoption cost c is made of a two components: a hassle cost of adopting the ad-blocker $c_0 > 0$ and a user fee $p \geq 0$ charged by the ad-blocker, such that $c = c_0 + p$. As noted before, the hassle cost includes consumers' time and effort needed to locate, install and configure the ad-blocker on their device. The ad-blocker sets the fee p in Stage 1, along with the LAB ad intensity limit a_B. As before, if $\frac{\theta_L}{\theta_H} \geq \beta$, then the ad-blocker cannot attract users and will not employ LAB or set a positive user fee. For $\frac{\theta_L}{\theta_H} < \beta$, Proposition 3 describes the ad-blocker's optimal LAB strategy given c. We therefore examine the implications of increasing c. We observe from Table 3 in Proposition 3 that ad-blocker user (type-H consumers) surplus is strictly increasing in c in Cases 2 and 4, is unaffected by c in Case 1, and is strictly decreasing in c in Case 3. Ad-blocker user base surplus is also decreasing in cases where LAB is not employed (i.e., $a_B^* = 0$). The following corollary describes this result.

Corollary 4. *Ad-blocker user base surplus is increasing in the ad-blocker user fee if and only if the consumer's net cost to adopt the ad-blocker satisfies either conditions of Case 2 or Case 4 in Table 3.*

Charging a positive user fee can increase ad-blocker user base surplus by lowering the LAB ad intensity a_B needed to incentivize higher content quality. Essentially, a positive fee makes the ad-blocker relatively less attractive for ad-blocker non-users, thereby enabling the publisher to increase the website ad intensity a_N to non-users. This higher ad-intensity for non-users in turn increases the publisher's incentive to invest in

[7] See AdBlock Plus response at https://www.quora.com/Why-do-so-few-websites-use-AdBlocks-acceptable-ads
[8] For example, see AdGuard https://adguard.com/en/license.html or AdLock https://adlock.com/purchase/

high content quality, thus allowing the ad-blocker to lower the LAB ad intensity. Said differently, a positive user fee can enable the publisher to extract more surplus from ad-blocker non-users, and thus shifts the burden of incentivizing content quality from ad-blocker users to non-users.

Recall Figure 4 that illustrates the different cases in Proposition 3. Let B_{ij} denote the boundary of Case i and Case j in the region where the ad-blocker employs LAB. Moreover, let B_4 denote the right boundary of Case 4 region. It follows that, depending on the initial level of consumer hassle cost c_0, the ad-blocker may either charge a positive user fee and/or employ LAB (with positive $a_B^* > 0$) in equilibrium. Specifically, for a given d, if $c = c_0$ falls under Case 2, then the ad-blocker will charge a positive user fee. The optimal user fee is such that $c = c_0 + p$ is either on B_{13}, B_{23}, or on B_4. In the first two instances, the ad-blocker charges a positive fee and also employs LAB, while in the last instance, it charges a positive fee but does not employ LAB. Similarly, if $c = c_0$ satisfies the condition for Case 4, then the ad-blocker will charge a positive user fee such that $c = c_0 + p$ is on B_4, and will not employ LAB. In contrast, if $c = c_0$ satisfies the condition for Case 3, then either the ad-blocker only employs LAB and does not charge a positive fee, or charges a positive fee such that $c = c_0 + p$ is on B_4 and does not employ LAB. Lastly, if $c = c_0$ falls outside these regions, then the ad-blocker may neither employ LAB nor charge a positive price. We fully characterize the ad-blocker strategy in the limiting case $c_0 \to 0$ below.

Proposition 5*. If consumers do not face a hassle cost to adopt the ad-blocker ($c_0 \to 0$), then a user-oriented ad-blocker charges a positive user fee if and only if $\frac{\theta_L}{\theta_H} < \beta$, $2q_L < q_H$, and $d < \beta \frac{v(q_H - 2q_L)}{\theta_L}$, and also employs LAB ($a_B^* > 0$) if and only if $d < (1-\beta)\frac{vq_L}{\theta_H}$.*

Proposition 5 shows that even if consumers face no hassle cost to adopt the ad-blocker, a user-oriented ad-blocker may intentionally raise their cost to adopt the ad-blocker by charging a positive price if the level of high content quality is sufficiently high ($2q_L \leq q_H$). If $2q_L > q_H$, then the LAB ad intensity limit needed to incentivize content quality is too high, and it is not feasible for LAB to improve content quality and user base surplus even with a positive user fee. We also observe that in the absence of hassle cost, it is never optimal for the ad-blocker to only employ LAB without charging a positive price. As noted before, for positive hassle cost such that $c = c_0$ falls under Cases 1 or 3, it can be optimal for the ad-blocker to employ LAB and not charge a positive user fee.

Our findings shed light on alternative ways in which a not-for-profit ad-blocker may induce the publisher to invest in high content quality in order to improve user base surplus. On the one hand, LAB incentivizes provision of high content quality by enabling the publisher to attract and monetize website traffic from ad-blocker users. On the other hand, charging ad-blocker users a positive fee shifts some or all of the burden of incentivizing provision of high content quality to ad-blocker non-users by enabling the publisher to better monetize website traffic from ad-blocker non-users. We find that depending on the ad-blocker hassle cost, either strategy may be used on their own or in conjunction.

8 Conclusions and Future Research

Ad-blockers have emerged as an important player in the online space, fundamentally reshaping the online industry by regulating the ability of website publishers to monetize their content through ads, leading to much debate and controversy. Our work represents a step towards understanding the rationale and implications of LAB by a user-oriented ad-blocker.

Some of our findings are as follows. First, LAB can potentially benefit ad-blocker users by incentivizing website publishers to provide better content, but may do so only if consumers' ad-blocker adoption cost is not too low. Second, to incentivize content provision it may not be sufficient that LAB simply increases the publisher's ability to monetize website visits from ad-blocker users. Instead, LAB may need to be designed to also limit the publisher's ability to monetize low-quality content; blocking sufficiently few ads so as to discourage ad-blocker users from visiting low-quality websites. Third, the ad-blocker may attract more users, and hence be more popular, when it offers LAB than if it did not. Fourth, while ad-blockers and LAB have attracted much criticism, they may in fact lead to a "better world for all"; ad revenue, content quality, ad-blocker user and non-user surplus, and even publisher profit may all be higher under a user-oriented ad-blocker than in its absence. In particular, LAB can emerge as a means to discriminate ad intensity across consumers, if consumers who are more ad averse consumers also value content quality sufficiently more but not too much more than consumers who are less ad averse; moreover, the publisher may actively leverage the ad-blocker by raising its website ad intensity and content quality to induce more ad-averse consumers to adopt the ad-blocker, thereby effectively sorting themselves based on their aversion to ads. Fifth, raising consumers' ad-blocker adoption cost may benefit ad-blocker users by effectively shifting the burden of incentivizing content quality from ad-blocker users to non-users. A user-oriented ad-blocker may, therefore, either charge its users a positive fee, employ LAB or both.

Our results suggest that the use of LAB does not necessarily imply that an ad-blocker has compromised its users' interests; instead, the ad-blocker may well be improving user surplus while also benefiting publishers, and may even attract a larger user base by offering LAB. Our findings may also explain why some publishers and industry experts have favored actively engaging with LAB rather than discouraging the use of ad-blockers on their websites by requiring ad-blocker users to disable the ad-blocker.

Our analysis can be extended in several directions. We analyzed the strategies of a user-oriented ad-blocker to shed light on the controversy surrounding ad-blockers. One can examine the implications of an ad-blocker that is also influenced by profit motive, in addition to user welfare. For example, the ad-blocker may receive a share of the ad revenue generated from ad-blocker users from LAB. We expect that the ad-blocker's profit motive will increase LAB ad-intensity and the scope for LAB. The scope for a win-win for ad-blocker users and publisher can be higher or lower depending on the ad-blocker's share of LAB revenue: ad-blocker users are better off than without the ad-blocker; the publisher may be better off because of higher LAB ad intensity if the ad-blocker's share of LAB revenue is not too high, but not otherwise.

Our analysis showed that LAB can make the publisher better off than in the absence of the ad-blocker (Proposition 4). However, in other situations the publisher can be worse off. One can examine the implications if a publisher could respond by blocking ad-blocker users from browsing its website, in an attempt to force them to visit without the ad-blocker and not avoid ads (as in the benchmark scenario). Blocking ad-blocker users can lead to consumer backlash and drop in website traffic (e.g., O'Reilly 2016, Söllner and Dost 2019). However, in the absence of such backlash, the ad-blocker must design its LAB to ensure that the publisher is not worse off than in the benchmark scenario and, hence, does not block ad-blocker users (users are better off under LAB than in the benchmark scenario). On the one hand, this may cause the ad-blocker to set a higher LAB ad intensity limit, thereby increasing the scope for LAB to occur. On the other hand, this may also cause the scope for LAB to be diminished as it might not be possible to make the publisher better off than in the benchmark scenario; e.g., in the main analysis with $v_H = v_L = v$.

Lastly, we focused on two discrete consumer segments and a single publisher. Allowing for multiple or continuous consumer segments could allow for analysis of more complex consumer sorting behaviors and publisher strategies. Publisher competition could lead to additional strategic effects that favor LAB, for example by relaxing publisher competition for ad-blocker non-users (as in Depotakis, Ravi and Srinivasan 2017), thus lowering the burden on ad-blocker users to incentivize content provision. We leave it for future research to examine these further.

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Appendix

Proofs of Lemma 1, Lemma 2, Lemma 3, Proposition 1, Proposition 2, and Corollary 1 follow directly from the main text.

A1. Proof of Lemma 4

In the main text we showed $R(q_H, a_B) = a_B + \beta \frac{c}{\theta_L}$. We now obtain $R(q_L, a_B)$ and $\Delta R(a_B)$ in each case of Lemma 4:

(i) If $c \in [0, vq_L)$ and $a_B \in \left[0, \frac{vq_L - c}{\theta_H}\right)$, then the condition of Case 4 in Table 2 holds. Thus, $R(q_L, a_B) = a_B + \beta \frac{c}{\theta_L}$ and thus $\Delta R(a_B) = 0$

(ii) If $c \in [0, vq_L)$ and $a_B \in \left[\frac{vq_L - c}{\theta_H}, min\{\frac{vq_L - c}{\theta_L}, \frac{vq_H - c}{\theta_H}\}\right)$ then condition of Case 2 or 3 in Table 2 holds. If $\beta\left(a_B + \frac{c}{\theta_L}\right) < \frac{vq_L}{\theta_H}$, then Case 2 holds and thus $R(q_L, a_B) = \frac{vq_L}{\theta_H}$. Otherwise, if $\beta\left(a_B + \frac{c}{\theta_L}\right) > \frac{vq_L}{\theta_H}$, then Case 3 holds and thus $R(q_L, a_B) = \beta\left(a_B + \frac{c}{\theta_L}\right)$. Thus, $\Delta R(a_B) = a_B + \beta \frac{c}{\theta_L} - max\left\{\beta\left(a_B + \frac{c}{\theta_L}\right), \frac{vq_L}{\theta_H}\right\}$

(iii) If $c \in [vq_L, vq_H)$, or if $c < vq_L$ and $\frac{vq_L - c}{\theta_L} < \frac{vq_H - c}{\theta_H}$ (i.e., $\frac{v(q_L\theta_H - q_H\theta_L)}{\theta_H - \theta_L} < c$) and $a_B \in \left[\frac{vq_L - c}{\theta_L}, \frac{vq_H - c}{\theta_H}\right)$, then the condition of Case 1 in Table 2 holds: $\frac{vq_L - c}{\theta_L} < a_B < \frac{vq_H - c}{\theta_H}$. Thus, $R(q_L, a_B) = \beta \frac{vq_L}{\theta_L}$. Hence, $\Delta R(a_B) = a_B + \beta \frac{c}{\theta_L} - \beta \frac{vq_L}{\theta_L}$

A2. Proof of Proposition 3

As elaborated in the manuscript, ad-blocker's optimization problem is

$$\min_{a_B > 0} a_B,$$

$$\text{subject to: (1) } \Delta R(a_B) \geq d,$$

$$\text{(2) } \Delta R(0) < d,$$

$$\text{(3) } U_H(q_H, a_B) - c > \max\{0, U_H(q_L, 0) - c\}.$$

For $c \in [vq_L, vq_H)$, we have from Lemma 4 that $\Delta R(a_B) = a_B + \frac{\beta(c - vq_L)}{\theta_L}$. Thus, constraints (1) and (2) become, respectively, $a_B + \frac{\beta(c - vq_L)}{\theta_L} > d$ and $\frac{\beta(c - vq_L)}{\theta_L} < d$. If constraint (2) does not hold, publisher will invest in high content quality even without LAB, and thus LAB is not employed. When constraint (2) holds, the publisher will not invest in high content quality without LAB. Thus, type-H consumers do not visit and $U_H(q_L, 0) = 0$. Thus, constraint (3) reduces to $vq_H - \theta_H a_B - c > 0$ or $a_B < \frac{vq_H - c}{\theta_H}$. Hence, $a_B^* = d -$

$\frac{\beta(c-vq_L)}{\theta_H}$, such that constraint (1) is binding, provided constraint (2) and (3) hold. It follows we should have $0 < d - \frac{\beta(c-vq_L)}{\theta_H} < \frac{vq_H-c}{\theta_H}$. This is Case 4 in Table 3.

When $c \in [0, vq_L)$, solving the optimization problem is more complicated since $\Delta R(a_B)$ takes different forms (see Lemma 4 and Figure 3 left panel). We characterize the optimal a_B in two steps. In Step 1, we develop possible "candidates" for a_B^*. In the Step 2, we derive the necessary and sufficient conditions for each of the candidates to be an equilibrium.

Step 1: Possible Equilibrium Candidates When $c \in [0, vq_L)$

We note that ad-blocker's optimization problem ($\min_{a_B>0} a_B$) is linear in a_B. Thus, the optimal a_B is a *corner solution;* a_B^* is smallest value of a_B that satisfies all three constraints. Note that constraint (2) always hold since $\Delta R(0) = 0$ when $c \in [0, vq_L)$. Moreover, constraint (3) becomes $vq_H - \theta_H a_B - c > vq_L - c$, or $a_B < \frac{v(q_H-q_L)}{\theta_H}$, thus imposing a *higher* bound on a_B. Consequently, the only possible candidates for equilibrium a_B must come from constraint (1). The first candidate is $a_{B1} = \frac{vq_L-c}{\theta_H}$ at which $\Delta R(a_B)$ has a discontinuous jump (from zero to a positive level). Other possible a_B^* candidates are derived by solving $\Delta R(a_B) = d$ for a_B, i.e., when constraint (1) binds. Per Lemma 4, we have three possible positive values for $\Delta R(a_B)$, namely, $\Delta R(a_B) = a_B + \beta\frac{c}{\theta_L} - \frac{vq_L}{\theta_H}$, $\Delta R(a_B) = (1-\beta)a_B$, or $\Delta R(a_B) = a_B + \frac{\beta(c-vq_L)}{\theta_L}$. Accordingly, three more possible equilibrium a_B candidates are $a_{B2} = \frac{vq_L}{\theta_H} - \beta\frac{c}{\theta_L} + d$, $a_{B3} = \frac{d}{1-\beta}$, and $a_{B4} = \beta\frac{vq_L}{\theta_L} - \beta\frac{c}{\theta_L} + d$. Next, we derive the necessary and sufficient conditions for each of the candidates to be an equilibrium.

Step 2. Deriving Necessary and Sufficient Conditions for Equilibrium Candidates When $c \in [0, vq_L)$

Ad-blocker optimally sets a_B at the *minimum* level that satisfies $\Delta R(a_B) \geq d$. Since $\Delta R(a_B) = 0$ for $a_B < a_{B1}$, we should have $a_B^* \geq a_{B1}$. Thus, for a_{B1} to be NE, all other candidates should be lower than a_{B1}, i.e., $\max\{a_{B2}, a_{B3}, a_{B4}\} < a_{B1}$. Since $a_{B2} < a_{B4}$, it follows $\max\{a_{B3}, a_{B4}\} < a_{B1}$. Moreover, Constraint (3) requires $a_{B1} < \frac{v(q_H-q_L)}{\theta_H}$ which implies $\max\{v(2q_L - q_H), 0\} < c$. Thus, the necessary and sufficient conditions for $a_B^* = a_{B1}$ is $v(2q_L - q_H) < c < vq_L$ and $\max\{\frac{d}{1-\beta}, \frac{vq_L}{\theta_H} - \beta\frac{c}{\theta_L} + d\} < \frac{vq_L-c}{\theta_H} < \frac{vq_H-vq_L}{\theta_H}$ (condition of Case 1 in Table 3).

For $a_B^* = a_{Bi}, i \in \{2,3,4\}$ to be equilibrium, we should have $a_{B1} < a_{Bi} < \frac{v(q_H-q_L)}{\theta_H}$. Thus, this is a common condition in Case 2, 3, and 4 in Table 3. Moreover, the Lemma 4 conditions corresponding to a_{Bi} should be satisfied. In particular, a_{B2} solved $d = \Delta R(a_{B2}) = a_{B2} + \beta\frac{c}{\theta_L} - \frac{vq_L}{\theta_H}$ (part (ii) of Lemma 4) requiring

$\beta\left(a_{B2}+\frac{c}{\theta_L}\right)<\frac{vq_L}{\theta_H}$ and $a_{B2}\in\left[a_{B1},min\{\frac{vq_L-c}{\theta_L},\frac{vq_H-c}{\theta_H}\}\right)$. Together, we get $0<a_{B1}<a_{B2}<min\left\{\frac{v(q_H-q_L)}{\theta_H},\frac{vq_L}{\beta\theta_H}-\frac{c}{\theta_L}\right\}$, which is the condition of Case 2 in Table 3. Hence, $a_B^*=a_{B2}$

Similarly, for a_{B3} to be NE we should have $\beta\left(a_{B3}+\frac{c}{\theta_L}\right)>\frac{vq_L}{\theta_H}$ and $a_{B3}\in\left[a_{B1},min\{\frac{vq_L-c}{\theta_L},\frac{vq_H-c}{\theta_H}\}\right)$ per part (ii) of Lemma 4. Combining with $0<a_{B1}<a_{B3}<\frac{v(q_H-q_L)}{\theta_H}$, we get $max\left\{a_{B1},\frac{vq_L}{\beta\theta_H}-\frac{c}{\theta_L},0\right\}<a_{B3}<min\left\{\frac{v(q_H-q_L)}{\theta_H},\frac{vq_L-c}{\theta_L},\frac{vq_H-c}{\theta_H}\right\}=min\left\{\frac{v(q_H-q_L)}{\theta_H},\frac{vq_L-c}{\theta_L}\right\}$ which is the condition for Case 2 in Table 3.

Finally, a_{B4} was derived from part (iii) of Lemma 4 requiring $0<\frac{vq_L-c}{\theta_L}<a_{B4}<\frac{vq_H-c}{\theta_H}$. Combining with $0<a_{B1}<a_{B4}<\frac{v(q_H-q_L)}{\theta_H}$ we get $0<\frac{vq_L-c}{\theta_L}<a_{B4}<\frac{v(q_H-q_L)}{\theta_H}$. Also, remind that when $vq_L<c<vq_H$ optimal a_B is a_{B4} if and only if $0<a_{B4}<\frac{vq_H-c}{\theta_H}$. Combining $c<vq_L$ and $vq_L<c<vq_H$ cases, we get the condition for Case 4 in Table 3, that is, $max\{0,\frac{vq_L-c}{\theta_L}\}<a_{B4}<min\left\{\frac{v(q_H-q_L)}{\theta_H},\frac{vq_H-c}{\theta_H}\right\}$

Therefore, based on Table 3, in Case 1, 2, 3, and Case 4 when $vq_L>c$, LAB is employed if $\max\{0,v(2q_L-q_H)\}<c<vq_L$ and d is sufficiently low. In Case 4 when $vq_L<c<vq_H$, LAB is employed if d is neither too high nor too low. This completes the proof of proposition.

A3. Model Solution When Valuations are Heterogeneous ($v_L\neq v_H$)

The procedure of deriving the equilibrium strategies in the case of ($v_L\neq v_H$) is similar to the main model. As discussed in the manuscript, only $v_H>v_L$ can result in a publisher revenue higher than benchmark. Thus, we consider only this case ($v_H>v_L$). After deriving consumer behavior, we derive publisher's optimal ad intensity given q and a_B. Then, we construct publisher's marginal revenue function, $\Delta R(a_B)$. Finally, we derive optimal LAB strategy.

A3-1. Consumer Ad-blocking Behavior

The type-i consumer's utility from installing the ad-blocker and visiting the website is $U_i^B(q,a_B)=v_iq-\theta_ia_B-c$. Thus, ad-blocker is a *viable option* for a type-i consumer if and only if $v_iq>c$ and $a_B\in\left[0,\frac{v_iq-c}{\theta_i}\right)$. When the ad-blocker is a viable option, a type-i consumer will visit the website without the ad-blocker if $a_N\leq a_B+\frac{c}{\theta_i}$, and will visit with the ad-blocker otherwise. When the ad-blocker is not a viable option ($v_iq\leq c$ or $a_B>\frac{v_iq-c}{\theta_i}$), a type-$i$ consumer will not install the ad-blocker and will visit the website if $a_N\leq\frac{v_iq}{\theta_i}$, and will not visit otherwise.

A3-2. Publisher Website Ad Intensity Decision

We consider the following 4 cases and construct the publisher's optimal ad intensity in each case.

- Case 1: ad-blocker is viable for both consumer segments.
- Case 2: ad-blocker is viable for type-L consumers but not viable for type-H consumers.
- Case 3: ad-blocker is viable for type-H consumers but not viable for type-L consumers.
- Case 4: ad-blocker is not viable for either consumer segment.

We note that unlike main model, it is possible that ad-blocker is viable for type-H consumers but not viable for type-L consumers (Case 3). Other three cases are similar to the main model.

Case 1: Ad-blocker is viable for both consumer segments if and only if $c < v_L q < v_H q$ and $a_B \leq \min\left\{\frac{v_H q - c}{\theta_H}, \frac{v_L q - c}{\theta_L}\right\}$. Then, publisher essentially faces a choice between the following two ad intensities: (i) $a_N = a_B + \frac{c}{\theta_H}$ to attract both segments to visit without the ad-blocker and earn revenues of $a_B + \frac{c}{\theta_H}$, (ii) $a_N = a_B + \frac{c}{\theta_L}$ to attract type-L consumers to visit without the ad-blocker and induce type-H consumers to visit with ad-blocker, and earn revenues of $\beta\left(a_B + \frac{c}{\theta_L}\right) + (1-\beta)a_B = a_B + \beta\frac{c}{\theta_L}$. The former is more profitable if $\frac{\theta_L}{\theta_H} \geq \beta$.

Case 2: Ad-blocker is viable for type-L consumers but not viable for type-H consumers if and only if $c < v_L q < v_H q$ and $\frac{v_H q - c}{\theta_H} < a_B < \frac{v_L q - c}{\theta_L}$. Then, publisher essentially faces a choice between the following two ad intensities: (i) $a_N = \frac{v_H q}{\theta_H}$ to attract both segments to visit without the ad-blocker and earn revenues of $\frac{v_H q}{\theta_H}$, (ii) $a_N = a_B + \frac{c}{\theta_L}$ to attract type-L consumers to visit without the ad-blocker and while losing type-H consumers, and earn revenues of $\beta\left(a_B + \frac{c}{\theta_L}\right)$. The former is more profitable if $a_B < \frac{v_H q}{\beta\theta_H} - \frac{c}{\theta_L}$.

Case 3: Ad-blocker is viable for type-H consumers but not viable for type-L consumers if and only if $v_L q \leq c < v_H q$ and $a_B < \frac{v_H q - c}{\theta_H}$, or $c < v_H q$ and $\frac{v_L q - c}{\theta_L} < a_B < \frac{v_H q - c}{\theta_H}$. There are two cases to consider:

- **Case 3a ($\frac{v_H}{\theta_H} < \frac{v_L}{\theta_L}$):** Then publisher faces a choice between: (i) $a_N = a_B + \frac{c}{\theta_H}$ to attract both segments to visit without the ad-blocker and earn revenues of $a_B + \frac{c}{\theta_H}$, (ii) $a_N = \frac{v_L q}{\theta_L}$ to attract type-L consumers to visit without the ad-blocker while type-H consumers visit with ad-blocker, and earn revenues of $\beta\frac{v_L q}{\theta_L} + (1-\beta)a_B$. The former is more profitable if $a_B > \frac{v_L q}{\theta_L} - \frac{c}{\beta\theta_H}$.
- **Case 3b ($\frac{v_H}{\theta_H} \geq \frac{v_L}{\theta_L}$):** Then,
    - If $\frac{v_L q}{\theta_L} < a_B + \frac{c}{\theta_H}$, publisher faces a choice between: (i) $a_N = \frac{v_L q}{\theta_L}$ to attract both segments to visit without the ad-blocker and earn revenues of $\frac{v_L q}{\theta_L}$, (ii) $a_N = a_B + \frac{c}{\theta_H}$ to attract type-H to visit without the ad-blocker while losing type-L, and earn revenues of $(1-\beta)(a_B + \frac{c}{\theta_H})$. The

former is more profitable if $\frac{v_L q}{(1-\beta)\theta_L} - \frac{c}{\theta_H} > a_B$.

- If $\frac{v_L q}{\theta_L} > a_B + \frac{c}{\theta_H}$, publisher faces a choice between: (i) $a_N = a_B + \frac{c}{\theta_H}$ to attract both segments to visit without the ad-blocker and earn revenues of $a_B + \frac{c}{\theta_H}$, (ii) $a_N = \frac{v_L q}{\theta_L}$ to attract type-L to visit without the ad-blocker while type-H install ad-blocker and visit, and earn revenues of $\beta \frac{v_L q}{\theta_L} + (1-\beta)a_B$.The former is more profitable if $a_B > \frac{v_L q}{\theta_L} - \frac{c}{\beta\theta_H}$.

Case 4: Ad-blocker is: ad-blocker is not viable for either consumer segment if and only if $c < v_L q$ and $a_B > \max\left\{\frac{v_H q - c}{\theta_H}, \frac{v_L q - c}{\theta_L}\right\}$, or $v_L q \leq c < v_H q$ and $a_B > \frac{v_H q - c}{\theta_H}$, or $v_H q \leq c$. These three condition can be stated as $\max\{\frac{v_H q - c}{\theta_H}, \frac{v_L q - c}{\theta_L}\} < a_B$.Then, publisher's optimal a_N is as in the benchmark scenario. Specifically,

- If $\frac{v_H}{\theta_H} \leq \frac{v_L}{\theta_L}$: $a_N = \frac{v_H q}{\theta_H}$ when $\frac{v_H}{\theta_H} > \beta \frac{v_L}{\theta_L}$ and $a_N = \frac{v_L q}{\theta_L}$ otherwise.
- If $\frac{v_H}{\theta_H} > \frac{v_L}{\theta_L}$: $a_N = \frac{v_L q}{\theta_L}$ when $\frac{v_L}{\theta_L} > (1-\beta)\frac{v_H}{\theta_H}$ and $a_N = \frac{v_H q}{\theta_H}$ otherwise.

These results are summarized in Table A1A (for $\frac{v_H}{\theta_H} \leq \frac{v_L}{\theta_L}$) and Table A1B (for $\frac{v_H}{\theta_H} > \frac{v_L}{\theta_L}$).

Table A1A ($\frac{v_H}{\theta_H} \leq \frac{v_L}{\theta_L}$): Publisher's Optimal Ad Intensity and Revenue Given a_B and q

$a_N^*(q, a_B)$		$R(a_B, q)$	Customer Behavior	Conditions
1	$\frac{v_H q}{\theta_H}$	$\frac{v_H q}{\theta_H}$	L:NI-V H:NI-V	**1*a***: $\frac{v_H}{\theta_H} > \beta \frac{v_L}{\theta_L}, \max\{\frac{v_H q - c}{\theta_H}, \frac{v_L q - c}{\theta_L}\} < a_B$ **1*b***: $\frac{v_H q - c}{\theta_H} < a_B < \min\{\frac{v_L q - c}{\theta_L}, \frac{v_H q}{\beta\theta_H} - \frac{c}{\theta_L}\}$
2	$\frac{v_L q}{\theta_L}$	$\beta \frac{v_L q}{\theta_L}$	L:NI-V H:NI-NV	**2*a***: $\frac{v_H}{\theta_H} < \beta \frac{v_L}{\theta_L}, \max\{\frac{v_H q - c}{\theta_H}, \frac{v_L q - c}{\theta_L}\} < a_B$
		$\beta \frac{v_L q}{\theta_L} + (1-\beta)a_B$	L:NI-V **H: I-V**	**2*b***: $\frac{\theta_L}{\theta_H} < \beta, \frac{v_L q}{\theta_L} - \frac{c}{\theta_L} < a_B < \min\{\frac{v_H q - c}{\theta_H}, \frac{v_L q}{\theta_L} - \frac{c}{\beta\theta_H}\}$
3	$a_B + \frac{c}{\theta_H}$	$\left(a_B + \frac{c}{\theta_H}\right)$	L:NI-V H:NI-V	**3*a***: $\frac{\theta_L}{\theta_H} > \beta, a_B < \min\{\frac{v_H q - c}{\theta_H}, \frac{v_L q - c}{\theta_L}\}$ **3*b***: $\max\{\frac{v_L q - c}{\theta_L}, \frac{v_L q}{\theta_L} - \frac{c}{\beta\theta_H}\} < a_B < \frac{v_H q - c}{\theta_H}$
4	$a_B + \frac{c}{\theta_L}$	$\beta\left(a_B + \frac{c}{\theta_L}\right)$	L:NI-V H:NI-NV	**4*a***: $\max\{\frac{v_H q - c}{\theta_H}, \frac{v_H q}{\beta\theta_H} - \frac{c}{\theta_L}\} < a_B < \frac{v_L q - c}{\theta_L}$
		$a_B + \beta \frac{c}{\theta_L}$	L:NI-V **H: I-V**	**4*b***: $\frac{\theta_L}{\theta_H} < \beta, a_B < \min\{\frac{v_H q - c}{\theta_H}, \frac{v_L q - c}{\theta_L}\}$

Table A1B ($\frac{v_H}{\theta_H} > \frac{v_L}{\theta_L}$): Publisher's Optimal Ad Intensity and Revenue Given a_B and q				
$a_N(q, a_B)$		$R(a_B, q)$	**Customer Behavior**	**Conditions**
1	$\frac{v_H q}{\theta_H}$	$(1-\beta)\frac{v_H q}{\theta_H}$	L:NI-NV H:NI-V	**1:** $\frac{v_L}{\theta_L} < (1-\beta)\frac{v_H}{\theta_H}, \frac{v_H q - c}{\theta_H} < a_B$
2	$\frac{v_L q}{\theta_L}$	$\frac{v_L q}{\theta_L}$	L:NI-V H:NI-V	**2*a*:** $\frac{v_L q}{\theta_L} - \frac{c}{\theta_H} < a_B < \min\{\frac{v_H q - c}{\theta_H}, \frac{v_L q}{(1-\beta)\theta_L} - \frac{c}{\theta_H}\}$ **2*b*:** $\frac{v_L}{\theta_L} > (1-\beta)\frac{v_H}{\theta_H}, \frac{v_H q - c}{\theta_H} < a_B$
		$\beta\frac{v_L q}{\theta_L} + (1-\beta)a_B$	L:NI-V **H: I-V**	**2*c*:** $\frac{\theta_L}{\theta_H} < \beta, \frac{v_L q - c}{\theta_L} < a_B < \frac{v_L q}{\theta_L} - \frac{c}{\beta\theta_H}$
3	$a_B + \frac{c}{\theta_H}$	$(1-\beta)\left(a_B + \frac{c}{\theta_H}\right)$	L:NI-NV H:NI-V	**3*a*:** $\frac{v_L}{\theta_L} < (1-\beta)\frac{v_H}{\theta_H}, \frac{v_L q}{(1-\beta)\theta_L} - \frac{c}{\theta_H} < a_B < \frac{v_H q - c}{\theta_H}$
		$a_B + \frac{c}{\theta_H}$	L:NI-V H:NI-V	**3*b*:** $\max\{\frac{v_L q - c}{\theta_L}, \frac{v_L q}{\theta_L} - \frac{c}{\beta\theta_H}\} < a_B < \frac{v_L q}{\theta_L} - \frac{c}{\theta_H}$ **3*c*:** $\frac{\theta_L}{\theta_H} > \beta, a_B < \frac{v_L q - c}{\theta_L}$
4	$a_B + \frac{c}{\theta_L}$	$a_B + \beta\frac{c}{\theta_L}$	L:NI-V **H: I-V**	**4:** $\frac{\theta_L}{\theta_H} < \beta, a_B < \frac{v_L q - c}{\theta_L}$

A3-3. Publisher Website Content Quality Decision

We now construct $\Delta R(a_B)$. Similar to the $v_L = v_H = v$ case, it is sufficient to focus on $\frac{\theta_L}{\theta_H} < \beta$ and $a_B < \frac{v_H q_H - c}{\theta_H}$ since otherwise ad-blocker cannot attract users. Moreover, per Lemma 5, publisher revenue under LAB is strictly below that in the benchmark scenario if $\frac{v_H}{\theta_H} > \frac{v_L}{\theta_L}$. Thus, we require $\frac{v_H}{\theta_H} \leq \frac{v_L}{\theta_L}$ (Table A1A).

Table A2: Publisher's Return on Content Quality Given a_B ($\frac{v_H}{\theta_H} \leq \frac{v_L}{\theta_L}$ and $a_B < \frac{v_H q_H - c}{\theta_H}$)		
	$\Delta R(a_B)$	**Conditions**
1	0	$a_B < \min\left\{\frac{v_H q_L - c}{\theta_H}, \frac{v_L q_L - c}{\theta_L}\right\}$
2	$\beta\frac{v_L q_H}{\theta_L} + (1-\beta)a_B - q_L \max\left\{\frac{v_H}{\theta_H}, \beta\frac{v_L}{\theta_L}\right\}$	$\max\left\{\frac{v_H q_L - c}{\theta_H}, \frac{v_L q_H - c}{\theta_L}\right\} < a_B < \min\left\{\frac{v_H q_H - c}{\theta_H}, \frac{v_L q_H}{\theta_L} - \frac{c}{\beta\theta_H}\right\}$
3	$\beta\frac{v_L}{\theta_L}(q_H - q_L)$	$\frac{v_L q_H - c}{\theta_L} < a_B < \min\left\{\frac{v_H q_L - c}{\theta_H}, \frac{v_L q_L}{\theta_L} - \frac{c}{\beta\theta_H}\right\}$
4	$\beta\frac{v_L q_H}{\theta_L} - \frac{c}{\theta_H} - \beta a_B$	$\max\left\{\frac{v_L q_H - c}{\theta_L}, \frac{v_L q_L}{\theta_L} - \frac{c}{\beta\theta_H}\right\} < a_B < \min\left\{\frac{v_H q_L - c}{\theta_H}, \frac{v_L q_H}{\theta_L} - \frac{c}{\beta\theta_H}\right\}$
5	$a_B + \beta\frac{c}{\theta_L} - \frac{v_H q_L}{\theta_H}$	$\frac{v_H q_L - c}{\theta_H} < a_B < \min\left\{\frac{v_H q_L}{\beta\theta_H} - \frac{c}{\theta_L}, \frac{v_H q_H - c}{\theta_H}, \frac{v_L q_L - c}{\theta_L}\right\}$
6	$a_B + \beta\frac{c}{\theta_L} - q_L \max\left\{\frac{v_H}{\theta_H}, \beta\frac{v_L}{\theta_L}\right\}$	$\max\left\{\frac{v_H q_L - c}{\theta_H}, \frac{v_L q_L - c}{\theta_L}\right\} < a_B < \min\left\{\frac{v_H q_H - c}{\theta_H}, \frac{v_L q_H - c}{\theta_L}\right\}$
6	$\beta a_B + \beta\frac{c - v_L q_L}{\theta_L}$	$\frac{v_L q_L - c}{\theta_L} < a_B < \min\left\{\frac{v_H q_L - c}{\theta_H}, \frac{v_L q_H - c}{\theta_L}, \frac{v_L q_L}{\theta_L} - \frac{c}{\beta\theta_H}\right\}$
7	$\beta\frac{c}{\theta_L} - \frac{c}{\theta_H}$	$\frac{v_L q_L}{\theta_L} - \frac{c}{\beta\theta_H} < a_B < \min\left\{\frac{v_H q_L - c}{\theta_H}, \frac{v_L q_H - c}{\theta_L}\right\}$
8	$(1-\beta)a_B$	$\max\left\{\frac{v_H q_L - c}{\theta_H}, \frac{v_H q_L}{\beta\theta_H} - \frac{c}{\theta_L}\right\} < a_B < \min\left\{\frac{v_H q_H - c}{\theta_H}, \frac{v_L q_L - c}{\theta_L}\right\}$

Consider conditions in the last column of Table A1A. We know that LAB is employed only if type-H install the ad-blocker. Thus, under high quality, we only need to consider $2b$ and $4b$, referred to as $2bH$ and $4bH$ under high quality. Under low quality, seven conditions (all except $3a$) can hold under low quality. Denote these seven conditions under low quality by $1aL$, $1bL$, $2aL$, $2bL$, $3bL$, $4aL$, and $4bL$. To construct $\Delta R(a_B)$, we intersect each of the two conditions under high quality ($2bH$ and $4bH$) with each of the seven conditions under low quality ($1aL$, $1bL$, $2aL$, $2bL$, $3bL$, $4aL$, and $4bL$) and calculate $\Delta R(a_B)$ at each of these 14 intersection (if they are non-empty). The results are summarized in Table A2 (analogous to Lemma 4 in the main text).

A3-4. Ad-blocker LAB Strategy

Similar to the homogeneous valuation case, ad-blocker's optimization problem is

$$\min_{a_B>0} a_B,$$

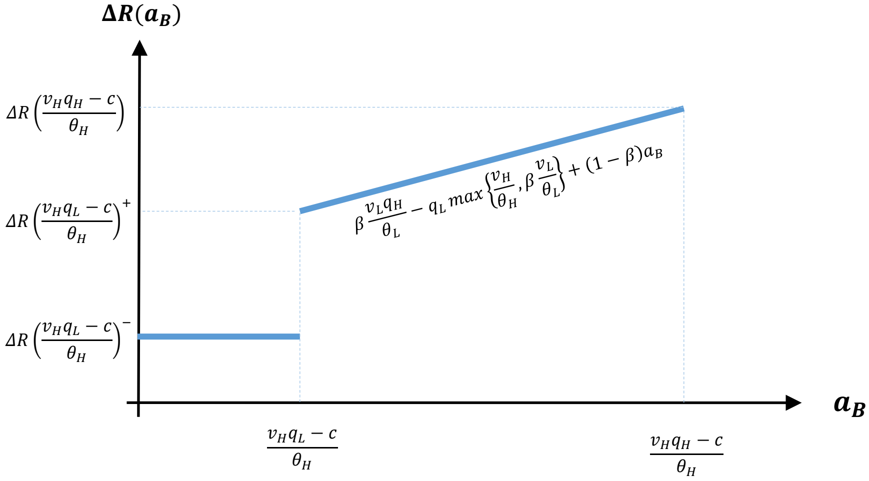
$$\begin{aligned} \text{subject to: } &(1)\ \Delta R(a_B) \geq d, \\ &(2)\ \Delta R(0) < d, \\ &(3)\ v_H q_H - \theta_H a_B - c > \max\{0, v_H q_L - c\}, \end{aligned}$$

where $\Delta R(a_B)$ is given in Table A2. There are several cases to consider depending on whether the ad-blocker is viable for none, one or both segments under low content quality. We present the analysis for the case when $v_L q_H < c < \hat{c} \triangleq \frac{\frac{v_L q_L}{\theta_L} - \frac{v_H q_L}{\theta_H}}{\frac{1}{\beta\theta_H} - \frac{1}{\theta_H}}$. The analysis for cases when c is outside this interval is similar and is available upon request. Given $v_L q_H < c < \hat{c}$, we simplify $\Delta R(a_B)$ in Table A2 and obtain,

$$\Delta R(a_B) = \begin{cases} \beta \dfrac{v_L}{\theta_L}(q_H - q_L) & \text{if } \ 0 \leq a_B < \dfrac{v_H q_L - c}{\theta_H} \\ \beta \dfrac{v_L q_H}{\theta_L} + (1-\beta) a_B - q_L \max\{\dfrac{v_H}{\theta_H}, \beta \dfrac{v_L}{\theta_L}\} & \text{if } \ \dfrac{v_H q_L - c}{\theta_H} < a_B < \dfrac{v_H q_H - c}{\theta_H} \end{cases}$$

Given $\Delta R(a_B)$, we solve the ad-blocker's optimization problem; we find minimum a_B such that constraints (1), (2) and (3) are satisfied. First, we note that constraint (3) requires $a_B^* < \frac{v_H}{\theta_H}(q_H - q_L)$. Second, constraint (2) requires $\Delta R(0) = \beta \frac{v_L}{\theta_L}(q_H - q_L) < d$. Otherwise, ad-blocker does not employ LAB since publisher provides high quality even when a_B. Third, we note $\Delta R(a_B)$ is discontinuous at $a_B = \frac{v_H q_L - c}{\theta_H}$: we have $\Delta R\left(\frac{v_H q_L - c}{\theta_H}\right)^- = \beta \frac{v_L}{\theta_L}(q_H - q_L)$ is less than $\Delta R\left(\frac{v_H q_L - c}{\theta_H}\right)^+$. Figure A1 illustrates $\Delta R(a_B)$.

Figure A1. Publisher Return on Quality ($v_L q_H < c < \hat{c}$)



Thus, if $d < \Delta R\left(\frac{v_H q_L - c}{\theta_H}\right)^-$, then LAB is not employed ($a_B^* = 0$). If $\Delta R\left(\frac{v_H q_L - c}{\theta_H}\right)^- < d < \Delta R\left(\frac{v_H q_L - c}{\theta_H}\right)^+$, then $a_B^* = \left(\frac{v_H q_L - c}{\theta_H}\right)^+$ provided constraint (3) is satisfied (i.e., $a_B^* < \frac{v_H(q_H - q_L)}{\theta_H}$). Finally, if $\Delta R\left(\frac{v_H q_L - c}{\theta_H}\right)^+ < d < \Delta R\left(\frac{v_H q_H - c}{\theta_H}\right) = \beta\frac{v_L q_H}{\theta_L} - q_L \max\left\{\frac{v_H}{\theta_H}, \beta\frac{v_L}{\theta_L}\right\} + (1-\beta)\frac{v_H q_H - c}{\theta_H}$, ad-blocker sets a_B such that constraint (1) binds (i.e., $\Delta R(a_B) = d$). Thus, $a_B^* = \frac{d + q_L \max\{\frac{v_H}{\theta_H}, \beta\frac{v_L}{\theta_L}\} - \beta\frac{v_L q_H}{\theta_L}}{1-\beta}$, provided that constraint (3) is satisfied. We summarize the ad-blocker optimal LAB strategy in the following Table A3.

Table A3. Ad-blocker's Optimal LAB ($a_B^* > 0$), for $\max\{v_L q_H, v_H(2q_L - q_H)\} < c < \hat{c}$

Case	a_B^*	**Conditions**
1	$\frac{v_H q_L - c}{\theta_H}$	**C1:** $\beta\frac{v_L(q_H - q_L)}{\theta_L} < d \le \beta\frac{v_L q_H}{\theta_L} - q_L\, max\left\{\frac{v_H}{\theta_H}, \beta\frac{v_L}{\theta_L}\right\} + (1-\beta)\frac{v_H q_L - c}{\theta_H}$
2	$\frac{d + q_L \max\left\{\frac{v_H}{\theta_H}, \beta\frac{v_L}{\theta_L}\right\} - \beta\frac{v_L q_H}{\theta_L}}{1-\beta}$	**C2:** $\beta\frac{v_L q_H}{\theta_L} - q_L\, max\left\{\frac{v_H}{\theta_H}, \beta\frac{v_L}{\theta_L}\right\} + (1-\beta)\frac{v_H q_L - c}{\theta_H} < d \le \beta\frac{v_L q_H}{\theta_L} - q_L\, max\left\{\frac{v_H}{\theta_H}, \beta\frac{v_L}{\theta_L}\right\} + (1-\beta)\frac{v_H(q_H - q_L)}{\theta_H}$

A4. Proof of Lemma 5

If $\frac{v_L}{\theta_L} < \frac{v_H}{\theta_H}$ (Table A1B), the publisher's maximum revenue is $\beta\frac{v_L q}{\theta_L} + (1-\beta)a_B$ at $a_B = \frac{v_L q}{\theta_L} - \frac{c}{\beta\theta_H}$. So, $R = \frac{v_L q}{\theta_L} - (1-\beta)\frac{c}{\beta\theta_H} < \max\{\frac{v_L q}{\theta_L}, (1-\beta)\frac{v_H q}{\theta_H}\}$, the last expression being the benchmark revenue. Thus, publisher's revenue cannot be higher than benchmark when $\frac{v_H}{v_L} > \frac{\theta_H}{\theta_L}$.

If $\frac{v_H}{v_L} < 1$, then, $\frac{v_H}{\theta_H} < \beta\frac{v_L}{\theta_L} < \frac{v_L}{\theta_L}$. Then, in the benchmark, $R^{Ben} = \beta\frac{v_L}{\theta_L}q$. With ad-blocker, publisher's revenue for small a_B is $a_B + \beta \frac{c}{\theta_L}$. So, the maximum revenue occurs at $\frac{v_H q - c}{\theta_H}$. Thus, $R = a_B + \beta \frac{c}{\theta_L} = \frac{v_H q - c}{\theta_H} + \beta \frac{c}{\theta_L}$ which is less than benchmark of $\beta \frac{v_L q}{\theta_L}$ because $\frac{1}{\theta_H}(v_H q - c) < \frac{\beta}{\theta_L}(v_L q - c)$ because $\frac{1}{\theta_H} < \frac{\beta}{\theta_L}$ and $(v_H q - c) < (v_L q - c)$. Thus, revenue is always below benchmark.

A5. Proof of Proposition 4

As noted above (see A3-4. Ad-blocker LAB Strategy), there are several cases to consider depending on the range of c. We present the analysis for the case when $\max\{v_H(2q_L - q_H), v_L q_H\} < c < \hat{c}$, for which the ad-blocker's optimal LAB was derived and summarized in Table A3. The analysis for remaining cases is similar and is available upon request.

Consider Case 1 in Table A3. Publisher profit in this case is $\pi^* = \beta \frac{v_L q_H}{\theta_L} + (1-\beta)\frac{v_H q_L - c}{\theta_H} - d$. Then,

- If $\frac{v_H}{\theta_H} > \beta \frac{v_L}{\theta_L}$, the condition of Case 1 becomes $\beta \frac{v_L(q_H - q_L)}{\theta_L} < d \leq \beta \frac{v_L q_H}{\theta_L} - \frac{v_H q_L}{\theta_H} + (1-\beta)\frac{v_H q_L - c}{\theta_H}$. If $\frac{v_H(q_H - q_L)}{\theta_H} < d$, then benchmark publisher profit $\pi^{Ben} = \frac{v_H q_L}{\theta_H} < \pi^*$. If $\beta \frac{v_L(q_H - q_L)}{\theta_L} < d < \frac{v_H(q_H - q_L)}{\theta_H}$, then $\pi^{Ben} = \frac{v_H q_H}{\theta_H} - d < \pi^*$ because $c < \hat{c}$.
- If $\frac{v_H}{\theta_H} \leq \beta \frac{v_L}{\theta_L}$, then the condition of Case 1 becomes $\beta \frac{v_L(q_H - q_L)}{\theta_L} < d \leq \beta \frac{v_L(q_H - q_L)}{\theta_L} + (1-\beta)\frac{v_H q_L - c}{\theta_H}$. Then, $\pi^{Ben} = \beta \frac{v_L q_L}{\theta_L} < \pi^*$.

We note that the condition $\max\{v_H(2q_L - q_H), v_L q_H\} < c < \hat{c}$ exists only if $v_L q_H < \hat{c}$ which requires $\frac{v_H}{v_L} < \hat{v} \triangleq \frac{\theta_H}{\theta_L} - \frac{1-\beta}{\beta}$ and $\frac{q_H}{q_L} < \hat{q} \triangleq \frac{\beta}{1-\beta}\left(\frac{\theta_H}{\theta_L} - \frac{v_H}{v_L}\right)$.

Thus, we proved that if $\frac{\theta_L}{\theta_H} < \beta$, $\frac{q_H}{q_L}$ is sufficiently small (particularly, $\frac{q_H}{q_L} < \hat{q}$), and $\frac{v_H}{v_L}$, c, d are all neither too high nor too low (particularly, $\frac{\theta_H}{\theta_L} < \frac{v_H}{v_L} < \hat{v}$, $\max\{v_H(2q_L - q_H), v_L q_H\} < c < \hat{c}$, and $\beta \frac{v_L(q_H - q_L)}{\theta_L} < d \leq \beta \frac{v_L q_H}{\theta_L} + (1-\beta)\frac{v_H q_L - c}{\theta_H} - q_L \max\{\frac{v_H}{\theta_H}, \beta \frac{v_L}{\theta_L}\}$), then the publisher's equilibrium profit in presence of a not-for-profit ad-blocker is higher than that in the benchmark scenario.

A6. Proof of Corollary 3

As $\frac{v_H}{\theta_H} < \beta \frac{v_L}{\theta_L}$ and $\beta \frac{v_L(q_H - q_L)}{\theta_L} < d$, benchmark outcomes are: $q^{Ben} = q_L$, $a_N^{Ben} = \frac{v_L q_L}{\theta_L}$ and $\pi^{Ben} = \beta \frac{v_L q_L}{\theta_L}$, and type-H and type-L surplus are both zero.

In the presence of the ad-blocker, given $\frac{\frac{v_L q_H}{\theta_L}-\frac{v_H q_H}{\theta_H}}{\frac{1}{\theta_L}-\frac{1}{\theta_H}} < c < \frac{\frac{v_L q_H}{\theta_L}-\frac{v_H q_L}{\theta_H}}{\frac{1}{\theta_L}-\frac{1}{\theta_H}}$, we have $\frac{v_L q_L - c}{\theta_L} < \frac{v_H q_L - c}{\theta_H} < \frac{v_L q_H - c}{\theta_L} < \frac{v_H q_H - c}{\theta_H} < \frac{v_L q_H}{\theta_L} - \frac{c}{\beta\theta_H}$. Thus, Table A2 becomes:

$$\Delta R(a_B) = \begin{cases} 0 & 0 \le a_B < \frac{v_L q_L - c}{\theta_L} \\ \beta a_B + \beta\frac{c}{\theta_L} - \beta\frac{v_L q_L}{\theta_L} & \frac{v_L q_L - c}{\theta_L} \le a_B < \frac{v_H q_L - c}{\theta_H} \\ a_B + \beta\frac{c}{\theta_L} - \beta\frac{v_L q_L}{\theta_L} & \frac{v_H q_L - c}{\theta_H} \le a_B < \frac{v_L q_H - c}{\theta_L} \\ \beta\frac{v_L q_H}{\theta_L} + (1-\beta)a_B - \beta\frac{v_L q_L}{\theta_L} & \frac{v_L q_H - c}{\theta_L} \le a_B \le \frac{v_H q_H - c}{\theta_H} \end{cases}$$

The $\Delta R(a_B)$ is discontinuous at $a_B = \frac{v_H q_L - c}{\theta_H}$: we have $\Delta R\left(\frac{v_H q_L - c}{\theta_H}\right)^- = \beta\frac{v_H q_L - c}{\theta_H} + \beta\frac{c}{\theta_L} - \beta\frac{v_L q_L}{\theta_L}$ which is less than $\Delta R\left(\frac{v_H q_L - c}{\theta_H}\right)^+ = \frac{v_H q_L - c}{\theta_H} + \beta\frac{c}{\theta_L} - \beta\frac{v_L q_L}{\theta_L}$. Thus, when d is in range $\Delta R\left(\frac{v_H q_L - c}{\theta_H}\right)^- = \beta\frac{v_H q_L - c}{\theta_H} + \beta\frac{c}{\theta_L} - \beta\frac{v_L q_L}{\theta_L} < \beta\frac{v_L(q_H - q_L)}{\theta_L} < d < \frac{v_H q_L - c}{\theta_H} + \beta\frac{c}{\theta_L} - \beta\frac{v_L q_L}{\theta_L}$, we have $a_B^* = \left(\frac{v_H q_L - c}{\theta_H}\right)^+$, $q^* = q_H$, $a_N^* = \frac{v_H q_L - c}{\theta_H} + \frac{c}{\theta_L}$, and $\pi^* = \frac{v_H q_L - c}{\theta_H} + \beta\frac{c}{\theta_L} - d$. Thus, we have $\pi^* > \pi^{Ben}$, $q^* > q^{Ben}$, and $a_N^* > a_N^{Ben}$. Also, Type-H surplus is positive with LAB. Type-L surplus is also positive with LAB since $U_L = v_L q_H - a_N^*\theta_L = v_L q_H - \left(\frac{v_H q_L - c}{\theta_H} + \frac{c}{\theta_L}\right)\theta_L = \theta_L\left(\frac{v_L q_H - c}{\theta_L} - \frac{v_H q_L - c}{\theta_H}\right) > 0$.

We note that $\beta\frac{v_L(q_H - q_L)}{\theta_L} < d < \frac{v_H q_L - c}{\theta_H} + \beta\frac{c}{\theta_L} - \beta\frac{v_L q_L}{\theta_L}$ requires $\frac{q_H}{q_L} < \frac{v_H}{v_L}$. Also, we should have $a_B^* < \frac{v_H(q_H - q_L)}{\theta_H}$, that is $v_H(2q_L - q_H) < c$, requiring $\frac{v_H}{v_L} < \frac{\frac{q_H}{q_L}}{2 - \frac{\theta_L}{\theta_H} - \frac{q_H}{q_L}}$.

Thus, if $\frac{\theta_L}{\theta_H} < \beta$, $\frac{q_H}{q_L} < \min\left\{2 - \frac{\theta_L}{\theta_H}, \frac{\beta\theta_H}{\theta_L}\right\}$ ($\frac{q_H}{q_L}$ sufficiently small), $\frac{q_H}{q_L} < \frac{v_H}{v_L} < \frac{\frac{q_H}{q_L}}{2 - \frac{\theta_L}{\theta_H} - \frac{q_H}{q_L}}$ ($\frac{v_H}{v_L}$ intermediate range), $\max\left\{v_H(2q_L - q_H), \frac{\beta\frac{v_L q_H}{\theta_L} - \frac{v_H q_L}{\theta_H}}{\beta\frac{1}{\theta_L} - \frac{1}{\theta_H}}, \frac{\frac{v_L q_H}{\theta_L} - \frac{v_H q_H}{\theta_H}}{\frac{1}{\theta_L} - \frac{1}{\theta_H}}\right\} < c < \frac{\frac{v_L q_H}{\theta_L} - \frac{v_H q_L}{\theta_H}}{\frac{1}{\theta_L} - \frac{1}{\theta_H}}$ *and* $\beta\frac{v_L(q_H - q_L)}{\theta_L} < d < \frac{v_H q_L - c}{\theta_H} - \beta\frac{v_L q_L - c}{\theta_L}$, then win-win-win happens.

A7. Proof of Corollary 4

Proof follows directly from expressions of Type-H surplus in Table 3.

A8. Proof of Proposition 5

We obtain the optimal price of ad-blocker. We need to compare type-H customer surplus with $p = 0$ with that in the boundaries of Case 2 and Case 4. Consider $2q_L > q_H$ (right panel in Figure 4). With zero price, Type-H surplus will be vq_L. At the right boundary of Case 4, $d = \beta \frac{c - vq_L}{\theta_L}$, Type-H surplus is $vq_H - vq_L - \frac{d}{\beta}\theta_L$, which is lower than vq_L. In Case 2, Type-H surplus is $vq_H - vq_L + \left(\frac{\beta\theta_H}{\theta_L} - 1\right)c - \theta_H d$, which is lower than vq_L since in this region $\left(\frac{\beta}{\theta_L} - \frac{1}{\theta_H}\right)c < d$. Thus, when $2q_L > q_H$, the optimal price that maximize type-H surplus is zero. Moreover, ad-blocker should set $a_B^* = 0$, resulting in low quality publisher.

Next, consider $2q_L < q_H$ (left panel in Figure 4). First, suppose d is sufficiently low. Then, customer surplus first increases in c (in Case 2), then remains constant (in Case1), then decreases (in Case 3), and then increases again (in Case 4). Thus, we need to compare surplus in Case 1, $v(q_H - q_L)$, with surplus at the boundary of Case 4, $v(q_H - q_L) - \frac{d}{\beta}\theta_L$, which is clearly lower. Thus, when d is sufficiently low, the optimal price should fall in the region of Case 1 – any price (p^*) in this region is optimal, and the optimal LAB is $\frac{vq_L - p^*}{\theta_H}$.

When $2q_L < q_H$ and d is higher, we need to surplus at the boundary of Case 2, $c = \theta_L\left(\frac{vq_L}{\beta\theta_H} - \frac{d}{1-\beta}\right)$, and boundary of Case 4, $c = vq_L + \frac{d}{\beta}$. Thus, we compare $U_H = vq_H - vq_L + \left(\frac{\beta\theta_H}{\theta_L} - 1\right)\theta_L\left(\frac{vq_L}{\beta\theta_H} - \frac{d}{1-\beta}\right) - \theta_H d$ and $U_H = vq_H - vq_L - \frac{d}{\beta}\theta_L$. Comparing these two, it turns out that if $d < (1-\beta)\frac{vq_L}{\theta_H}$, then $p^* = \theta_L\left(\frac{vq_L}{\beta\theta_H} - \frac{d}{1-\beta}\right)$ and $a_B^* = \frac{d}{1-\beta}$. Otherwise, $p^* = vq_L + \frac{d}{\beta}$ and $a_B^* = 0$. When d is even higher, we should also compare boundary of Case 4 and $p = 0$, that is $vq_H - vq_L - \frac{d}{\beta}\theta_L$ and vq_L. If $d < \beta\frac{v(q_H - 2q_L)}{\theta_L}$, then $p^* = vq_L + \frac{d}{\beta}$, otherwise, $p^* = 0$. Thus, price is positive if and only if $\frac{\theta_L}{\theta_H} < \beta$, $2q_L < q_H$, and $d < \beta\frac{v(q_H - 2q_L)}{\theta_L}$, and also employs an LAB if and only if $d < (1-\beta)\frac{vq_L}{\theta_H}$.