Essays on Digital Marketing Strategies: An Analytical Investigation

Inauguraldissertation
zur Erlangung des akademischen Grades
eines Doktors der Wirtschaftswissenschaften
der Universität Mannheim

vorgelegt an der
Fakultät für Betriebswirtschaftslehre
der Universität Mannheim

von

Gökhan Gecer

Mannheim

Juni, 2021

Dekan: Joachim Lutz

Erstreferent: Prof. Dr. Florian Kraus

Zweitreferent: Prof. Dr. Florian Stahl

Tag der mündlichen Prüfung: 15. Juni 2021

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1. General Introduction

The internet has changed temporal conditions of consumers and firms by virtually extending the reach of physical goods and services. Consumers are able to reach products and services digitally at any given time without leaving the comfort of their home (Ming-Sun Cheng et al. 2009). The new digital era also created a new platform for communication by letting firms launch advertisements (ads) digitally. Media outlets have been selling space to ad-givers since the internet started being a part of daily life, with online ads taking first place among all advertising types in recent years and resulting in higher revenues for firms. The abovementioned online advertising popularity has led to ad-givers overloading online platforms with ads. However, this overloading led to users feeling interrupted and/or distracted. Users might be concerned about their privacy or harmful ads. As a result, users have started looking for ways to avoid online ads.

Online ad-avoidance has some differences with traditional ad-avoidance. For example, users cannot simply change the channel as in TV commercials, or they cannot simply look somewhere else as in printed media ads. In today's world, the most common way to avoid online ads is ad-blockers. An ad-blocker is an internet extension that users install in their web browsers to block online ads. They are mostly free and easy to install. When ad-blockers are used, the content or layout of the webpage does not change. Ad-blockers have become so popular lately that more and more users have them installed. Although this is an easy way for users to avoid online ads, the high usage of ad-blockers has raised concerns in the media industry because media outlets' revenues come mainly or entirely from ads. As a result, media outlets have been looking for strategies to avoid the harm from ad-blockers.

The first essay, co-authored with Florian Kraus and Pinar Yildirim, titled "Ad-blockers and Content Differentiation," focuses on the main strategies publishers follow against ad-blockers by analyzing a series of analytical models. The literature in this area mainly focuses on online ad-avoidance (Tag 2007) and experimental and empirical ad-blocking studies (e.g., Anderson and Gans 2011, Goldstein et al. 2014, Miroglio et al. 2018). There are also a few studies analyzing ad-blocker-related questions with the application of analytical models (Aseri et al. 2018, Gritckevich et al. 2018). Our study contributes to the literature by including analysis of content differentiation, a subscription option, and competition.

In this study, we develop an optimization problem maximizing the publisher's income in a two-sided market where users have the utility of consuming online content and the disutility of seeing online ads, paying for the content, consuming the same content more than once, and consuming substitutable content. As a part of the model, we also optimize content quality and a subscription fee as well as the number of advertisements in the extension. On the publisher side of the model, we examine online markets where publishers could have revenue coming from advertising and subscription markets and expenses of content production.

We analyze the profit-maximizing model in monopolistic and duopolistic markets, also showing the effect of competition. We mainly focus on two publisher strategies: (1) The content wall strategy where publishers ask users to turn ad-blockers off or leave the website, and (2) the pay to avoid strategy where publishers ask the users to subscribe, turn the ad-blockers off, or leave the website. In the first strategy, we show the optimal content quality and in the second strategy, we show the optimal content strategy as well as the subscription fee. Finally, we have an extension in which the ad-giver is a decision maker where we show the optimal amount of ads the ad-giving firm puts online in a monopolistic market.

In the second essay, co-authored with Florian Kraus, titled "Maximizing Customer Lifetime Value through Strategic Channel Management: How to Incentivize Customers to Use a Mobile App versus a Website," we focus on price discrimination strategies in a multi-channel sales environment with online and mobile sales channels. Increasing wireless internet availability and innovative technologies aided in overcoming the physical constraints, resulting in today's ability to shop anywhere at any given time through instant connectivity (Larivière et al. 2013). Even when access to a fixed PC exists, consumers may choose to use their personal mobile device for transactions (Chuck and Kirby 2013). Mobile devices have become omnipresent and are globally classified as the most commonly used daily consumer goods (Bigne et al. 2005, Larivière et al. 2013, Shankar et al. 2016). This has created a new type of commerce: mobile commerce (m-commerce).

There are some certain differences between smartphones and laptops. Laptops typically have a larger screen than mobile devices and are supported by a permanent power supply and a high-capacity, high-speed internet connection (Cao et al. 2015). This can be contrasted with several limitations and usability issues of mobile devices, such as small screens, short-lived batteries, and low-speed or unstable wireless internet (Clarke 2001, Shankar et al. 2016). Over the past decade, however, technical features of higher generation mobile devices have converged with the abovementioned positive aspects of laptops, thus improving user interface while keeping their advantageous mobility (Matthews et al. 2009). The mere exposure effect mentioned in Moore and Taylor's (2011) studies has been applied to mobile devices' ubiquity in the context of addiction (Chen et al. 2016), finding that the extensive exposure to mobile devices, especially smartphones, influences convenience. People use their smartphones to fulfill social gratifications (Patel et al. 2013), to escape daily pressure (Bianchi and Phillips 2005), and reduce its negative effects (Billieux et al. 2007). Melumad (2017) has shown that smartphones play a role as adult pacifiers and supply a distinct feeling of comfort as well as a faster recovery from stressful situations.

All the differences between fixed devices and mobile devices have created an opportunity for online retailers to follow differentiated price strategies through different digital channels. The second essay of this dissertation examines the price differentiating strategy through online and mobile commerce channels.

Our approach is based on the idea that customers who start using a mobile device to purchase products online also start using the mobile channel on a regular basis, turning this behavior into a habit. Therefore, those mobile app users, who have a higher net monetary value in total spending, may become more valuable customers for companies. In this paper, we analyze the strategy where firms choose to offer a discount to their customers to steer them toward the mobile channel. Focusing on this option, the purpose of the second article is to develop a modeling approach analyzing the customer lifetime values of online and mobile customers in the existence and non-existence of such a discount. Our aim is answering two research questions. In the first question, we investigate the performance of this strategy over different customer types through their current purchasing probabilities over online and mobile channels, potential purchasing probabilities over the mobile channel, and app adoption ability. Hence, we investigate the following research question: (1) To what type of customers should a discount be offered when purchases are conducted over mobile apps? In the second research question, we investigate how the optimal discount rate changes through how the discount changes the customer purchasing probability, the customer's current and potential activity, and app adoption ability. Hence, we investigate the following research question: (2) What is the optimal discount rate that should be offered?

In both essays, we explore two important problems in digital marketing by developing and analyzing analytical models. In the first essay, we show the optimal strategy an online publisher follows against the ad-blockers. In the second essay, we develop a price discrimination strategy an online retailer follows in a multi-channel sales environment with online and mobile channels.

The remainder of this thesis is organized as follows. Chapters 2 and 3 present scientific working papers on the abovementioned essays. Chapter 4 provides a general conclusion that summarizes the findings and discusses the insights and implications of this dissertation.

2. Essay I - Ad-blockers and Content Differentiation

Gokhan Gecer

Florian Kraus

Pinar Yildirim

Abstract

Ad-blocking technologies are increasingly adopted by consumers. For content producers whose major source of revenue is advertising, this creates a challenge for survival. Facing the threat from ad-blockers, content managers are implementing a range of strategies, ranging from declining to serve customers who install ad-blockers to asking them to be paid subscribers. In this study, we consider the impact of content managers' strategies against the ad-blockers based on the differentiation of content in online media. Our findings suggest that publishers decide on their strategies against ad-blockers based on their content production cost and content differentiation. A publisher that produces differentiated content for a low cost, such as personal blogs, follows the "content wall" strategy where they do not give access to those who use ad-blockers while other publishers follow the "pay to avoid" strategy where they offer an ad-free version of the website. Content differentiation is also important for the publishers that produce content for a high cost. In this case, content production is profitable only when the content is differentiated. We also show that competition does not increase content quality all the time. A monopolistic company that produces its content for a low cost decreases its content quality when a new publisher produces substitutable content. Last but not least, when the ad-giving firm is a decision maker, the decision process of the publisher is restricted.

Keywords: ad-blockers; content production; game theory; competitive markets

2.1. Introduction

Understanding the potential to reach the majority of consumers through online marketing, advertisers flooded the web hoping to increase advertising revenue online. Ad-givers are expected to spend $375 billion online in 2021 (eMarketer 2017). This overloading causes many users to avoid online ads. While one fourth of all online users tolerate two ads per web page, one fourth of them tolerate only one ad (Tips and Tricks HQ 2018). Users mostly find the ads annoying, especially when they are not relevant for them (Baek and Morimoto 2012). Also, many users are concerned with potential privacy and security issues if they see customized and/or harmful ads (e.g., Storey et al. 2017). This irritation motivates users to look for ways to block ads (Kim and Sundar 2010). One of the most common and efficient ways users avoid online ads are ad-blockers. An ad-blocker is an internet extension that blocks the ads users do not want to see. They are easy to install, anonymous, and free.

Ad-blocker software can be downloaded by users. The aim of such software is to reduce and filter the ads that users are exposed to by blocking ad requests on websites (see a website with and without ad-blockers in Figure 1). Within this process, the website's layout and content do not change (Internet Advertising Bureau 2016). Ad-blockers intend to protect user interests and ensure that web surfers are not distracted by dominant ads.

An increasing number of users employ ad-blockers (Richman 2016). By 2017 615 million devices with ad-blockers installed existed worldwide (Scott 2017). Thus, approximately 30% of all internet users had ad-blockers installed. The numbers are constantly increasing (O'Reilly 2017). The ad-blocking usage costs the publishing industry billions of dollars every year (Southern 2020). This raises concerns among publishers. Managers of digital media companies (e.g., Nick Flood, managing director of digital at Dennis and Brian Kane, co-founder and COO at Sourcepoint) highlight the threat coming from ad-blockers (Southern 2020). Pierre Buffet, head of digital at the French newspaper Le Monde, put the ad-blocker as their main priority in 2017 (Phillips 2019). Online publishers are forced to act more

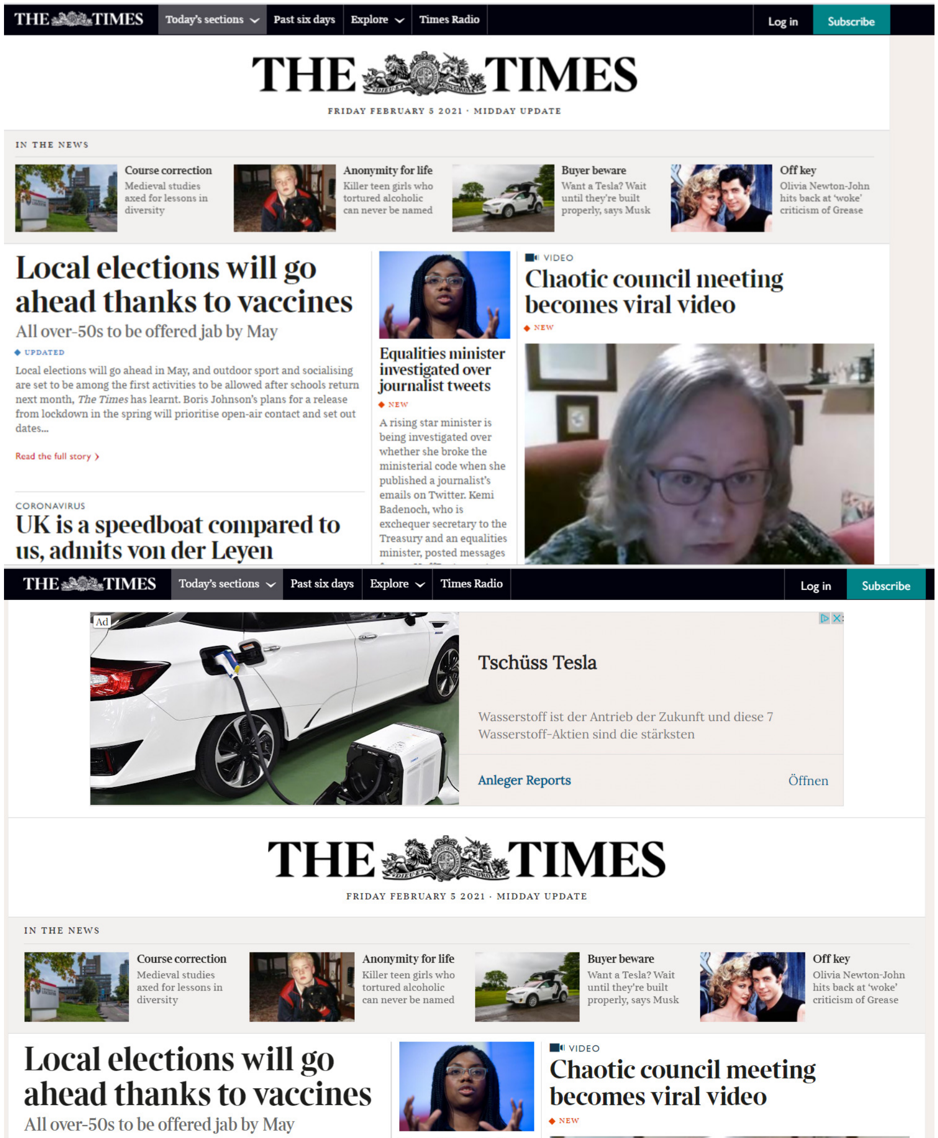


Figure 1. Webpage Example with and without Ad-blockers

aggressively against ad-blockers because they have the potential to essentially change one of the core elements on which the web is built: free content as financed by the online advertising industry (Pujol et al. 2015).

Publishers develop strategies to reduce the harm by ad-blockers. The BBC published a study including interviews with people from the publishing industry pointing out how they are looking for ways to avoid the harm from ad-blockers (Thomas 2016). Some of them adhere to freemium models while some of them, such as Facebook, change the ads in a way that makes them harder for ad-blockers to detect. Some other publishers such as Wired and The Guardian offer an ad-free (premium) version of the websites to customers who pay or donate to the website (Saeed 2019). The premium accounts can compensate for the revenue loss due to blocked ads. Bay Area News Group conducted an experiment in 2017 and showed that ad-blocker users tend to subscribe instead of seeing ads (Phillips 2018). However, this method is effective only for powerful, international websites and small websites with a focused market (Ingram 2015). Another strategy publishers pursue against ad-blockers is to ask users to turn off the ad-blocker. In this case, users either turn off the ad-blocker or leave the website. The IAB Ad Blocking Report (2016) states that the users tend to turn off the ad-blockers as long as they are in control, they are assured of site safety, and their flow is not disturbed. The report also includes experiment results showing that users are most likely to turn off the ad-blocker when their access to the website is blocked.

Different strategies the publishers currently follow against ad-blockers indicate that the publisher's characteristics determine which strategy it should follow. We mainly focus on these strategies and analyze to show how a publisher decides on its optimal strategy. We specifically address the following research questions: (1) What is the optimal profit of a publisher under each strategy in question? (2) What are the publisher's optimal content quality and subscription fee under each strategy? (3) What is the publisher's optimal strategy? (4) What is the effect of competition? We handle these questions with a focus on the publishers' content differentiation.

We develop a model of a media ecosystem that contains publishers and users. Publishers provide online content through websites. They maximize their profits from advertising income and/or subscription fees. Users consume the content provided by the publishers deciding on the amount of content they consume. They are utility maximizers. They increase their utility by consuming more unique content and decrease their utility when they consume substitute content. Their utility also decreases from seeing ads as well as paying to the publisher to access the content. We present two types of users: those with low disutility and those with high disutility from seeing ads. The users have the opportunity to install ad-blockers. The ad-blocker supplier is an exogenous player. When a user installs and runs an ad-blocker, the publisher still serves the content but not the ads to the user. In this case, the publisher cannot earn from this user. It can follow different strategies to make those users profitable again. In our setup, a publisher can follow two strategies: (1) it does not give access to the website to users with an ad-blocker on, or (2) it offers an ad-free, paid version of the website (subscription option) along with not giving access to the website. In the first strategy, the publisher decides on its content quality. In the second strategy, the publisher decides on its content quality as well as its subscription fee. Lastly, the publisher has a cost of content production which increases quadratically with the content quality. We analyze this model in monopoly and duopoly markets.

We firstly focus on the monopoly case in which there is only one publisher on the market. In this case, the publisher makes its decision based on content production cost. Our results show that when producing content is costlier, the publisher decreases its content quality, and the number of users decreases accordingly. As a result of fewer users, the advertising income decreases. The publisher offers a subscription option as long as producing content is profitable. When users are more ad-averse, the publisher tends to offer a subscription option as well. In this case, when highly ad-averse users do not have this option, they leave the website instead of turning off the ad-blocker.

We, then, move to the duopoly market. We consider content substitutability. When the publishers offer similar content, the substitutability increases. For example, while the content of a newspaper producing news on a broad scale of topics is substitutable, the content of a newspaper producing specific content, such as finance, politics, and sports, is differentiated. We analyzed the duopolistic market when both publishers follow the same strategy as well as when they follow different strategies. We showed that the solution in the duopolistic market is in the symmetric case. Our findings show that the publisher increases the content quality when the content is more substitutable to attract more users. However, producing higher content quality increases the content production cost. As a result, the publisher firstly loses profit, then it becomes nonprofitable to produce the content.

Our analysis of the optimal strategy for a duopolistic publisher shows that when a publisher produces less substitutable content at a low cost (such as bloggers), it does not offer a subscription option. On the other hand, when the content is more substitutable (such as newspapers and tabloids) and when the content is less substitutable but costly to produce (such as websites with specific focuses), the publisher offers a subscription option. Our results are consistent with the literature. Ingram (2015) shows that offering a subscription option is only effective for big, international websites and websites with a focused market. The first type of those publishers is highly substitutable, and the second type is less substitutable but costly to produce. We show that those big newspapers should offer a subscription option to their users.

Then, we moved on to the competition effect on publisher strategy as well as content quality and subscription fee. When content production is costly, both monopolistic and duopolistic publishers offer a subscription option. However, the differentiation between the duopolistic publishers' content matters when the content production is less costly. When the content is differentiated, publishers do not offer subscriptions as in the monopoly case. Here, competition increases the content quality. However, when the content is substitutable, the optimal strategy changes in the existence of competition, and the duopolistic publishers offer a subscription option while a monopolistic publisher does not offer one. The duopolistic publisher's content quality is lower than the monopolistic publisher's content quality, meaning that competition decreases content quality. Later, we focus on publishers that produce content for a higher cost. In this case, content production is nonprofitable when the content is substitutable.

Lastly, we have analyzed the case that the number of ads is decided endogenously. We show here that user ad-aversion plays an important role in this case. The publisher either increases the content quality or decreases the number of ads it shows on the website to appeal to those who turn the ad-blockers off while also decreasing the subscription fee to appeal to those who subscribe. Different from the case in which the number of ads is decided exogenously, when the number of ads is decided endogenously, user ad-aversion takes an important place in the publisher?s strategy decision. This means the publisher has to consider a factor that is not directly related to itself.

Our insights contribute to the literature and managers in many ways. Although ad-blockers are a relatively new version of ad-avoidance, they have affected online publishers heavily. Researchers have been studying ad-avoidance for a while. However, the literature on ad-blockers is weak. Researchers have shown the reasons users install ad-blockers and also the negative effects of ad-blockers on the internet world. However, how a publisher fights against them has been poorly researched thus far. Furthermore, only a limited number of articles have applied a modeling approach to find a solution to this problem. In this article, we show the optimal strategy a publisher should follow to combat ad-blockers in monopoly and duopoly markets. We also show how a publisher decides on its content quality and subscription fee. To our best knowledge, we are the first ones focusing on this issue in a duopoly market and showing the competition effect on publisher decisions.

The rest of the paper is organized as follows. We present an overview of the relevant literature in the following section. In Section 2.3, we set up the model presenting user segments, user utility, publisher strategies, and a timeline of the game. In Section 2.4, we analyze the model. Firstly, we present a simple model in a monopoly market. Then, we focus on the duopoly market and show the impact of competition. In Section 2.5, we focus on the case where the ad-giving firm is a decision maker. Lastly, in Section 2.6, we discuss the results and conclude the article.

2.2. Literature Review

Pollay (1986) indicates that ads are an intellectual submission that is omnipresent, almost inescapable, and implanted into our minds, which is why ads are widely accepted. Media users do, nevertheless, complain about being exposed to advertising clutter. If the number of ads exceeds the accepted level, users fear manipulation, which is why ads are often subject to criticism (Pollay and Mittal 1993). Therefore, besides the factors that create acceptance for ads, reasons for which people actively avoid them have always been a matter of interest.

Advertisement avoidance (ad-avoidance) is defined as "all actions by media users that differentially reduce their exposure to content" (Speck and Elliott 1997). It has been studied by researchers for decades. However, most of the studies focus on classical media types like TV ads rather than advertising on the internet. An early study on ad-avoidance conducted by Speck and Elliot (1997) shows that ad-avoidance is more relevant to television and magazine compared with other communication channels (such as radio and newspapers). It is important to point out here that this study was conducted before the internet was widely used. Online ads are considered to be more annoying, disruptive, and intrusive than ads in traditional media because the users are considered to be more engaged with the content on the web (Goldfarb and Tucker 2011). The unexpected appearance of pop-up ads, for example, creates a feeling of intrusiveness especially when users consider advertising messages to interfere with the motivation for visiting a specific website (Edwards et al. 2002).

Several strategies to avoid online ads are observed. The internet users can avoid online ads in three ways: (1) cognitive avoidance (intentionally ignoring the ads), (2) effective avoidance (negative feelings towards the ads), and (3) behavioral avoidance (actions to avoid ad-exposure, such as scrolling down the website). For example, banners and pop-up ads are ignored and actively avoided by scrolling down or closing the pop-up ad (Cho and Cheon 2004). Another phenomenon is banner blindness which describes users who tend to avoid focusing their eyes on anything resembling a banner ad. This progressive reduction of attention to ads results in a lower click-through rate (Benway 1998). Another way to avoid ads is by subscribing. Prasad et al. (2003) analyzed the case in which users could subscribe to see fewer or no ads when the publisher generates ad income and subscription income. They show that the optimal strategy is offering options to consumers instead of forcing them to follow a certain strategy. Tag (2009), in a similar setup, shows that advertisement quantity increases when the publisher offers a subscription option. The last and most popular online ad-avoidance strategy is use of ad-blockers. Web users are increasingly reducing their exposure to online advertisements by using these plug-ins (Anderson and Gans 2011).

Although ad-blockers have attracted the attention of the computer science community recently (e.g., Storey et al. 2017, Walls et al. 2015), in marketing the research about ad-blockers is rather scarce. The current literature focuses mostly on three research streams: (1) reasons to use ad-blockers, (2) consequences and impacts of ad-blockers, and (3) reactions to ad-blockers by content publishers. Ad-blockers are used to inhibit targeted ads and to restore a sense of privacy (Goldfarb and Tucker 2011). In addition, ad-blockers reduce data usage and increase the loading speed of websites.

Ad-blocker users may act differently than those who do not use ad-blockers. Miroglio et al. (2018) ran a field experiment on the Firefox browser to see the effect of ad-blockers on users' web engagement. The results show that ad-blocker users spend more time in the browser and view more pages despite there being no significant change in the search numbers. However, although users employing ad-blockers spend more time on the internet, ad-blockers harm the websites, worsening their traffic rank especially if the initial rank of the website is low (Shiller et al. 2018).

The ad-blocker effect on publishers is different. A reduction of online ad display leads to a reduction in ad-generated profits for publishers which incurs serious economic costs (Pujol et al. 2015). Furthermore, a decrease in website quality lowers the number of website visitors in the long term (Shiller et al. 2017). In this case, the publisher focuses on non-ad-blocker users and shows them more ads (Anderson and Gans 2011). As a consequence, more users install ad-blockers (Goldstein et al. 2014). On the other hand, Despotakis et al. (2017) analyze the case showing that ad-blockers could be beneficial for the websites which increase the ad intensity. Aseri et al. (2018) approach the issue by focusing on the network effect, concluding that ad-blockers could be beneficial for the publishers under certain circumstances.

Because publishers are negatively affected by ad-blockers, they are looking for ways to avoid them. Such tactics include the development of ad-recovery technologies, software that identifies ad-blockers and restores disclosure of ads by deterring ad-blockers (Shiller et al. 2018). Also, some websites restrict the access to the website as long as ad-blockers are installed (Shiller et al. 2018). Finally, paywalls introduce a mechanism that separates paid and free content on a website (Chiou and Tucker 2013).

Lastly, Gritckevich et al. (2018) develop an analytical model focusing on publishers, ad-blockers, and consumers. Our study distinguishes from this one in two ways. First, we include a subscription option in the optimal strategies that the publishers should follow by analyzing a game-theoretical model. Second, we focus on this problem in monopolistic and duopolistic markets and show the competition effect. To the best of our knowledge, we are the first ones approaching this issue in a duopolistic market.

2.3. Model

Consider a two-sided market with users and publishers on each side of the market. Publishers maximize profits by producing and distributing content via their websites. They obtain revenue from selling advertising slots to advertisers and selling a premium, no-ad subscription option to users. They compete in content provision. Producing better content (which we will refer to as “content quality”) has the potential to increase demand. At the same time, higher content quality is costly to produce. The cost of content production is cv_i^2 where c is a scaling factor. Each publisher i maximizes its profit by determining the quality of its content $v_i > 0$ and its subscription fee $p_i > 0$.

Publisher i earns profit from subscription fees and advertising:

$$\pi_i = \pi_{ad,i} + \pi_{sub,i} - cv_i^2,$$

where $\pi_{ad,i}$ is the revenue from advertising and $\pi_{sub,i}$ is the revenue from subscription. Advertising revenues come from the consumers to whom Publisher i serves ad impressions, $\pi_{ad,i} = x_{ad,i} y_i q$, where $x_{ad,i}$ is the number of customers who are served ad impressions by i, y is the number of impressions served by the publisher,[1,2] and q is the ad revenue from each consumer for each ad. The subscription revenue comes from the consumers who buy the content, $\pi_{sub,i} = x_{subs,i} p_i$, where $x_{subs,i}$ denotes the number of subscribers.

Users maximize their utility from consuming unique content. They decide whether to subscribe to an outlet or not, and the volume of content to consume from each publisher. Their utility increases with the amount of content consumed. However, this utility is discounted when the content consumed across different outlets is substitutable. Consumers also incur a disutility d when their content consumption is interrupted by ads. We assume that consumers are heterogeneous with respect to how much they dislike seeing ads, where an endogenous proportion α of users incurs a disutility of $d + \delta, \delta > 0$ (segment H), and the remaining consumers incur a disutility of d from seeing ads (segment L). Let the low-type users have a minor disutility from seeing ads.[3]

2.3.1. Ad-blockers and Publisher Strategies

We assume a reduced form ad-blocker market, where blocking software is offered by a third-party company. We also assume that the software is made available to consumers at a fixed one-time cost and normalize this cost to zero. As such software costs do not depend on the

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

[2] We assume each publisher shows an identical number of ads to consumers since they are ex ante identical.

[3] We assume that $d = 0$ without loss of generality.

amount or the type of content consumed, they do not create a complication in the setting we consider. Given the disutility from seeing ads, some consumers may choose to adopt ad-blockers at no cost. If they do, however, they may face a response from the publishers.

If users install ad-blockers, a publisher cannot serve them ads. In response, it may develop a strategy that is a derivative of recovering the lost advertising revenue by charging for the privilege of not seeing ads. Currently in the industry, there are two common practices followed by publishers in response to ad-blockers. In our model, we focus on these as possible strategies to study their implications.

Strategy 1 (S1): Content Wall. First, publishers may ask users to whitelist their site individually by removing it from the ad-blocker list while on their site and continue to serve them ads. This way, publishers force users to pay in "attention" or advertising dollars. Of course, they may also lose a part of the market to competitors as some consumers cannot be served. In this strategy, each publisher maximizes its advertising revenue by providing content to those who see ads. The publishers decide on the optimal content quality ($v > 0$) simultaneously. Publisher i's total profit $\pi^P_{i,S1}$ is equal to advertising revenue ($\pi^P_{i,ad,S1}$): $\pi^P_{i,S1} = \pi^P_{i,ad,S1}$. We call this strategy "content wall."

Strategy 2 (S2): Pay to Avoid. For the consumers who are willing to pay a fee rather than see ads, publishers may offer an ad-free subscription option at some rate p.[4] We include the option that the user gets access to the website when she turns the ad-blockers off in this strategy as well because our problem arises from the ad-blockers and giving access to those who turn it off is an option in Strategy 2. Wired, for instance, offers consumers the option to subscribe in exchange for not seeing their ads. In this strategy, publishers maximize revenue from advertising and subscription. The publishers decide on the optimal content quality ($v > 0$) and the optimal subscription fee ($p > 0$) simultaneously. Publisher i's total profit

[4] Since we assume all consumers have a minor disutility from seeing ads, all consumers have a small willingness to pay to avoid seeing them. This prevents a third strategy where the publisher offers a combination of reduced-ad and subscription fee strategy. While this strategy is possible, it does not add novel qualitative insights, and for simplification we exclude it from the analysis.

$\pi^P_{i,S2}$ in Strategy 2 is the sum of its advertising revenue $\pi^P_{i,ad,S2}$ and subscription revenue $\pi^P_{i,subs,S2}$: $\pi^P_{i,S2} = \pi^P_{i,subs,S2} + \pi^P_{i,ad,S2}$. We call this strategy "pay to avoid."

In what follows, we compare how these strategies impact the quality and differentiation among content providers by considering the two strategies to ward off ad-blockers. While the content wall strategy supports advertising revenues, the pay to avoid strategy tries to recover the loss with subscription revenue.

The timeline of events is as follows:

1. The publisher decides which strategy to follow (content wall or pay to avoid).
2. The publisher decides its content quality and subscription fee.
3. Users observe the provision of content and options provided by the publishers and decide whether to turn off their ad-blocker, subscribe, or not consume any content.
4. The users decide their content consumption. When they do not consume any content, their utility is 0. When they prefer to consume content, they receive utility of consumption.

We solve this game using backward induction, starting from the users' decision and then moving on to the publishers' decision.

2.3.2. Users

We set the utility function as in Singh and Vives (1984) and Godes et al. (2009). A user maximizes her utility:

$$U(x_1, x_2) = \sum_{i=1}^{2} x_i v_i - D(x_1, x_2)$$

$$D(x_1, x_2) = x_i dy + x_i p_i + \frac{1}{2}(\sum_{i=1}^{2} x_i^2 + 2\phi \sum_{i \neq i'} x_i x_{i'})$$

where $i = 1, 2$ are the duopolistic publishers, x_i is the amount of Publisher i's content the user consumes, and v_i is Publisher i's content quality. We assume that the content produced by different publishers are imperfect substitutes since the publishers never produce the same content.

A consumer may also incur a composite disutility $D(x_1, x_2)$ from consuming substitute content, paying subscription fees, and seeing advertising. The ad-seeing disutility is equal to $x_i dy$ and subscription disutility is equal to $x_i p_i$. The marginal utility of consuming additional content is decreasing (captured by x_i^2). Moreover, if the content consumed are imperfect substitutes across different publishers, the consumer also incurs a disutility (captured by $\phi x_i x_{i'}$). The degree of substitutability ($0 < \phi < 1$) among content produced by different publishers is captured by ϕ. A small value of ϕ indicates that the content of each publisher is differentiated. A high value, on the other hand, indicates that the content provided by the publishers are close substitutes. We assume that the content of different publishers are never perfect substitutes ($\phi < 1$).

2.4. Analysis

We will first provide the analysis involving the monopoly and then that of the duopoly. For both monopoly and duopoly markets, using backward induction, we first derive the demand under each strategy and then focus on deriving the optimal content quality, the subscription fee, and total profit.

2.4.1. Monopoly

The monopolistic publisher's revenue is equal to its advertising revenue (π_{ad}^{M}) when it follows the content wall strategy and the sum of advertising (π_{ad}^{M}) and subscription revenue (π_{subs}^{M}) when it follows the pay to avoid strategy ($\pi_{ad}^{M} + \pi_{subs}^{M}$).

Content Wall Strategy

Consider a low-type user who consumes x_i amount of Publisher i's content as well as the ads. She has the utility

$$U(x) = xv - \tfrac{1}{2}x^2.$$

On the other hand, a high-type user who consumes x_i amount of content has the utility

$$U(x) = xv - x\delta y - \tfrac{1}{2}x^2.$$

The quantity of content that maximizes the utility of low-type users is $x_{L,S1}^{M*} = v$, and for high-type users, it is $x_{H,S1}^{M*} = v - \delta y$. This suggests that $(1-\alpha)v$ of the low-type and $\alpha(v - \delta y)$ of the high-type users will consume content when publishers put up a content wall.

The total profit in this case is equal to the difference between advertising revenue from the two segments of consumers and the cost of content production, and the publisher maximizes its total profit by choosing the quality of the content:

$$\arg\max_{v} \pi_{S1}^{M} = (v - \alpha\delta y)yq - cv^2,$$

which yields $v_{S1}^{M*} = \frac{qy}{2c}$. We summarize the optimal outcomes of the publishers in this case.

Lemma 1. *In a monopolistic market, if a publisher follows the content wall strategy, the quality of the content is* $v_{S1}^{M*} = \frac{qy}{2c}$*, and the profit of the publisher is* $\pi_{S1}^{M*} = \frac{(q-4c\alpha\delta)qy^2}{4c}$.

Proof. See Appendix.

Lemma 1 states that the content quality (v^*) decreases with content production cost while it increases with advertising income per ad per user (q) and the number of ads (y). The solution implies that the number of low-type users is equal to $\frac{(1-\alpha)qy}{2c}$ and the number of low-type users is equal to $\frac{\alpha y(q-2c\delta)}{2c}$. It shows that higher content production cost affects those who are affected by the ads more.

Characteristics that are related to user ad-aversion, such as user disutility of seeing ads and the proportion of high-type users, decrease the publisher's income. Remember that the publisher does not offer a subscription option in this strategy. Its revenue depends only on advertising. When the user's disutility of seeing ads is high, she tends to leave the website instead of turning the ad-blocker off to access the content. The intuition is that the publisher increases its content quality to captivate those who are highly ad-averse.

Pay to Avoid Strategy

Under Strategy 2, when a user (low-type or high-type) subscribes to the website and consumes x_i units of Publisher i's content at a subscription fee of p, she has the utility

$$U(x) = xv - xp - \tfrac{1}{2}x^2.$$

The x value that maximizes the utility function of a user who subscribes is $x^{M*}_{S,S2} = v - p$. The users who do not subscribe either turn off the ad-blocker or leave. The x value that maximizes the utility function of a low-type user who turns the ad-blockers off is $x^{M*}_{L,S2} = p$, and the x value that maximizes the utility function of a high-type user who turns the ad-blockers off is $x^{M*}_{H,S2} = p - \delta y$. This suggests that $v - p$ subscribing users, $(1-\alpha)p$ low-type users, and $\alpha(p - \delta y)$ high-type users consume content when the publisher follows a pay to avoid strategy.

The number of users who subscribe to avoid ads is $(v-p)$. The rest of the users either turn off the ad-blocker or leave. The number of low-type users who turn off the ad-blocker is $(1-\alpha)p$, and the number of high-type users is $\alpha(p-\delta y)$. In this strategy, the publisher's profit is equal to the difference between the summation of advertising and subscription revenues and the cost of content production. The publisher maximizes its total profit by deciding on the optimal subscription fee (p^*) as well as optimal content quality (v^*). The total profit (π_{S2}^{M}) is given by

$$\arg\max_{v,p} \pi_{S2}^{M} = (v-p)p + (p-\alpha\delta y)yq - cv^2$$

which yields $p_{S2}^{M*} = \frac{2cyq}{4c-1}$ and $v_{S2}^{M*} = \frac{yq}{4c-1}$.

Lemma 2. *Under the pay to avoid strategy, a monopolistic publisher sets its subscription fee at* $p_{S2}^{M*} = \frac{2cyq}{4c-1}$ *and content quality at* $v_{S2}^{M*} = \frac{yq}{4c-1}$*, and the profit of the publisher is* $\pi_{S2}^{M*} = \frac{((1-4c)\alpha\delta+cq)qy^2}{4c-1}$.

Proof. See Appendix.

Lemma 2 states that when it is costly to produce content, the publisher decreases its content quality and subscription fee. Accordingly, the number of users decreases. To assure that the publisher produces content in the pay to avoid strategy and focuses on the effect of content production cost, we assume that $\alpha < \frac{q}{2\delta}$. The solution implies that the number of users who subscribe is equal to $\frac{yq(1-2c)}{4c-1}$, the number of low-type users is equal to $\frac{(1-\alpha)qy}{2c}$, and the number of high-type users is equal to $\frac{\alpha y(q-2c\delta)}{2c}$. It shows that a higher content production cost decreases the number of all types of users. Hence, the publisher makes less profit. Under the pay to avoid strategy, higher user ad-aversion decreases the publisher's profit. The reason is that the negative effect of ad-seeing disutility on the ad income decreases the publisher's income. This loss in income cannot be compensated for by the subscription revenue. In this case there are two ways the publisher can proceed: (1) it can increase the content quality and captivate all kinds of users, leading to an increase in both advertising and subscription revenues; (2) it can decrease the subscription fee. In this case, the number of those who subscribe increases while the number of those who turn the ad-blockers off decreases. However, the increase in the subscription revenue compensates for the loss in advertising revenue. Hence, the publisher has a higher profit. Exogenously, a higher advertising income increases the content quality as well as the subscription fee, and the profit accordingly.

A monopolistic publisher decides on its optimal strategy based on how costly it is to produce content.

Proposition 1. (Monopolist's Optimal Strategy). *The strategy of publishers against ad-blockers depends on the cost of content production.*
(i) When the cost is low ($c < \frac{1}{2}$), publishers follow the content wall strategy.
(ii) When the cost is intermediate ($\frac{\alpha\delta}{4\alpha\delta - q} > c > \frac{1}{2}$), the publisher follows the pay to avoid strategy.
(iii) Otherwise ($c > \frac{\alpha\delta}{4\alpha\delta - q}$), the market is not viable, and the publisher chooses not to produce any content.

Proof. See Appendix.

The results from the monopoly solution are fairly straightforward. Proposition 1 demonstrates that, in the absence of competition, the strategy choice purely depends on the cost of content production. When a monopolistic publisher produces the same content for a lower cost, it follows the content wall strategy ($\pi_{S2}^{M*} < \pi_{S1}^{M*}$). When the content production cost increases, the publisher decreases its content quality, follows the pay to avoid strategy, and starts offering a subscription option. The higher content production cost in the pay to avoid strategy decreases both content quality and the subscription fee. Hence, the decrease in the number of subscribing users is affected less than the decrease in the number of users who turn the ad-blockers off under the high content production cost range. Accordingly, subscription revenue suppresses the ad revenue leading the firm to follow the pay to avoid strategy. Finally, when it is very expensive to produce content, it becomes nonprofitable, and the publisher stops content production. To sum up, publishers who have lower content production costs (e.g., personal bloggers) choose not to offer a subscription option whereas publishers who face higher costs (e.g., online newspapers) find it optimal to offer a subscription fee.

2.4.2. Competitive Strategy

Following the monopoly analysis, we investigate a publisher's decision against ad-blockers when it faces competition in the market. As in the monopoly case, we firstly describe the market, find out demand under each strategy, analyze them, and show the optimal strategy a duopolistic publisher follows.

The profit for Publisher i under the content wall strategy and the pay to avoid strategy (respectively $\pi^D_{i,S1}$ and $\pi^D_{i,S2}$) are determined by

$$\pi^D_{i,S1} = \pi^D_{i,S1,ad} - cv_i^2$$

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

We analyze publishers' profits as well as the optimal content quality and subscription fee strategies next.

Both Publishers Follow the Content Wall Strategy

We start with the analysis of a strategy which generates a content wall for consumers. In this case, users cannot access the content that they are interested in unless they consume ads. Recall that a low-type user who consumes x_i amount of Publisher i's content and is subjected to advertising has a utility of

$$U(x_1, x_2) = x_1 v_1 + x_2 v_2 - \tfrac{1}{2}(x_1^2 + x_2^2 + 2\phi x_1 x_2),$$

and a high-type user who consumes the same amount of content as well as the ads has the utility

$$U(x_1, x_2) = x_1 v_1 + x_2 v_2 - (x_1 + x_2)\delta y - \tfrac{1}{2}(x_1^2 + x_2^2 + 2\phi x_1 x_2).$$

Users consume content to maximize their utility. In a duopolistic market, the optimal content consumed (x^D) for a low-type user is given by $x_{i,L,S1}^{D*} = \frac{1}{(1-\phi^2)}(v_i - \phi v_{i'})$ and for high-type users, it is given by $x_{i,H,S1}^{D*} = \frac{1}{(1-\phi^2)}(v_i - \phi v_{i'} + (\phi - 1)\delta y)$, $i = 1, 2$. Notice that high-type users consume more content under this policy if there is more advertising supporting a platform.

The number of low-type users is $\frac{1-\alpha}{(1-\phi^2)}(v_i - \phi v_{i'})$, and the number of high-type users is $\frac{\alpha}{(1-\phi^2)}(v_i - \phi v_{i'} + (\phi - 1)\delta y)$. The total number of users is $\frac{1}{(1-\phi^2)}((v_i - \phi v_{i'}) + (\phi - 1)\alpha\delta y)$.

The total income $\pi_{i,S1}^D$ is given by

$$\arg\max_v \pi_{i,S1}^D = \frac{1}{(1-\phi^2)}((v_i - \phi v_{i'}) + (\phi - 1)\alpha\delta y)yq - cv_i^2$$

where $v_{1,S1}^{D*} = v_{2,S1}^{D*} = \frac{yq}{2c(1-\phi^2)}$.

The total number of users who turn ad-blockers off is equal to $\frac{1}{1-\phi^2}\left(\frac{yq}{2c(1+\phi)} + (\phi - 1)\alpha\delta y\right)$. When the content is more differentiated, fewer users consume it. Hence, the publisher's advertising income decreases. In the content wall strategy, the market size is bigger in a duopoly market than a monopoly market. However, how competition changes the number of users for each duopolistic publisher depends on content quality. When a monopolistic publisher increases its content quality, more users turn off the ad-blockers. However, when the publisher decreases its content quality, fewer users turn the ad-blockers off although the market size is bigger.

Lemma 3. *In a duopolistic market, if a publisher follows the content wall strategy, it sets* *its content quality at* $v_{1,S1}^{D*} = v_{2,S1}^{D*} = \frac{yq}{2c(1-\phi^2)}$, *and the profit of the publisher is*

$$\pi_{i,S1}^{D*} = \frac{(q(1-2\phi) - 4c(1-\phi^2)(1+\phi)\alpha\delta)qy^2}{4c(1-\phi^2)^2}.$$

Proof. See Appendix.

The derivative of the optimal profit based on substitutability[5] shows that when there is lower substitutability between the content produced by duopolistic publishers, the publisher has a higher margin from the advertising market. However, Lemma 3 states that when the publisher produces differentiated content, the content quality decreases, and users prefer to consume less content because of the lower content quality. On the other hand, when it is costly to produce content, advertising income cannot compensate for the content production cost, and content production becomes nonprofitable for this strategy no matter how differentiated the content is. The publishers producing content for higher amounts stop content production if they can only follow the content wall strategy. Lastly, user ad-aversion decreases the publisher's profit since fewer users consume the content. Publishers with ad-averse users lose profit when they follow this strategy.

Both Publishers Follow the Pay to Avoid Strategy

Both types of users who consume x_i units of Publisher i's content and ads have the utility

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

The x value that maximizes the utility function of a subscribing user in a duopolistic market is given by $x_{i,S,S2}^{D*} = \frac{1}{(1-\phi^2)}(v_i - p_i - \phi(v_{i'} - p_{i'}))$,   i=1,2. The rest of the users will either turn off the ad-blocker or leave. The number of low-type users who turn off the ad-blocker is given by $x_{i,L,S2}^{D*} = \frac{1}{1-\phi^2}(p_i - \phi p_{i'})$, and the number of high-type users who turn off the

[5] $\frac{\partial \pi_{S1}^{D*}}{\partial \phi} = \frac{-2c\alpha\delta(\phi-1)(\phi+1)^3 + q\phi(3\phi-2(1+y^2))+q}{2c(\phi^2-1)^3}$

ad-blocker is given by $x^{D*}_{i,H,S2} = \frac{1}{1-\phi^2}(p_i - \phi p_{i'} + (\phi-1)\delta y), \quad$ i=1,2.

The number of users who subscribe is $\frac{1}{(1-\phi^2)}(v_i - p_i - \phi(v_{i'} - p_{i'}))$. The number of low-type users who turn off the ad-blocker is $\frac{1-\alpha}{1-\phi^2}(p_i - \phi p_{i'})$, and the number of high-type users who turn off the ad-blocker is $\frac{\alpha}{1-\phi^2}(p_i - \phi p_{i'} + (\phi-1)\delta y)$. The total income $\pi^D_{i,S2}$ is given by

$$\arg\max_{v,p} \pi^D_{i,S2} = \frac{1}{(1-\phi^2)}(v_i - p_i - \phi(v_{i'} - p_{i'}))p_i + \frac{1}{(1-\phi^2)}(p_i - \phi p_{i'} + (\phi-1)\alpha\delta y)yq - cv_i^2$$

where $p^{D*}_{1,S2} = p^{D*}_{2,S2} = \frac{2qyc(1+\phi)}{2c(2-\phi)(\phi+1)-1}$ and $v^{D*}_{1,S2} = v^{D*}_{2,S2} = \frac{qy}{(\phi-1)(1+2c(\phi^2-\phi-2))}$.

The total number of users who subscribe is equal to $\frac{qy(2c(1-\phi^2)-1)}{(\phi-1)^2(1+2c(\phi-2)(\phi+1))}$, and the impact of content substitutability follows a U-shaped pattern on the number of users who subscribe such that it maximizes when content is highly differentiated or highly substitutable. The number of those who subscribe is at its minimum when the content is fairly differentiated.

The total number of users who turn off ad-blockers is equal to $\frac{2cqy}{1+2c(\phi-2)(\phi+1)} - \frac{\alpha\delta y}{1+\phi}$. The impact of content substitutability follows an inverse U-shaped pattern on the number of users who turn off the ad-blockers such that it maximizes when the content is fairly differentiated. Figure 2 shows the relationship between content substitutability and the numbers of different types of users. In the pay to avoid strategy, the market size is bigger in a duopoly market than in a monopoly market. The number of users who turn ad-blockers off is lower when there is competition in the market. However, the total advertising market grows due to higher demand. On the other hand, how competition changes the number of users who subscribe depends on the content substitutability in that it increases when the provided content is highly substitutable because the publisher increases the content quality and decreases the subscription fee. When content is not highly substitutable, the number of subscribing users decreases, and the users who do not subscribe turn the ad-blockers off or leave. In this case, the subscription market shrinks, and the advertising market grows.

Lemma 4. *In a duopolistic market, if a publisher follows the pay to avoid strategy, it sets*

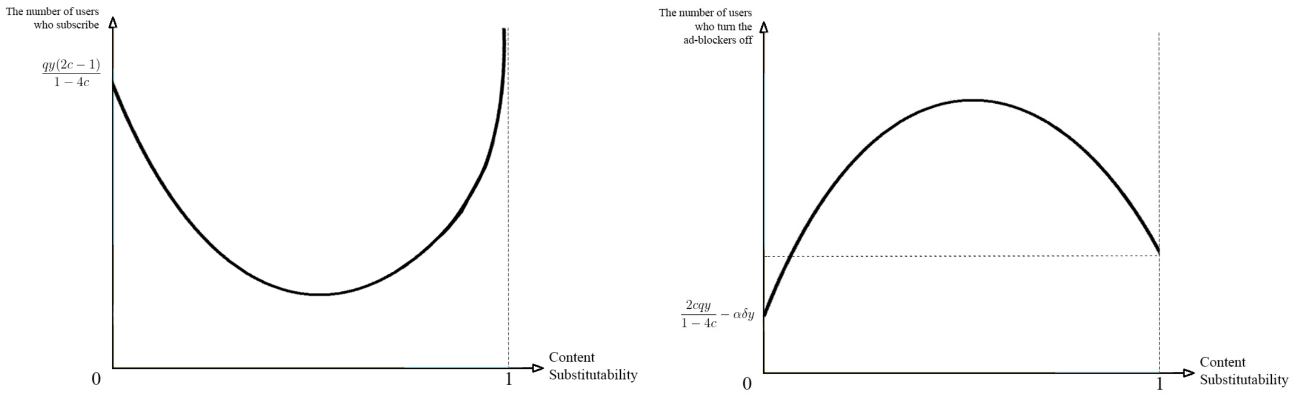


Figure 2. The Effect of Content Substitutability on The Number of Users in the Pay to Avoid Strategy

its subscription fee at $p^{D*}_{1,S2} = p^{D*}_{2,S2} = \frac{2qyc(1+\phi)}{2c(2-\phi)(\phi+1)-1}$ *and content quality at* $v^{D*}_{1,S2} = v^{D*}_{2,S2} = \frac{qy}{(\phi-1)(1+2c(\phi^2-\phi-2))}$*, and the profit of the publisher is*

$$\pi^{D*}_{i,S2} = -qy^2 \left(\frac{cq(4c(\phi-1)^3(\phi+1)+2\phi(\phi-1)+1)}{(\phi-1)^2(2c(\phi-2)(\phi+1)+1)^2} + \frac{\alpha\delta}{\phi+1} \right).$$

Proof. See Appendix.

Lemma 4 shows the optimal values of the subscription fee, content quality, and profit. The derivative of the optimal profit based on substitutability[6] shows how the way content substitutability affects the publisher's profit is similar in both the pay to avoid strategy and the content wall strategy. When the content is more substitutable, the publisher makes less profit. In the range where content is differentiated, the gain in subscription income compensates for the loss in advertising revenue better than the range where content substitutability is high because those who do not wish to subscribe prefer to leave rather than see the ads and substitutable content together. Moreover, when it is costly to produce highly substitutable content, content production becomes nonprofitable, and the publisher stops

[6] $\frac{\partial \pi^{D*}_{S2}}{\partial \phi} = qy^2 \left(\frac{\alpha\delta}{(1+\phi)^2} + \frac{2cq(\phi+2c(1+4c(\phi-1)^3(\phi^3+1)+\phi(-5+\phi(3+\phi(2\phi-3)))))}{(\phi-1)^3(2c(\phi-2)(\phi+1)+1)^3} \right)$

producing it. Take a tabloid, for example. The content is highly substitutable in that users can reach celebrity gossip easily. If the publisher makes the content for a high cost, the content production is nonprofitable under the pay to avoid strategy.

User ad-aversion has an important effect on the publisher's income. Users who are highly ad-averse prefer subscribing or leaving instead of turning off ad-blockers. When the users of a website are more ad-averse, the publisher loses profit. When the number of ad-averse users is sufficiently high, content production becomes nonprofitable for highly substitutable content. When it is not possible to change user ad-aversion, the way for a publisher to make content production profitable again is to make differentiated content such that the publisher can focus on a specific topic.

Proposition 2. (Content Substitutability Effect on Content Quality and Subscription Fee).
(i) When there is higher substitutability between the content provided by duopolistic publishers, the publisher increases its content quality in both the content wall and pay to avoid strategies and increases the subscription fee in the pay to avoid strategy relative to lower substitutability.
(ii) When content production is less costly, the publisher increases the content quality in both the content wall and pay to avoid strategies and increases the subscription fee in the pay to avoid strategy relative to the high content production cost.

Proof. See Appendix.

Proposition 2 shows that publishers that produce differentiated content produce lower quality content than those that produce substitutable content. The differentiated ones also decrease the subscription fee in the pay to avoid strategy because of lower content quality. Take, for example, a newspaper publishing focused content. When it strays from its focus and starts producing general news, it increases its content quality as long as content production cost is the same. Higher content quality brings more users, so the publisher receives higher advertising and subscription revenue. On the other hand, when content production is costly, the optimal content quality decreases. Again, take a newspaper with a specific focus and a blog with the same focus. The blogger makes the same differentiated content with less cost. Hence, it produces higher quality content and sells it for a higher price, resulting in higher advertising and subscription revenue.

Only One Publisher Follows the Content Wall Strategy

Until now, we have focused on the cases where duopolistic publishers follow symmetric strategies. In this section, we analyze the case where Publisher 1 follows the content wall strategy while Publisher 2 follows the pay to avoid strategy. The publishers make decisions sequentially. In the first period, Publisher 1 decides on its content quality (v_1^A). It knows that there is Publisher 2 in the market. However, when Publisher 1 decides on its content quality, it does not know Publisher 2's content quality. Following that in period 2, Publisher 2 sees Publisher 1's content quality, and it decides on its content quality (v_2^A) as well as its subscription fee (p_2^A). Those who would like to subscribe consume Publisher 2's content whereas those who would not like to subscribe consume either publisher's content.

As in the symmetric case, we find the demand under each strategy for each type of customer. The customer utilities are the same with symmetric cases. Hence, the number of users who consume Publisher 1's content is $\frac{1}{1-\phi^2}(v_1 - \phi v_2 + (\phi - 1)\delta y)$. These users are the ones who turn off ad-blockers and consume ads since Publisher 1 follows the content wall strategy. Publisher 2 offers a subscription. Hence, $v_2 - p$ users subscribe while $\frac{1}{1-\phi^2}(v_2 - \phi v_1 + (\phi - 1)\delta y) - (v_2 - p)$ users turn off the ad-blocker and consume the ads. As stated before, the game starts with Publisher 1's move. It has an advertising income and content production spending. In this case, Publisher 1 finds its optimal content quality (v_1^{A*}) to maximize its revenue (π_1). Later, Publisher 2 finds its optimal content quality (v_2^{A*}) as well as its subscription fee (p^{A*}) to maximize its revenue (π_2^{A*}). Publisher 2 knows Publisher 1's content quality when it makes its decision.

The total income π_1^{A*} is given by

$$\arg\max_{v} \pi_1^{A*} = \frac{1}{(1-\phi^2)}((v_i - \phi v_{i'}) + (\phi - 1)\alpha\delta y)yq - cv_i^2$$

where $v_1^{A*} = \frac{qy}{2c(1-\phi^2)}$.

The total income π_2^{A*} is given by

$$\arg\max_{v,p} \pi_2^{A*} = \frac{1}{(1-\phi^2)}(v_i - p_i - \phi v_{i'})p_i + \frac{1}{(1-\phi^2)}(p_i + (\phi - 1)\alpha\delta y)yq - cv_i^2$$

where $v_2^{A*} = \frac{yq(2\phi+1-\phi^2)}{(1-\phi^2)(4c-1)}$ and $p_2^{A*} = \frac{yq(2c(\phi^2-1)-\phi)}{(\phi^2-1)(4c-1)}$.

Lemma 5. *When Publisher 1 follows the content wall strategy and Publisher 2 follows the pay to avoid strategy,*
(i) Publisher 1 sets its content quality at $v_1^{A*} = \frac{yq}{2c(1-\phi^2)}$*, and the profit of Publisher 1 is* $\pi_1^{A*} = \frac{qy^2(4c(4c-1)\delta(\phi-1)^2+4cq(2\phi^2+\phi-1-\phi^3))}{4c(1-4c)(\phi^2-1)^2}$*;*
(ii) Publisher 2 sets its optimal content quality at $v_2^{A*} = \frac{yq(2\phi+1-\phi^2)}{(1-\phi^2)(4c-1)}$ *and its optimal subscription fee at* $p^{A*} = \frac{yq(2c(\phi^2-1)-\phi)}{(\phi^2-1)(4c-1)}$.
Publisher 2's profit is $\pi_2^{A*} = \frac{qy^2(q(\phi+2c^2(\phi^2-1)^2-2c\phi(\phi(\phi-2)+2))-2c(4c-1)\delta(\phi-1)^2(\phi+1))}{2c(4c-1)(\phi^2-1)^2}$.

Proof. See Appendix.

To assure that the publisher produces content in the pay to avoid strategy and focus on the effect of the content production cost, we assume that $\alpha < -\frac{q(5+q+2\phi^2(q+3)-2\phi(5+q))}{4\delta(\phi-1(6-2q^2+\phi(2\phi(1+q^2)-7)))}$. Lemma 5 shows that Publisher 2 changes its content quality with the content production cost. When its content production cost is low, its content quality gets higher than in the case where both duopolistic publishers follow the pay to avoid strategy. On the other hand, when its content production cost is high, its content quality is lower than when both publishers follow the pay to avoid strategy. Hence, asymmetry increases the content quality when it is less costly to produce. Lemma 5 implies that when a publisher knows that its rival offers a subscription option, the optimal result is that it also offers a subscription option. On the other hand, when a publisher knows that its rival does not offer a subscription option, offering a subscription option is more profitable. Hence, both publishers follow the same strategy in that the optimal solution of this problem is the symmetric solution. Hence, we continue our analysis focusing on the symmetric case.

After showing duopolistic publishers' optimal values in asymmetry and symmetry under both strategies, we move on to the optimal strategy a publisher follows. A duopolistic publisher decides on its optimal strategy based on how costly it is to produce content and how differentiated the content is.

Proposition 3. (Optimal Strategy in a Duopoly Market). *The strategy of publishers against ad-blockers depends on the cost of content production and content differentiation.*
(i) When the cost is low ($c < \frac{1}{2}$), the publisher's strategy depends on its content differentiation. It follows the content wall strategy when the content is highly differentiated, and it follows the pay to avoid strategy when the content is substitutable.
(ii) If the cost is intermediate ($\frac{K+L}{M} > c > \frac{1}{2}$), the publisher follows the pay to avoid strategy.
(iii) Otherwise ($c > \frac{K+L}{M}$), the market is not viable, and the publisher chooses not to produce any content.

where

K=-$(\phi + 1)(4\alpha\delta(\phi - 2)(\phi - 1)^2 + 2q\phi(\phi - 1) + q)$
$L = q(q(-2\phi^3 + \phi - 1) - 8\alpha\delta\phi(\phi^2 - 1)^2)$
$M = 8(\phi^2 - 1)^2(\alpha\delta(\phi - 2)^2 + q(\phi - 1))$

Proof. See Appendix.

Proposition 3 shows that a duopolistic publisher's optimal strategy depends on content production cost and content substitutability. Figure 3 shows that the publisher's optimal strategy is to not offer a subscription option to users when its content is differentiated and less costly to produce. Examples of this include personal bloggers and YouTubers. Their content is created by individuals. Since the content is mostly formed by the creator's ideas, it is differentiated and also less costly to produce since it requires less research or mobility. Hence, a blogger or Youtuber follows the content wall strategy in that she does not offer a subscription to her followers. In another area of the graph, the publisher produces more substitutable content. The publisher follows the pay to avoid strategy independent of the content production cost. Tabloids are substitutable and less costly while big newspapers are substitutable and more costly. Publishing tabloid content is generally less costly since it does not require much mobility or many people to work on the content. Also, this kind of content is substitutable. Publishing newspapers is more costly. However, the content could still be substitutable. Hence, newspapers and tabloids follow the pay to avoid strategy in that they offer a subscription option to their users. The last area is where content production cost is high and the content is differentiated. In this area, the publisher follows the pay to avoid strategy. Websites with a specific focus take place in this area. Producing such specific content is costly, and the content is highly differentiated since it has a specific focus. To sum up, while individually created content follows the content wall strategy, tabloids, newspapers, and websites with a specific focus follow the pay to avoid strategy. These results correspond to the strategies that those content creator types follow in reality. We witness that many newspapers, tabloids, and websites with a specific focus offer an ad-free version of their websites (besides the regular ad-showing version) while individual bloggers do not offer a subscription option to their followers.

Proposition 4. *When the content production cost is high, the content of a publisher focusing on a specific topic is profitable while the content production of a publisher focusing on general topics is nonprofitable.*

Proof. See Appendix.

Proposition 4 states that the duopolistic publisher does not produce any content when

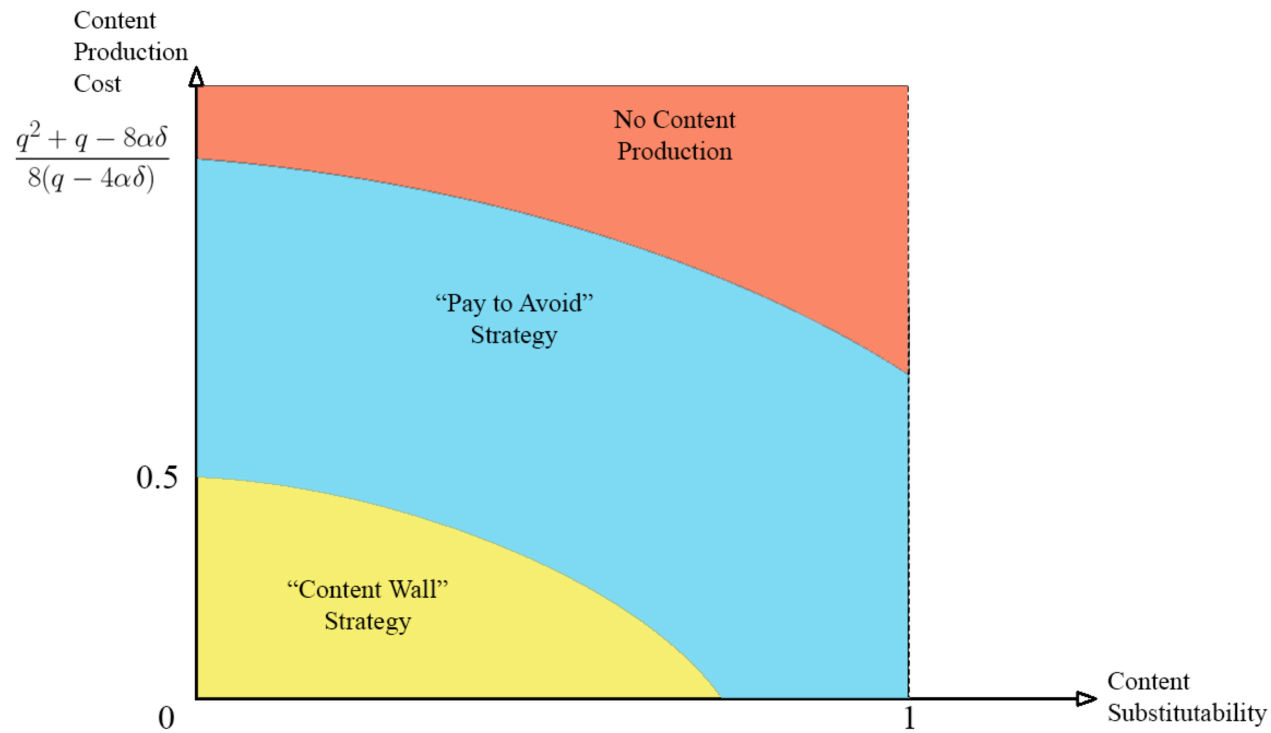


Figure 3. Publisher's Optimal Strategy in A Duopoly

$c > \frac{q(2\phi-1)}{4\alpha\delta(\phi-1)(\phi+1)^2}$ if it follows the content wall strategy because content production is nonprofitable. On the other hand, the publisher does not produce any content when $c > \frac{K+L}{M}$ when it follows the pay to avoid strategy to ensure that content production is profitable. Thinking that publishers follow the pay to avoid strategy when it is more costly to produce content, the second restriction is binding. In a case where a publisher's content is highly substitutable and highly costly to produce, content production is nonprofitable. Accordingly, this publisher stops producing content. Consider a website with a specific focus and a big newspaper. Content production cost is high for both of them. In this case, content production is profitable for the website with a specific focus such as sports, finance, and politics while it is nonprofitable for the newspaper which has a general focus.

Proposition 5. *(i) Competition decreases content quality when the content in a duopoly market is less costly to produce and highly substitutable.*

(ii) Competition increases content quality in all other cases.

Proof. See Appendix.

Proposition 5 states how competition changes the optimal content quality. In the case where the monopolistic publisher's content production cost is high, it follows the pay to avoid strategy. When the duopolistic publishers' content is highly differentiated from or fairly similar to each other, they follow the same strategy. However, when they have highly similar content, content production becomes nonprofitable, and the publishers stop content production. At the same time, competition does not affect the optimal strategy as long as the content is not highly substitutable when the content production cost is high. Furthermore, in this case, the publisher increases its content quality and decreases its subscription fee in case of competition. This result is fairly expected. Take a monopolistic website producing content on science for high prices. Users could consume the ads to get access to the content or subscribe for the premium version. When there are two websites on the market producing content on politics (differentiated content), the science website keeps offering subscription to the users, increases its content quality, and decreases the subscription fee.

When the content production cost is low, on the other hand, the monopolistic publisher follows the content wall strategy and does not offer a subscription option to the users. However, the competition effect is different in this case. In the case where duopolistic publishers produce differentiated content, they follow the content wall strategy and also increase their content quality. However, when the duopolistic publishers produce substitutable content, they change strategy and follow the pay to avoid strategy. In this case they offer a subscription option. Unexpectedly, they decrease the content quality. Take a monopolistic website producing content about celebrities' lives. It does not offer a subscription option, and users turn ad-blockers off if they want to consume this content. In a duopolistic market where the publishers produce content about celebrities' lives, they offer a subscription option and decrease the content quality. Although competition increases the content quality in other cases, the result is different here because the websites earn profit from the subscription market as well as a smaller profit from the advertising market.

2.5. Extension

2.5.1. When the Ad-giver Is a Decision Maker

In the previous section, we considered the number of ads (y) as an exogenous variable. In this section, we take a monopolistic ad-giving firm as a decision maker where it decides on the level of advertising. An ad-giver is a utility maximizer. It has a utility of ad effectiveness (g) when low-type users consume its ads. On the other hand, its utility decreases when a high-type user sees its ad because these users are highly ad-averse and seeing an ad creates negative feelings towards the ad-giving firm. The disutility is h. The ad-giver also incurs a disutility when users see the same ad more than once. We set the utility function of an ad-giving firm after Singh and Vives (1984). An ad-giver maximizes its utility is

$$U(ag) = (1-\alpha)gy - \alpha hy - \tfrac{1}{2}y^2.$$

The ad-giving firm maximizes $U(ag) - qy$ where q is the revenue from each user for each ad representing the indirect ad demand. The optimal value of the indirect demand is equal to $q^* = (1-\alpha)g - \alpha h - y$. In the following section, we focus on a monopolistic publisher's strategy.

Content Wall Strategy

The numbers of low- and high-type customers are as previous. The publisher maximizes its total profit by solving the following problem:

$$\arg\max_{v,y} \pi_{S1}^{E} = (v - \alpha\delta y)y[(1-\alpha)g - \alpha h - y] - cv^2$$

which yields $v^{E1*} = \alpha\delta g(1-\alpha) - \alpha^2\delta h$ and
$y^{E1*} = \frac{(1+\alpha-2\alpha^2)\delta g - 2\alpha^2\delta h + \sqrt{\delta^2((1-\alpha)^2(1+\alpha+\alpha^2)g^2+(\alpha-1)\alpha^2(1+2\alpha)gh+\alpha^4h^2)}}{3\alpha\delta}$.

Lemma 6. *In a monopolistic market, where the number of ads is an exogenous variable, if a publisher follows the content wall strategy, the quality of the content and the number of ads take their optimal values, and the profit of the publisher is*

$\pi_{S1}^{E*} = -c((\alpha^2-1)\delta g + \alpha^2\delta h)^2 - \frac{1}{27\alpha^2}$

$(d((\alpha-1)^2 g + \alpha^2 h)((\alpha^2+\alpha-2) + \alpha^2 h)((\alpha-1)(2\alpha+1)g + 2\alpha^2 h)$

$+\frac{2(d^2((\alpha-1)^2(\alpha^2+\alpha+1)g^2+(\alpha-1)\alpha^2(1+2\alpha)gh+\alpha^4h^2))^{3/2}}{d^2})$.

Proof. See Appendix.

Lemma 6 reveals that the number of low-type users is equal to $(1-\alpha)(\alpha\delta g(1-\alpha) - \alpha^2\delta h)$, and the number of high-type of users is equal to $\frac{1}{3}(-\delta(\alpha-1)(3\alpha^2+\alpha-1)g + \alpha^2(3\alpha-2)h) - \sqrt{\delta^2((1-\alpha)^2(1+\alpha+\alpha^2)g^2 + (\alpha-1)\alpha^2(1+2\alpha)gh + \alpha^4h^2)})$. The total number of users who turn ad-blockers off decreases with user ad-aversion, as expected. User ad-seeing disutility also follows an inverse U-shaped pattern on the content quality. The publisher follows two ways to avoid losing profit. Firstly, it can increase the content quality to appeal to ad-averse users and keep them on the website. Secondly, it can decrease the number of ads, so ad-averse users do not leave the website. The content quality increases with ad-effectiveness on low-type users while it decreases with high-type users' negative feelings toward the ads. In the first case, the number of ads increases with higher ad-effectiveness. The publisher attracts more low-type customers with higher content quality and shows them more ads. This way, it increases its advertising income. However, in the second case, high-type customers leave the publisher with a higher number of ads, forcing the publisher to decrease the content quality. Different from the case where the number of ads is an exogenous variable, the publisher decides on its content quality independent of the content production cost. This solution implies that the ad-giving firm has an influence on the publisher, such that content production cost becomes unimportant and user-related characteristics become binding.

The results related to the publisher's income are fairly straightforward. The content production cost as well as characteristics related to user ad-aversion decrease the publisher's income. However, it is important here that the publisher's income in this case is lower than in the case where the ad-giver is not a decision maker. When the ad-giving firm makes its own decision, the number of ads increases. Accordingly, some of the users leave the publisher, and the publisher loses profit. To address this, the publisher can increase its content quality to increase the number of users.

Pay to Avoid Strategy

The numbers of low-type and high-type customers are as previous. The publisher maximizes its total profit by solving the following problem:

$$\arg\max_{v,p,y} \pi^{E}_{S2} = (v-p)p + (p - \alpha\delta y)y[(1-\alpha)g - \alpha h - y] - cv^2$$

which yields $v^{E2*} = \frac{A}{2c}$[7], $p^{E2*} = A$, and $y^{E2*} = \frac{A+B+\sqrt{(A+B)^2-3AB}}{3\alpha\delta}$ [8].

Lemma 7. *In a monopolistic market where the ad-giver is a decision maker, if a publisher follows a pay to avoid strategy, the quality of the content, the subscription fee, and the number of ads take their optimal values, and the profit of the publisher is* π^{E*}_{S2}.

[7] A$=9\alpha^2\delta^2(8 - (1/c)16c) - 8\alpha\delta g(1 + \alpha + 4c + 4\alpha c) + 4cg^2(1 - 2\alpha + \alpha^2) + 8\alpha^2\delta h(1 - 4c) - 4\alpha ch(2g - 2\alpha g - \alpha h) + ((3\alpha\delta(4c - 1) - 2cg + 2\alpha c(g + h))/c)\sqrt{4c^2g^2 + 4\alpha cg(d - 4cd - 2c(g+h)) + \alpha^2(9\delta^2(1-4c)^2 + 4c\delta(4c-1)(g+h) + 4c^2(g+h)^2))}_{\overline{16(4c-1)}}$

[8] B$=\alpha\delta g - \alpha^2\delta(g+h)$

Proof. See Appendix.

Lemma 7 implies that the number of users who subscribe is equal to $A(\frac{1-2c}{2c})$, the number of low-type users who turn ad-blockers off is equal to $(1-\alpha)A$, and the number of high-type users who turn ad-blockers off is equal to $\frac{3\alpha\delta A - A - B - \sqrt{(A+B)^2 - 3AB}}{3\delta}$.

Corollary 1. *(i) User ad-seeing disutility follows an inverse U-shaped pattern on the number of users who subscribe while it follows a U-shaped pattern on the number of users who turn the ad-blockers off.*
(ii) Higher ad-seeing disutility does not necessarily decrease the number of users who turn ad-blockers off in the existence of a subscription market.

Proof. See Appendix.

Corollary 1 implies that higher ad-aversion increases the number of those who turn ad-blockers off when user ad-seeing disutility is high. This happens only in a case where the publisher exists in both advertising and subscription markets. User ad-seeing disutility follows a U-shaped pattern on the subscription fee. In the lower range of user ad-seeing disutility, as its value increases, the subscription fee decreases. Accordingly, the number of those who subscribe increases, leaving fewer users turning off ad-blockers even though the content quality is lower. In this range, the publisher makes more profit in the subscription market than the advertising market. However, in the higher range of ad-seeing disutility, as its value increases, the subscription fee increases. In this range, the number of subscribing users decreases, and the number of users who turn off ad-blockers increases. The advertising market dominates the subscription market. Hence, with highly ad-averse users, the publisher decreases the subscription fee to induce more users to subscribe. This way, it can compensate for the loss in advertising market. Another approach the publisher can follow is decreasing the number of ads so as not to lose its users because of ad-aversion.

Proposition 6. (Monopolist's Content Strategy where the Number of Ads is Endogenous). *The strategy of publishers against ad-blockers depends on the cost of content production and* *user ad-aversion.*

(i) When the content production cost is low, the publisher's strategy depends on user ad-aversion. It follows the pay to avoid strategy when user ad-aversion is low and high, and the content wall strategy when user ad-aversion is in the middle.

(ii) When the content production cost is high, the publisher always follows the pay to avoid strategy.

Proof. See Appendix.

We have previously stated that a publisher decides on its optimal strategy in a monopoly purely on its content production cost. However, Proposition 6 states that in the case where the number of ads is an endogenous variable, a monopolistic publisher decides on its optimal strategy by considering not only its content production cost but also user ad-aversion. The publisher follows the content wall strategy only when its content production cost is low and users are fairly ad-averse. In this range, the advertising income in the content wall strategy takes a middle value while the advertising income in the pay to avoid strategy takes its lowest value and the subscription revenue takes its highest value. When the content production cost is low, the publisher increases the content quality. This leads to the advertising revenue in the first strategy beating the combination of both advertising and subscription revenues in the second strategy. The publisher follows the pay to avoid strategy in all other cases. Once again, the ad-giver making its own decision restricts the publisher's decisions, making the cost of content production less important while user ad-aversion becomes more important in the publisher's strategy making process.

2.6. Conclusion

In this paper, we have developed an analytical model to evaluate the strategies that publishers follow to combat ad-blockers. In many cases, the publishers mainly or solely earn money from ads. However, the users are looking for ways to escape ads. Using ad-blockers is a popular way to avoid online ads. This could result in a big problem for the internet community because this means a shortage for the publisher's income. The publisher may even stop producing content. This is why publishers are looking for ways to fight against ad-blockers. In our paper, we have analyzed the two most commonly applied strategies: the publisher does not give access to those who use ad-blockers (content wall strategy), and the publisher offers a subscription option alongside the content wall where users can have content access without seeing ads (pay to avoid strategy).

In our model, we started with defining the market as well as publishers' potential strategies, followed by the user segments. The users have a utility of seeing repeated or substitutable content. Furthermore, the user has a disutility of paying for the content and being interrupted by ads. We define two types of users in terms of their ad-seeing disutility: (1) those who have a minor disutility of seeing ads and (2) those who have a higher disutility of seeing ads. The users have three options: pay a subscription fee to get access to the ad-free version of the website (when the publisher offers it), turn off the ad-blockers, or leave. Following this, we analyzed the model for monopoly and duopoly markets. In this analysis, we aimed to reach the optimal content quality and the optimal subscription fee, thus reaching the optimal profit. Firstly, we found out the user demand under each strategy the publisher follows in monopoly and duopoly markets. Then, we concluded with the optimal values under each strategy and which strategy the publisher follows. Later, we analyzed the cases in which duopolistic publishers follow asymmetric strategies and the number of ads is decided endogenously.

Our findings show that a monopolistic publisher decides on its optimal strategy based on its content production cost. It offers a subscription option only when content production is costly. User ad-aversion decreases the publisher's income under the content wall strategy since highly ad-averse users prefer subscribing instead of turning the ad-blockers off. In this case, the publisher either increases the content quality or decreases the subscription fee to appeal to more users. In a duopoly market, a publisher decides on its strategy based on its content production cost as well as content differentiation. We define four types of publisher: websites with a specific focus (differentiated content, high content production cost), big newspapers (substitutable content, high content production cost), personal blogs (differentiated content, low content production cost), and tabloids (substitutable content, low content production cost). Among these only personal blogs do not offer a subscription option to its users. We also show that when content production is nonprofitable due to a high content production cost, content production is profitable only when the content is differentiated. When it is not possible to decrease the content production cost, the publisher narrows its focus down to attract more users who are interested in a specific topic. Thirdly, we have shown that competition does not necessarily increase content quality. Competition decreases content quality when the monopolistic publisher's content is less costly and the duopolistic publishers' content is substitutable and less costly. Last but not least, when the ad-giver is a decision maker, the publisher's decision-making power is more restricted, and it has to consider user ad-aversion, contrasting with the case in which the publisher does not consider the number of ads.

Our model excludes ad-blocking firms from the decision process. We assume that ad-blockers are free of charge and give no disutility to users to install them. The ad-blocking firm may be in a monopolistic, duopolistic, or oligopolistic market. It has a potential income from the users (paid ad-blocker) or from the publishers (free ad-blockers). In the case where ad-blockers are purchased, the user decision may change, especially for those who are highly sensitive to spending. When ad-blockers are free to users but allow the publisher to show some ads for a share of advertising income, the user decision may change, especially for those who are highly ad-averse. The existence of ad-blockers as a source of disutility either for the users or the publishers affects the content quality as well the subscription fee and as a result the number of users. Future research could consider ad-blocking firms as decision makers.

Another topic we do not cover in our model is the network effect. It is inevitable to lose some users when the publisher does not give access to those who use an ad-blocker. This may result in a lower place on the search engine result page. Consequently, the site may have fewer users. In our model, we only consider those who install an ad-blocker and how to convert them into profitable users. However, we do not consider non-ad-blocker users. A user who would be willing to consume the ads could turn into a user because of the network effect. On the publisher side, this could cause higher content quality by converting more and more users to the publisher's website.

Lastly, we assume the disutility of paying for content is higher than the disutility of consuming ads. However, one can certainly claim that some users are willing to pay instead of seeing ads. Considering heterogeneity over user disutility of seeing ads and paying for the content could be an alternative path for future research. That a publisher may draw user segmentation and target only some of them is definitely not anomalous and is worth analyzing.

Although ad-blockers are an important topic for today's internet world, researchers have just recently started working on them. To the best of our knowledge, there are only a limited number of articles focusing on this topic specifically and only a few of them use an analytical model. Among those, again to the best of our knowledge, our paper is the first one analyzing the subscription model in conjunction with the content wall. We further extend this analysis by including a duopoly market and showing how competition changes the publishersâ€™ actions.

3. Essay II - Maximizing Customer Lifetime Value through Strategic Channel Management: How to Incentivize Customers to Use a Mobile App versus a Website

Gokhan Gecer

Florian Kraus

Abstract

Customer engagement with mobile devices has changed customers' habits in online purchasing, in particular the usage of mobile apps for shopping increases the customer lifetime value (CLV). Based on a quasi-field experiment, we show that once customers start using their mobile devices to purchase, they adopt this channel and keep purchasing through it. Also, we support the literature showing that purchasing over mobile apps increases the customer lifetime value (CLV). Hence, we suggest the idea that online retailers should steer their customers to the mobile channel by offering a permanent discount over the mobile app. Although this strategy decreases the short-term income, it may increase the CLV. Based on this suggestion, we develop a probability-based CLV model to show to what type of customers an online retailer should offer a discount over the mobile app as well as the optimal value of that discount. Following an analytical modeling approach, we are able to show that the online retailer should offer such a discount to a customer who is either very likely or unlikely to increase her purchasing probability. Also, the firm could offer such a discount to encourage the customer to switch to the mobile app. Online retailers should not offer the discount to those who already have a high purchasing probability because their CLV is already huge. Last but not least, an online retailer should not follow this strategy to gain new customers (customer acquisition) but rather apply it to increase customer retention.

Keywords: customer lifetime value; customer-base analysis; mobile purchasing adoption; multi-channel sales

3.1. Introduction

As a result of the growing number of mobile device users in recent years, the transactions and revenues generated through mobile commerce are growing at skyrocketing rates. The marketing news source Adweek (2018) stated that the consumers in the US spent $7.8 billion over smartphones in 2012 while this number increased to $60.2 billion in 2016, and it is predicted to jump to $175.4 billion in 2022. The share of mobile commerce (m-commerce) in electronic commerce (e-commerce) was 52.4% in 2016, and it is expected to increase to 72.9% by 2021 (Statista, 2018).

Another example to underline the importance of mobile apps involves "big buying days" like Cyber Monday, Black Friday, and Singles' Day in China for online sellers. The online retailer Alibaba, for example, set a new record by making sales worth $38.4 billion on Singles' Day sales on November 11, 2019, an increase of 26% over 2018. Alibaba reported selling $1 billion worth of goods in the first 68 seconds and $12 billion in the first hour. 90% of the total sales came from smartphones and other mobile devices, emphasizing the tremendous importance of m-commerce (CNBC, 2019).

This development shows that understanding mobile buying behaviors is extremely important for digital commerce managers. They need to understand the important factors that steer customers to use mobile devices to make purchases. Also, acquiring deeper insights on how mobile customers affect companies' overall sales seems to belong on the agenda of every successful marketing manager in the digital economy. Hence, many big companies started offering advantages to mobile customers. For example, for over a year, McDonald's has given away free fries on Fridays if a customer spends $1 on its app. While H&M (clothing retailer) offers a discount on the first mobile order, Alibaba does that for all offers.

Although mobile shopper marketing has become an important area for academics and practitioners alike and a few articles point out that mobile devices could be used as an effective marketing tool due to their portable and personal nature (Shankar et al., 2010), literature in this area is still scarce (Shankar et al., 2016).

The defining characteristics of the mobile channel compared to other sales channels are that (1) at least one of the engaged parties (seller and buyer) is not at a fixed location and (2) these parties can communicate with each other at any time (Balasubramanian et al., 2002). Okazaki and Mendez (2013) point out that mobile devices come with the unique nature of ubiquity. They differ from fixed devices by showing benefits such as continuity (they are always on), immediacy (quickness of the devices), portability (light enough to be carried), and searchability (capability of making a thorough examination).

Thus, mobile devices have the following advantages over fixed devices, which are the other central sales channels for companies selling online:

1. *Notification:* Mobile devices are portable and can transfer data to the customer immediately (Lariviere et al., 2013). The best way to communicate with customers is sending them a notification to inform them about a product, offer mobile coupons, or remind them to make a purchase at any time.

2. *Better personalization:* Mobile devices offer personalization to increase customer satisfaction by saving time with less data transmission (Lee and Park, 2006). Mobile devices save personal information such as passwords, addresses, and credit card information. They track past purchases, make offers accordingly, and notify the customer on time. Fill-in forms, better mobile payment systems, and better security systems are further examples for cornerstones of personalization (de Haan et al., 2015).

3. *Customer engagement and adoption:* Mobile devices are irreplaceable parts of today's life. Mobile apps are a central aspect of this trend. Marketing managers are realizing that engaging with customers via mobile channels helps to establish a continuous interaction. Hence, there is an indication that mobile channels might be more effective in terms of

triggering purchasing than other sales channels, including websites (Dinner et al., 2015). Mobile devices are more successful than fixed devices, including PCs and laptops, when it comes to predicting customers' preferences and potential purchase intentions because mobile devices are location specific, portable, wireless, and personable. Thus, mobile devices play a unique role by offering convenience to customers during the pre-purchase, purchase, and post-purchase phases for the customer decision process (Shankar and Balasubramanian, 2009). This unique nature gives customers the impression of a close relationship with the retailer and therefore leads them to develop habitual interactions with the firm (Wang et al., 2015). Moreover, perceived emotional values lead the users to adopt mobile devices for purchases (Nysveen et al., 2005; Ström et al., 2014).

In the first part of our article's methodology section, we developed and ran an experiment to show that people develop a habitual behavior with mobile channels as well as tending to make more frequent transactions. In the experiment, we offered extra points to students in two courses over a semester when they completed some tasks. While some of the students took only one of these two courses, some of them took both courses. In one of the courses (the one that started earlier in the semester), we offered more points to those who completed the tasks using their mobile devices (smartphone or tablet), but we did not offer this in the second course (the one that started later in the semester). Our results showed that the students used their mobile devices to complete the tasks in the first course. The ones who took both of the courses kept using their mobile devices in the second course although they were not offered extra points for this. Lastly, the students who took only the second course showed higher participation when they used their mobile devices compared to the ones who used their laptops. The result of this experiment confirms the existing research presented above. Once people adopt mobile devices, they keep using them for their transactions. Also, they tend to increase their rates of transaction.

Against this background as well as the experimental results presented above, we theorize that when the customers adopt mobile devices for their purchases, they start using these devices regularly and turn this into a habit. We assume that the customer lifetime value (CLV) of those mobile channel users tends to be larger than the CLV of website users. One of the main reasons behind this assumption is that users' order rates increase when they adopt mobile apps, resulting in a higher net monetary value in total spending (Naarang and Shankar, 2016; Wang et al., 2015). Moreover, smartphone and tablet computer users have a higher basket-to-conversion rate compared with fixed device customers purchasing over websites (de Haan et al., 2015). Consequently, online retailers should encourage their customers to switch to using mobile devices. In practice, some firms already offer coupons, games, or points for this purpose. Naturally, another powerful option to incentivize the use of mobile devices could be offering a discount for purchases made through mobile commerce (m-commerce). The purpose of this article is to develop a modeling approach to answer the following research questions:

1. *To what type of customers should a discount be offered when purchases are conducted over mobile apps?*

2. *What is the optimal discount rate that should be offered?*

Our approach is based on the idea that customers who start using a mobile device to purchase products online also start using the mobile channel on a regular basis and turn this behavior into a habit. Therefore, those mobile app users, who have a higher net monetary value in total spending, may become more valuable customers for companies. Thus, firms could choose to offer a discount to their customers to steer them to the mobile channel. On the one hand, the firm loses some of its profit in the short term because of the discount. On the other hand, the customer increases her CLV in the long term. This is why the firm should be careful with this strategy. In our analysis, we show to which customers the firm should offer a discount via the mobile app. The firm makes its decision based on how a discount rate changes the customer's purchasing probability, how well the customer adopts the mobile channel, what the current purchasing probability of the customer is, and how active the customer is.

Our analysis builds on a market where the firm (i.e. an online retailer) sells over two sales channels (website and mobile app) to its customers to maximize its profit. The consumers purchase over one or both of these sales channels. The firm follows one of two strategies for each customer individually: offering a discount over the mobile app or not offering the discount. In the strategy in which it offers a discount, the firm sells its products for a lower price. Its aim here is steering the customer to the mobile channel to increase her purchasing probability as well as her CLV. The firm loses some of its profit in the short term. However, the profit increases in the long term because the customer increases her purchasing probability. In the second strategy, the firm does not offer a discount to the customer over the mobile app. The price of a product is the same over the web page and mobile app. In order to find the optimal strategy of a firm, we calculate the CLV of a customer by multiplying her discounted expected transaction (DET) and average spending (Fader et al., 2004). The DET of a customer is calculated by using her current purchasing probabilities over the sales channels as well as her probability of being active in the firm. It is worth noting that if the customer's average spending is constant, her CLV and DET are equivalent.

Our findings indicate that the firm is more likely to offer a discount over the mobile app to a customer who is either unlikely or very likely to increase her purchasing probability after being offered the discount. In these ranges, the increase in CLV in the long run outweighs the decrease in the short term profit. The result is the opposite for moderate values of purchasing probability change. Another important customer characteristic that affects the firm's decision is how well a customer adopts the mobile channel. The firm is more likely to offer a discount over the mobile app when a customer does not adopt the mobile app. In other words, if the customer stays on the website, the firm should offer a discount on the mobile app to encourage the customer to switch to the mobile app. On the other hand, the firm should not offer a discount to a customer who already has a high purchasing probability. Her CLV is already high, and the discount brings nothing but loss of profit to the firm. Finally, an important result of the model shows that the firm should not apply the strategy of offering a discount over the mobile app to increase its customer acquisition. In this case, we find that new customers tend to use the discount for one-time purchases and leave the firm afterward.

In the second part of our analysis, we focus on the optimal discount rate when offering it is part of the optimal strategy of a firm. In this part of the analysis, we calculate the discount rate that gives the DET its optimal value. We also show how the optimal discount rate changes based on different customer characteristics. First of all, we show that when the discount greatly increases the customer's purchasing probability, the firm offers a higher discount rate. Similarly, the firm offers a higher discount rate to those who tend to adopt the mobile app quickly as well as to more active customers. The idea behind the increase in those three customer characteristics is the same: the customer tends to spend more and increase her CLV with the discount. On the other hand, the firm decreases the discount rate when the current purchasing probability of a customer is high. It is important to note that, the strategy of offering a discount to the customers with high current purchasing probabilities is not the optimal one most of the time. However, even when it is the optimal strategy, the firm keeps the discount rate to these customers low. The logic behind this is simple: the customer's CLV is already high and offering a higher discount rate only decreases the firm's profit.

In the following section, we provide the literature review. In Section 3.3, we present the methodology. In the first part of this section, we focus on the experimental study. In the second part, we introduce the analytical model, including the proposed approach and its analysis. Finally, in Section 3.4, we discuss the results and present the future work as well as the limitations.

3.2. Literature Review

3.2.1. Mobile Commerce

An important research stream on mobile commerce is mobile channel effect on total sales. Mobile apps influence customers in informational and experiential ways (Narang and Shankar, 2016). Online customers start their journey by gathering information on mobile devices; they decide on the purchases and finish this journey in either mobile devices (smartphones and tablet computers) or fixed devices (laptops and PCs) (de Haan et al., 2015). Mobile apps increase customer loyalty and purchase intention as well as brand popularity both over mobile devices (Dinner et al., 2015) and laptops because mobile apps increase the same firm's website traffic as well (Xu et al., 2014; Bellman et al., 2011). Since it is difficult to track the rate of mobile apps increasing website visits, the net effect of mobile apps on overall monetary value is unclear (Narang and Shankar, 2016).

Another important research stream on mobile commerce is geo-targeting and mobile coupons. As the usage of mobile devices increases, traditional coupons start to disappear and mobile coupons become more and more important. Firms can target customers by sending mobile coupons based on location since people carry their personal mobile devices all the time (Dube et al., 2017). One of the most important concerns should be the scheduling of the mobile coupons (De Reyck and Degraeve, 2003). The redemption rate of mobile coupons is basically based on the coupon's time and location as well as its expiry length (Danaher et al., 2015). Furthermore, geo-targeting is an important factor in mobile coupons. Firms can increase store sales by sending mobile coupons to customers who are already in the store (Hui et al., 2013). Similarly, firms can target consumers in locations where competitors are present. Targeting the customers who are at a competitor's location may be even more effective than targeting the customers who are at the firm's own location (Fong et al., 2015). In a competitive duopoly market, both firms may prefer to target the customers geographically.

While competition increases the profit when the prices are symmetric, it may decrease the profit when the prices are asymmetric (Dube et al., 2017). Lastly, Andrews et al. (2016) find that consumers especially redeem coupons when they are alone in crowded places.

3.2.2. Multichannel Sales

In 2016, 86% of global customers used at least two channels to shop (Total Retail, PwC, 2016), including channels like stores, websites, catalogs, the sales force, third-party agencies, and call centers (Neslin and Shankar, 2009). Since customers are more complex in today's world (i.e. using more than one channel, comparing the products and prices online, having higher expectations, etc.), companies should pay more attention to those who shop using more than one channel (Wind and Mahajan, 2002). Thomas and Sullivan (2005) suggest that multichannel managers should assign each existing and new customer into these channel segments and develop a segment-specific communication strategy. Channel coordination is another important topic (Dukes and Liu, 2010). Neslin et al., (2006) recommend that marketing managers should consider data integration among different sales channels, be careful about resource allocation across channels, and decide on dedicated channel strategies. According to Zhang et al. (2010), they should also pay attention to consistent pricing, inventory management, return policies, and promotions across channels (Zhang et al., 2010).

One of the most important concerns for multichannel retailers is the adoption of new channels. Venkatesan et al. (2007) point out that a higher purchase frequency, a higher level of price discounts, and a higher level of cross-buying expedite new channel adoption. Moreover, multichannel customers adopt a new channel faster. Social involvement is another factor that affects new channel adoption. Less experienced customers and internet users get affected by the environment/neighborhood more (Bilgicer et al., 2015; Choi et al., 2010).

Some studies point out that multichannel customers are more valuable customers because each channel will support and complement each other and this leads to higher total sales

(Kumar and Venkatesan, 2005; McKinsey, 2000). However, after customers started using the internet to purchase, this argument became weaker because the online channel may be disruptive for deep-seated channels, such as stores and catalogs (Deleersnyder et al., 2002). Ansari et al. (2008) clarify that the effect of channels on profitability depends on how customers react to the channels, including online and offline ones. Internet-loyal customers behave differently than other customers. They prefer the internet as a sales channel and spend more money online. This phenomenon is explained by loyalty to the internet as a sales channel.

3.3. Methodology

Our methodology section is following a two-step approach: (1) experimental study and (2) analytical modeling. In the first part of the methodology, we focus on the main assumption of the analytical model. We assume that once a customer adopts the mobile channel, she increases her purchasing frequency. Wang et al. (2015) show that mobile app users have a higher average order rate than non-users. However, the article points out that there may be limitations due to potential selection bias. We designed an experiment to test if a selection bias is the case. In the second part of our study, we designed an analytical model based on this assumption. In the analysis of this model, we calculate the CLV of a customer based on her discounted expected transactions (DET) and show how offering a discount (e) over the mobile app increases or does not increase the CLV. Below, we firstly present the proposed approach followed by the modeling analysis.

3.3.1. Experimental Study

Wang et al. (2015) showed that the users who adopt mobile sales channels show a significant increase in their order rate, although the average spending of each order stays the same.

However, this might be a result of users' self selection. Maybe the users of mobile sales channels have already higher order rates rather than the mere adoption of a mobile sales channel increases the order rate. The purpose of this study is to test if users who adopt mobile devices show an increase in transaction rates.

Method

One hundred forty-two students taking one or both of two courses at a European university participated in this study. Ten students were not taken into the analysis since they withdrew from the courses. Thus, 132 participants were evaluated. The courses were taught in the same semester. Course 1 started in the beginning of the semester while Course 2 started in the middle. Seventy-three participants took only Course 1, 41 participants took only Course 2, and 18 participants took both courses. In the beginning of both courses, the students were informed about nine tasks without being told that this was an experiment. The tasks included questions related to the courses. We used the same questions for both courses only by changing the theme based on the course topic. The participants of Course 1 were told that they would earn extra course credit for each task they completed on a mobile device (smartphone or tablet) and 10 % less extra course credit for each task they completed on a laptop. They were asked to take a screenshot of their work to show which device they used to complete the tasks. The participants of Course 2 were told that they would earn equal extra course credit for each task they completed. In the corresponding last week of the tasks, the participants were asked what the purpose of the study was and none of them could guess it correctly. As such, we kept all answers in the analysis. The purpose of this study is to see if encouragement to use a certain device to complete the tasks and usage of a certain device change the task participation rate. We predict that higher extra credit for Course 1 would steer the students to complete the tasks on a mobile device. Those who took both courses would continue completing the tasks on a mobile device in Course 2, although they would not earn any higher credit for this; and those who completed the tasks on a mobile device would show higher participation in the tasks.

Results

Firstly, as we assumed, the results show that students developed habitual usage of mobile devices when they got encouragement to use them, such that the students who took both courses completed the tasks in Course 2 on a mobile device (μ_{both}=0,67) at significantly higher rates than those who took only Course 2 (μ_{C2} =0,1; p<0,001). It is important to keep in mind that students were given extra course credit in Course 1 to complete the tasks on a mobile device. However, they were not given any extra course credit in Course 2. This shows that once the students started using mobile devices to complete the tasks, they kept this behavior in Course 2 as well, although they were not offered any extra credit in this course.

Secondly, the results reveal that the participation rate is higher when the students are offered extra credit to complete the tasks on a specific device. The average number of tasks the students completed in both courses are not significantly different (μ_{C1}=7,98; μ_{C2}=7,76; p=0,19). However, the average number of students who completed all the tasks in Course 1 (μ_{C1}=0,59) was significantly higher than those in Course 2 (μ_{C2}=0,42; p=0,021). We conclude that when the students were encouraged to use mobile devices to complete the tasks, they showed higher participation compared with the case when they were not given any encouragement.

Lastly, we analyzed the students in Course 2. The results showed that the students who used mobile devices to complete the tasks had a higher participation rate than those who used laptops even when there was no extra course credit for using mobile devices. We found out that although the average number of completed tasks by mobile device users and laptop users in Course 2 are not significantly different (μ_{C1}=8,06; μ_{C2}=7,65; p=0,15), the average number of mobile device users who completed all the tasks in Course 2 (μ_{C1}=0,56) was significantly higher than those who used a laptop (μ_{C2}=0,37; p=0,1). We conclude that even when there is no encouragement to use mobile devices to complete the tasks, the students who used them showed higher participation.

3.3.2. Analytical Model

Proposed Approach

Our modeling approach focuses on 1) how to calculate the CLV of a customer, 2) the idea of offering a discount to those who purchase over the mobile app, 3) which customers to target with a discount offer over the mobile app, 4) the optimal value of the discount rate, and 5) which strategy the firm should follow. Offering a discount to mobile app users may decrease the short-term profit. However, marketing managers should not only focus on the short-term profit but rather pay more attention to customer satisfaction on a long-term basis (Zhang et al., 2015). A firm should be able to create a strong relationship with its customers to increase their long-term customer value (Bucklin et al., 2002). Among other strategies, offering a discount to customers is a way to strengthen the relationship between the firm and its customers because the customers tend to increase their expected utilities (Kumar and Reinartz, 2016).

Wang et al. (2015) show that the average order rate of mobile app users is higher than non-users. Our previous experiment has shown that once a customer adopts the mobile app, she keeps using the app rather than the website. We also showed that once she adopts the mobile app, she increases her transaction probability. Our objective is to increase the CLV of the customers by increasing their purchase rates (frequency) through mobile sales channel adoption. For this purpose, we propose the idea of offering a discount to mobile app purchasers to steer them to these sales.

In the analytical model, we apply discrete time transactions to reach the discounted expected transactions (DET) (Fader et al., 2004). We calculate the CLV of a customer by multiplying the cash flow and DET. We assume that the cash flow of each transaction does not change.

Our analytical model follows with the calculation of the DET in two cases: (1) In this case a discount "e" over the mobile app is offered and (2) the discount is not offered. Then, we compare these transactions to find out in which cases it is more profitable for the firm to offer the discount. Lastly, we will show how to calculate the optimal discount level when it is optimal to offer it and how the components of the DET affect it.

In the analytical model, there are two sides: the firm and the customer. The firm is a profit maximizer. It sells its products over two sales channels: the web page and the mobile app. It chooses between the strategies of offering or not offering a discount over the mobile app. The customer simply purchases on the firm's sales channels. She has a utility from purchasing products. Hence, we assume that she may purchase on a regular basis. Her DET is equal to the summation of all her transactions. When the firm offers a discount over the mobile app, she chooses between adopting the mobile app or not. In the beginning, we assume that the customer is active and purchases over the web page and/or the mobile app. Then, the firm decides on its strategy (offers or does not offer a discount over the mobile app) as well as the discount rate (e) if it decides on offering it.

Analysis

1. Transactions when a discount "e" is not offered

In the first part, we focus on the case in which the firm has two sales channels: the website and the mobile app. The firm sells the products for the same prices over both of the channels. For example, if the price of a product X is \$Y on the website, it is \$Y on the mobile app as well. Assuming that the customer is active at the beginning of the first period, her possible purchases follow the basic structure in Table 1.

Table 1. Transaction Probabilities When a Discount "e" Is not Offered

Period	1	2	3	...	n	...
$p(active)$	1	q	q^2	...	q^{n-1}	...
$p(web/active)$	p^W	p^W	p^W	...	p^W	...
$p(app/active)$	P^M	p^M	p^M	...	p^M	...
Interest	1	$(1+d)$	$(1+d)^2$	...	$(1+d)^{n-1}$	...

In this structure, we assume that an active customer in period n will stay active at the beginning of period $n+1$ with a probability of q. The probability of being active (q) has been studied in depth by researchers before. For this reason and to avoid making the model more complicated, we take q as an exogenous variable. The customer purchases over the website with a probability of p^W and over the app with a probability of p^M on any period ($0<p^W$, $p^M<1$). It is important to note that when a customer purchases over the app, it does not mean that she has adopted it as long as she purchases over the website as well. We do not take into account that a customer makes purchases over both of the channels in the same period because this case is very uncommon in real life. Purchasing over the website and the app are mutually exclusive. An interest rate d exists. Customer channel adoption is not relevant in this case.

We calculate the DET by summing the transactions over an infinite time period by applying the sum of an infinite geometric series:

$$\overline{DET} = \sum_{t=0}^{\infty}(p^W + p^M)(\tfrac{q}{1+d})^{t-1} = \tfrac{(p^W+p^M)(1+d)}{1+d-q}$$

We can easily see that the customers who have higher p^W, p^M, and q have a higher DET. It means that the customers who purchase more over the web page and/or mobile app as well as more active customers have a higher DET.

2. Transactions when a discount "e" is offered

In the second part of the analytical model, we focus on the case that the firm has two sales channels: the website and the mobile app. The firm offers a discount e when the customer purchases over the mobile app. For example, if the price of a product X is \$Y on the website, it is \$Y(1-e) on the mobile app (e.g. a 10% discount). Assuming that the customer is active in the beginning of the first period, her possible purchases follow the basic structure in Table 2.

Table 2. Transaction Probabilities When a Discount "e" Is Offered

Period	1	2	3	...	n	...
$p(active)$	1	q	q^2	...	q^{n-1}	...
$p(adopted/active)$	0	1-α	1-α^2	...	1-α^{n-1}	...
$p(web/active, nonadp)$	p^W	p^W	p^W	...	p^W	...
$p(web/active, adp)$	-	0	0	...	0	...
$p(app/active, nonadp)$	p^M	p^M	p^M	...	p^M	...
$p(app/active, adp)$	$\overline{p}$	$\overline{p}$	$\overline{p}$	...	$\overline{p}$	...
Interest	1	$(1+d)$	$(1+d)^2$	...	$(1+d)^{n-1}$	...

e is a permanent discount rate over the mobile app. The discount plays a role in steering the customers to use the mobile app on a regular basis. When the customers use only the app for their purchases, it means that they have adopted it. It is important to note that the discount does not guarantee mobile channel adoption for all the customers sooner or later. Some customers may prefer to keep using the website because they may not have a smartphone or they simply may not like purchasing over a smartphone. A non-adopted customer at period "n" will stay non-adopted at the beginning of period "n+1" with a probability of α. As long as a customer does not adopt the mobile sales channel, she could make her purchase over both of the channels. The purchasing probabilities over the website and mobile app are p^W and p^M respectively before adoption. These probabilities are mutually exclusive as in the first part of the analytical model. However, once a customer has adopted the mobile app, she purchases only through it. It means that the probability that an adopted customer purchases a product over the website is 0. In this case, the customer purchases over the mobile app with a probability of $\overline{p}$. We assume that a customer's probability of purchasing after adoption ($\overline{p}$) increases correlated with the discount rate (e) as well as a constant h. The constant exists to capture how well the customer increases her probability of purchasing after the mobile app adoption. When the h value of a customer is high, she increases her purchasing probability highly once she adopts the mobile app. When the h value of a customer is low, the increase in her purchasing probability is low as well. It is important to note here that no matter how high the h value is, the probability of purchasing after adoption ($\overline{p}$) cannot exceed 1 ($0<\overline{p}<1$). Overall, the purchasing probability after adoption ($\overline{p}$) is higher than the summation of the purchasing probabilities over the web page and the mobile app before the adoption ($p^W + p^M$). The difference increases with a higher discount rate as well as the customer-specific h value which shows how well a customer increases her purchasing probability after her adoption of the mobile app.

$$\overline{p}=p^W + p^M + he(1 - p^W - p^M)$$

An interest rate d exists.

The summation of these transactions gives us the discounted expected transactions ("DET"). The calculation of the summation is different than in the previous case since a customer cannot adopt the mobile app in the first period without experiencing the mobile sales channel discount offer. The transactions for the periods are as follows:

[1] $p^W + p^M(1 - e)$

[2] $[\alpha(p^W + p^M(1 - e)) + (1 - \alpha)(p^w + p^m + he(1 - p^w - p^m))(1 - e)](\frac{1}{1+d})$

.

.

.

[n] $[\alpha^{n-1}(p^w + p^m(1 - e)) + (1 - \alpha^{n-1})(p^W + p^M + he(1 - p^W - p^M))(1 - e)](\frac{1}{1+d})^{n-1}$

The summation of the transactions over the customer's life time is as follows:

$$\text{DET}= \frac{q(1-e)(p^W+p^M+he(1-p^W-p^M))}{1+d-q}+\frac{(1+d)(p^W-(1-e)(he(1-p^W-p^M)+p^W))}{1+d-\alpha q}$$

The optimal discount rate (e^*) is given by

$$\mathrm{e}^* = \frac{h+1}{2h}+\frac{d^2-1}{2q}+\frac{(1-\alpha)(d^2-1)}{2(\alpha q-d-1)}+\frac{1}{2h(p^W+p^M-1)}.$$

The firm offers a discount over the app when the customer tends to increase her purchasing probability after her adoption. We measure this with the variable h. We need to limit this variable $\frac{q(\alpha q-d-1)(p^W+p^M)}{((d-1)(d+1)^2-d(d+1)q-\alpha q^2)(p^W+p^M-1)} > h > \frac{q(\alpha q-d-1)(p^W+p^M)}{((d-1)(d+1)^2-(d-2)(d+1)q-\alpha q^2)(p^W+p^M-1)}$ as the regularity condition to ensure that e^* takes a value between 0 and 1.

Lemma 8. *(i) When the discount effect on the purchasing probability increases, the firm offers a higher discount rate.*
(ii) When the customer is more active, the firm offers a higher discount rate.
(iii) When the probability that the customer adopts the app increases, the firm offers a higher discount rate.
(iv) When the customer already purchases on the web and app with a high probability, the firm offers a lower discount rate.

Proof. See Appendix.

Lemma 8 states several results. The e^* value increases when the h value increases. If the firm sees that the customer increases her purchasing probability when a discount rate exists over a certain sales channel, it offers a higher discount rate over this channel. Similarly, the firm offers a higher discount rate to more active customers. These customers are more loyal to the firm and they will continue purchasing from the firm in the future. We can already see that the CLV of these customers is higher and the firm can increase this value by offering a higher discount rate to these customers. The firm offers a higher discount rate to those who adopt the mobile app with a higher probability. When the adoption probability is lower, the customer keeps purchasing from the less preferred sales channel (website) through which the firm offers her a lower discount rate. Lastly, the firm offers a lower discount rate to those who already purchase with a high probability. These customers already have a high CLV which means that the firm does not profit by offering a discount to them.

Proposition 7. *The problem has a unique solution when a discount over the mobile app is offered at e^* and this implies that the optimal DET of a customer is*

$$DET^* = \frac{1}{4q(1+d-\alpha q)^2}\left(\frac{K}{h(1+d-q)(1-p^W-p^M)} + L\right)$$

where

$$K = (q(1+d-\alpha q)((p^W+p^M)(1-h)+h))^2 - (h(1-d^2)(1+d-q)(1-p^W-p^M))^2$$

$$L = 2(1+d)(q(1+d-\alpha q)(p^W(1+d)+p^M(1-d)) + h(1-p^W-p^M)(d-1)((d-1)(d+1)^2 - q(d-2)(d+1) - \alpha q^2)).$$

Proof. See Appendix.

There are several results we take from Proposition 7. First of all, it is important to point out that there is non-monotonicity in the relationship between the optimal DET value and the probabilities that the customer purchases over the web page and the app before the adoption. This situation is caused by different reasons in the different values of these probabilities. Consider the cases that these probabilities are very small and very large. When the purchasing probabilities over the web page and the app before adoption are small, it means that the customer is unlikely to make purchases before she is offered a discount rate over the app. In this case, the firm is less likely to offer a discount rate because it loses profit coming from her when it offers a discount. In this region, sales are profitable. On the other edge of the region, when the purchasing probabilities over the web page and the app before adoption are high, the sales become profitable again for all h values. The customer is profitable to the firm. Even if she does not increase her purchasing rate after a discount offer, she is still profitable to the firm. On the other hand, when these probabilities increase and take moderate values, the sales become nonprofitable if the h value is low. In this region, the customer is still unlikely to make purchases, and offering a discount to her only decreases the profit because the discount does not increase her purchasing probability. The firm discontinues sales to this customer under this strategy because it is nonprofitable. The sales are still profitable in this region when the h value is high because the firm knows that the customer increases her purchasing rate when she is offered a discount. We conclude that the optimal DET value takes a U-shaped curve and takes its lowest value for the moderate p^W and p^M values. This case underlines the idea that the firm does not offer a discount rate to the customer who purchases over the mobile app when she purchases over the existing channel with moderate probabilities before adoption. Such a customer is not likely to increase her purchasing rate after she is offered a discount.

Another important point is the relationship between the optimal DET and how the customer is affected by the discount offer. We measure this value with h. The following lemma presents how h changes the optimal DET.

Lemma 9. *When all the other variables are constant,*

(i) When $h > \frac{q(1+d-\alpha q)(p^W+p^M)}{\sqrt{(\alpha q^2+(d-2)(d+1)q-(d-1)(d+1)^2)^2(p^W+p^M-1)^2}}$*, the higher h is, the higher DET is.*

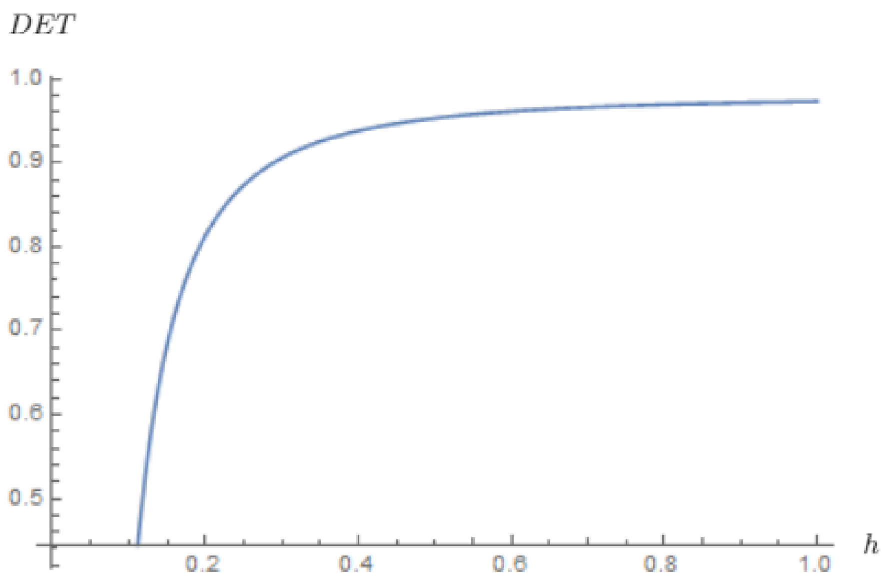
(ii) When $h < \frac{q(\alpha q-d-1)(p^W+p^M)}{\sqrt{(\alpha q^2+(d-2)(d+1)q-(d-1)(d+1)^2)^2(p^W+p^M-1)^2}}$*, the higher h is, the higher DET is.*

(iii) When $\frac{q(\alpha q-d-1)(p^W+p^M)}{\sqrt{(\alpha q^2+(d-2)(d+1)q-(d-1)(d+1)^2)^2(p^W+p^M-1)^2}} < h < \frac{q(1+d-\alpha q)(p^W+p^M)}{\sqrt{(\alpha q^2+(d-2)(d+1)q-(d-1)(d+1)^2)^2(p^W+p^M-1)^2}}$*, the higher h is, the lower DET is.*

Proof. See Appendix.

Lemma 9 states that there is a non-monotonicity between the h value and the optimal DET

value. Consider the extreme cases. When the customer is unlikely to be affected by the discount rate or when she is very likely to be affected by it, her DET increases with higher effect (higher h values). In these cases, the increased purchasing probability effect is larger than the profit lost coming from the discount. On the other hand, for the moderate values of h, higher h values decrease the optimal DET because the firm loses out of the discount more than it earns from the higher purchasing probability. Figure 4 shows how higher h values increase the DET for some small values of the other variables.



In this plot: $\alpha = 0.1$, $d = 0.1$, $q = 0.1$, $p^W = p^M = 0.2$

Figure 4. Optimal Discounted Expected Transactions based on h

So far, we have discussed the cases in which the firm does not offer a discount over any sales channel and the firm offers a discount rate over the mobile app. We have analyzed this case and found the optimal discount rate and the optimal DET accordingly. From now on, we will analyze the optimal strategy for the firm to follow. It makes a decision based on the customer's characteristics. This decision has to be made on the individual customer level. The firm may offer a discount to one customer while it does not offer it to another one. The optimal discount rate is also customer-specific. Now, we will focus on how customer characteristics, such as the discount effect on her and the probability of mobile app adoption, change the strategy the firm follows. It is important to remember that the firm loses profit when it offers a discount. The main point here is increasing the CLV of a customer in the long term. However, the increase in CLV may not always be enough to compensate for the profit loss. This is why the firm should make its decision carefully, considering the characteristics of a customer.

As we explained above, the variable h shows how a customer is affected by a discount offer, in other words, how she changes her probability of purchase after the discount offer. As expected, this characteristic of a customer has an important impact on the firm's discount offer decision. The following lemma presents it.

Lemma 10. *When all the other variables are constant,*

(i) When $h > \frac{M+2\sqrt{N}}{O}$[9][10][11]*, the firm offers a discount over the mobile app channel to the customer.*

(ii) When $h < \frac{M-2\sqrt{N}}{O}$*, the firm offers a discount over the mobile app channel to the customer.*

(iii) When $\frac{M-2\sqrt{N}}{O} < h < \frac{M+2\sqrt{N}}{O}$*, the firm does not offer a discount over the mobile app channel to the customer.*

Proof. See Appendix.

Lemma 10 is an important one for the firm to understand which strategy it should follow for a customer based on how much her purchasing probability is affected by a discount offer over the mobile app. When a customer's h value is low, it means that she does not increase

[9] $M = q(\alpha q - d - 1)(p^W + p^M - 1)(p^W(\alpha q^2 + (d+1)(d-2\alpha)q - (d-1)(d+1)^2 + ((d+1)^3 - (d+1)(d+2\alpha)q + \alpha q^2)p^M$

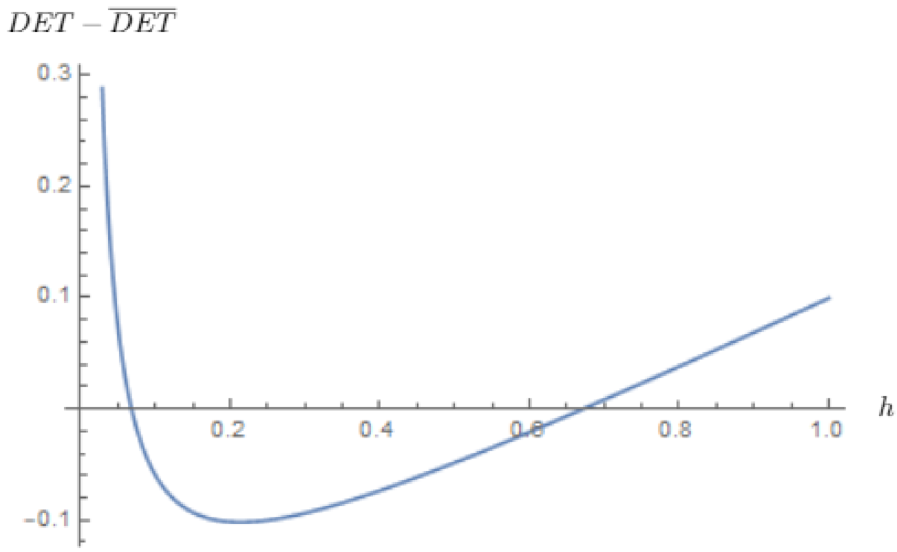
[10] $N = (1+d)(1+d-q)q^2(1+d-\alpha q^2)(p^W + p^M - 1)^2((\alpha-1)p^W q - dp^M(1+d) + (\alpha+d-1)p^M q)(p^W(\alpha q + d^2 - 1) - (1+d-\alpha q)p'$

[11] $O = (\alpha q^2 + (d-2)(d+1)q - (d-1)(d+1)^2(p^W + p^M - 1)^2)$

her purchasing probability after adopting the mobile channel. When this value is high, she increases the probability highly. There is non-monotonicity in this relationship. The firm follows the strategy that it offers a discount to the customer over the mobile app when her probability of purchasing is affected by this offer to a very high or low extent. For the moderate values of h, the firm does not offer a discount over the mobile app. It is important to remember that the optimal discount rate (e^*) is small for the small h values. Hence, when the customer does not increase her purchasing probability with a discount offer (small h), the gain coming from the higher purchasing probability is greater than the loss coming from the discount. For the region in which h is large, the customer will increase her purchasing probability to a high extent. In this case, the profit increase will be high, and it will be bigger than the profit loss from the discount. On the other hand, for the moderate values of h, although the customer increases her purchasing probability when she adopts the use of the mobile app, the increase is not enough to cover the profit loss coming from the discount. This is why the firm does not offer a discount to the customers who are moderately affected by the discount. Figure 5 shows how h changes the firm's decision. In the graph, the firm offers a discount to the customer for the positive values of (DET-$\overline{DET}$) and does not offer a discount to the customer for the negative values of (DET-$\overline{DET}$) for given values of all the other variables.

Another characteristic of a customer which is very important for the firm's decision is the probability of a customer not adopting the mobile app channel (α). The firm is more likely to offer a discount over the mobile app when the α value of a customer increases. This means that when a customer is unlikely to adopt the mobile app (with a low probability), in other words, when a customer insists on staying on the web page channel, the firm is more likely to offer a discount to her to encourage her to switch to the mobile channel.

After focusing on the characteristics of a customer, we now investigate how the current purchasing habits of a customer (before adoption of the mobile app) change the firm's strategy. We check the p^W and p^M values of a customer to understand her current purchasing prob-



In this plot: $\alpha = 0.1$, $d = 0.1$, $q = 0.2$, $p^W = p^M = 0.2$

Figure 5. Optimal Strategy The Firm Follows based on h

ability. She purchases with a higher probability for the higher values of p^W and p^M. The firm prefers not to offer a discount over the mobile app to customers with high purchasing probabilities. It is important to remember that the firm offers the discount to increase the customer's CLV. However, when the customer already purchases with a high probability, we conclude that her CLV is already high. The customer is already highly profitable to the firm. Offering a discount to her brings nothing but loss of profit to the firm. For the high values of p^W and p^M, the firm does not offer a discount. On the other hand, when the current probability of a customer is low, the firm makes its decision based on the h value of the customer. When the h value is high, it means that the customer will increase her low probability of purchase to a high extent. In this case, the firm offers a discount over the mobile app to her. The less profitable customer increases her purchasing probability. As a result, she increases her CLV. However, when her h value is low, the firm knows that the customer will not increase her purchasing probability very much. Since her CLV will not increase, the firm does not offer a discount over the mobile app to her.

Last but not least, the probability of a customer being active (q) is an important aspect of the firm's decision. The reason this aspect is especially important to the firm is that the firm should know if it can use the discount strategy for both new and existing customers. The results show that the firm is less likely to offer a discount over the mobile app to customers with lower q values, in other words, less active customers. However, the firm is more likely to offer the discount to active customers. It would not be wrong to assume that active customers are existing ones while less/non-active customers are new or leaving/left ones. Hence, we can conclude that the firm applies this strategy to increase the existing customers' CLV. However, it may not be the best decision to apply this strategy to increase customer acquisition. It can be assumed that many customers will purchase from this firm to take advantage of the discount when the firm uses this strategy to attract new customers. As a result, we recommend that the firm should offer a discount over the mobile app to increase customer retention, hence the CLV of a customer, while it should not use this strategy to increase customer acquisition.

3.4. Discussion

The introduction of mobile devices has a significant impact on the retail industry. These devices have become an important part of customers' daily lives. Scholars have observed that people develop habitual behaviors with mobile devices caused by higher customer engagement and adoption. This habitual effect leads to higher transaction rates. In this article, we have presented the strategy that firms offer a discount over the mobile apps to steer customers to this channel. The logic behind this strategy is that once the customers adopt the mobile channel, their CLV increases. Although the firm loses some of its profit in the short term because of the discount, it increases its profit in the long run because of the customers' higher transaction rates, in other words, their CLVs.

We have included two studies in this article: an experimental and a modeling one. In the experimental part, we have shown two important aspects. First of all, once the customers adopt the mobile channel, they keep using that. Secondly, those who adopt the mobile channel have higher average transaction rates compared to those who use fixed devices. These results are consistent with the existing literature.

In the second part of the methodology, we have developed an analytical model to analyze to which customers the firm offers a discount via the mobile app. Furthermore, we evaluate the optimal value of this discount. We found three important aspects. Firstly, the firm does not offer a discount over the mobile app to those who already have high purchasing probabilities over the website and mobile app. For those customers, there is not much room to increase the purchasing probability. It is important to remember that the firm follows this strategy to increase its long-term profit. However, if the customer is already profitable to the firm, it does not lose some of its profit by offering a discount to this customer. Secondly, the firm should observe how a discount offer changes the customer's purchasing behavior. If the increase in the purchasing probability is not big enough to surpass the profit loss, the firm does not follow this strategy. This is the case for the intermediate effect of the discount. The firm offers a discount to those who are unlikely or very likely to increase their purchasing probabilities. Last but not least, the firm does not follow this strategy to increase its customer acquisition. The strategy works best on existing and active customers.

Our findings are informative for managers. This article presents a strategy to increase a firm's long-term profit. It clearly shows that this strategy is not a good one for customer acquisition. This is why it is not a good idea to try to attract someone who is not a customer by offering her a discount on the mobile app. The same is true for a strategy such as "shipping is free on mobile." The main takeaway for managers is that although this strategy increases the CLV of some customer types, certainly one discount does not fit all.

3.4.1. Limitations and Future Work

Our experiment and model have some limitations. First of all, it is important to note that we held our experiment at a university. Our participants are in their early twenties. Younger people adopt new technologies more easily compared to older people. Hence, we should investigate if age has any effect on mobile channel adoption.

In our model, we assume that installing the online retailer's mobile app has no disutility. However, customers spend some time, and possibly money, on downloading and installing apps. Moreover, many users delete apps after a short time. In our model, we assume that the user already has the mobile app in her mobile device, and she does not delete it until she leaves the firm. Another assumption we made is about a customer purchasing over the website and mobile app in the same period. We ignored this probability because it is very small. Hence, we included mutually exclusive purchasing probabilities over the sales channels. Lastly, we included the assumption that customers use their fixed devices to access the online retailer's website. However, it is possible to access the web pages over mobile devices. We ignored those who purchase over the website using mobile devices since the proportion of these customers is small (Econsultancy, 2018). That is why we only focus on the website on fixed devices and apps on mobile devices.

Besides the experimental and modeling limitations, there are possible extensions for future research. We analyzed this model for the online retailers that sell consumer goods over a website and a mobile app. We suggest extending this work to examine other retailers that sell other types of products, such as luxury goods and also services. Another interesting aspect to focus is sales channels. Our work focuses on online and mobile channels. Does this model work for offline channels as well? Do customers develop habitual behaviors when it comes to other channels? What happens when there are more than two sales channels? Future studies should focus on these questions to better understand how this phenomenon works.

4. General Conclusion

This dissertation investigates answers to two important issues arising in digital marketing: (1) publisher strategies against ad-blockers and (2) price discrimination through online and mobile sales channels. The first essay covers the first topic while the second essay covers the second topic.

The first essay, co-authored with Florian Kraus and Pinar Yildirim, titled "Ad-blockers and Content Differentiation," analyzes a series of analytical models exploring the two most common strategies publishers follow against ad-blockers. Although scholars have investigated ad-aversion for several decades, ad-blockers have been understudied. To the best of our knowledge, our study is one of few studies that work on ad-blockers as they apply to analytical modeling. As an addition to the existing literature, we have included content differentiation, a subscription option, and competition in our analysis. Our findings focus on monopolistic and duopolistic markets. The results in the monopolistic market are fairly straightforward. The optimal strategy a monopolistic publisher follows against ad-blockers depends on the publisher's content production cost. When the cost is low, the publisher does not offer a subscription option to the user whereas when the content production is costly, the publisher offers a subscription option. Finally, when content production is too costly, the publisher does not produce any content since it is unprofitable.

We have more insightful results in the duopolistic market. We have analyzed the markets where duopolistic publishers follow symmetric and asymmetric strategies and found out that the optimal solution is always in one of the symmetric cases. A duopolistic publisher's strategy against ad-blockers depends on the content production cost and content differentiation. In the case where both publishers follow the content wall strategy, higher content differentiation decreases the content quality. Hence, fewer users consume the content and content production becomes less costly. Although ad revenue decreases, the publisher's profit increases. Secondly, a higher content production cost decreases the content quality. As a result of this, fewer users consume the content. A higher content production cost makes content production more costly. In addition, ad revenue decreases, and the publisher's profit decreases. When content production cost is too high, content production is nonprofitable, and the publisher does not produce any content. In the case where both publishers follow the pay to avoid strategy, one publisher decreases its content quality as well as subscription fee when content differentiation is high. Its expenses decrease, and as a result, the total profit increases. When content production cost increases, the publisher decreases its content quality as well as the subscription fee. As a result of higher expenses, its total profit decreases.

We also show the optimal strategy publishers follow based on content production cost and content differentiation. When the content is differentiated and less costly to produce, the publisher follows the content wall strategy and does not offer a subscription option. In all other cases, the publisher follows the pay to avoid strategy and offers a subscription option. When content production is too costly, content production becomes nonprofitable. The threshold decreases when the content is more substitutable. Hence, while it is profitable to produce content for a publisher that focuses on specific content, it is nonprofitable to produce content for a publisher that concentrates on general topics.

Next, we analyzed the competition effect on market size, content quality, and subscription fee. When there is competition in the market, the total market size and advertising market size increase while the subscription market size depends on content differentiation. The existence of competition in the market decreases the content quality when the content is less costly to produce and highly substitutable. In all other cases, competition increases the content quality. The subscription fee decreases with competition.

Finally, we analyzed the case in which the ad-giver is a decision maker and the number of ads is an exogenous variable in monopolistic markets. In this case, when the publisher follows the content wall strategy, fewer users turn the ad-blockers off when the users are ad-averse.

In this case, the publisher either increases its content quality or decreases the number of ads to keep its users. When the publisher follows the pay to avoid strategy, higher ad-seeing disutility does not necessarily decrease the number of users who turn the ad-blockers off. The optimal strategy the publisher follows depends on the content production cost and user ad-seeing disutility. When the content production cost is high, the publisher always follows the pay to avoid strategy. When the content production cost is low, the publisher follows the content wall strategy when user ad-aversion takes an average value while the publisher follows the pay to avoid strategy when user ad-aversion takes a high or low value.

The second essay, co-authored with Florian Kraus, titled "Maximizing Customer Lifetime Value through Strategic Channel Management: How to Incentivize Customers to Use a Mobile App versus a Website," analyzes a series of analytical models to answer these questions: (1) To what type of customers should a discount be offered when purchases are conducted over mobile apps? (2) What is the optimal discount rate that should be offered? To answer these questions, we have designed and run experimental studies. We also developed probability-based analytical models and analyzed them to maximize the customer lifetime value of customers in a market where online and mobile sales channels exist. Experimental results show that when people start using mobile devices to complete a series of tasks, mobile device usage becomes a habit. Secondly, when people get incentives to use mobile devices to complete the tasks, they show higher participation on average.

We also have insightful results from analyzing the analytical models. At first, we derived results on the optimal value of the discount rate. The online retailer offers a higher discount rate when the customer reacts more to the rate, when the customer is more likely an active customer, when the customer adopts the mobile channel more, and when the customer's current purchasing rate is low. Secondly, we focused on the cases in which the retailer offers a discount over the mobile channel to the customers. When the customer's purchasing probability is low, the retailer does not offer a discount over the mobile channel because it only decreases the profit since these customers are unlikely to increase their purchasing rates. When the probability is very high, the retailer again does not offer a discount to the customer over the mobile page because the customer is already very profitable and offering a discount only decreases the profit. However, when the customer's previous purchasing rate is moderate, the retailer makes a decision based on how likely the customer will increase her purchasing probability after getting offered a discount. If the increase in profit is not high enough to cover the loss due to the discount, the retailer does not offer a discount. The retailer offers a discount only if the customer is unlikely or very likely to increase her purchasing rate. We conclude that this strategy increases the profit for customer retention. However, it does not increase the profit with customer acquisition because it is very likely that non-customers use the discount for one time and do not stay at the company long-term. Our study is the first that analyzes price discrimination strategies in a multi-channel environment where the retailer steers the customers to a more profitable channel.

Appendix. Proofs

Proof of Lemma 1:

In this strategy, the publisher offers only one option, namely, that the user gets access to the content only when she turns ad-blockers off. The publisher maximizes its total profit of $(v - \alpha\delta y)yq - cv^2$ where it decides on the content quality v. We find the optimal content quality (v^*) by differentiating the profit function with respect to v, setting the derivative to 0, and solving for v^*.

The value of v^* is equal to $\frac{qy}{2c}$. There is only one solution to this derivation. Hence, v^* can take only this value. We substitute it into the profit function and show that $\pi_{S1}^{M*} = \frac{(q-4c\alpha\delta)qy^2}{4c}$. Since v^* can take only the value given above, the profit function can take only this value.

Proof of Lemma 2:

In this strategy, the publisher offers an ad-free subscription option along with the other option given above. It maximizes its total profit of $(v-p)p+(p-\alpha\delta y)yq-cv^2$ where it decides on its content quality v and subscription fee p. Differentiating the profit function with respect to p, setting the derivative to 0, and solving for p^*, we get $p^* = \frac{v+yq}{2}$. Differentiating the profit function with respect to v, setting the derivative to 0, and solving for v^*, we get $v^* = \frac{p}{2c}$. Substituting the first result into the second one, we get that $v^* = \frac{yq}{4c-1}$ and $p^* = \frac{2cyq}{4c-1}$. There are only single solutions for v^* and p^*.

We substitute the optimal content quality and subscription fee values into the profit function and get that $\pi_{S2}^{M*} = \frac{((1-4c)\alpha\delta+cq)qy^2}{4c-1}$.

Proof of Proposition 1:

Using the optimal profits under each strategy drafted above, we find out the optimal strategy a monopolistic publisher follows in this proposition. Let $\Delta\pi = \pi_{S2}^{M*} - \pi_{S1}^{M*}$ where $\Delta\pi = \frac{(1-2c)^2 q^2 y^2}{4c(4c-1)}$. The publisher follows Strategy 2 when $\Delta\pi > 0$ and Strategy 1 when $\Delta\pi < 0$.

When we set $\Delta\pi$ to 0, there are two solutions for c and both solutions go to 0 ($c \rightarrow \frac{1}{2}$). Hence, when $c < 0$, the publisher follows the content wall strategy which proves (i).

We set the optimal profit functions for each case to 0, to find out the interval where the publisher's content production is nonprofitable. A publisher that follows Strategy 1 does not produce content when $c > \frac{q}{4\alpha\delta}$, and a publisher that follows Strategy 2 does not produce content when $c > \frac{\alpha\delta}{4\alpha\delta - q}$.

Our assumption that $q > 2\alpha\delta$ ensures that the publisher produces content when it follows Strategy 2 as well. Due to this assumption, the restriction on π_{S1}^{M*} is out of interest because the publisher follows Strategy 2 in the range that $c > \frac{1}{2}$. Hence, the publisher follows the pay to avoid strategy when $\frac{\alpha\delta}{4\alpha\delta - q} > c > \frac{1}{2}$ and does not produce content when $\frac{\alpha\delta}{4\alpha\delta - q} < c$, which proves (ii) and (iii).

Proof of Lemma 3:

Publisher i maximizes its total profit of $\frac{1}{(1-\phi^2)}((v_i - \phi v_{i'}) + (\phi - 1)\alpha\delta y)yq - cv_i^2$ where it decides on the content quality v_i. We find the optimal content quality (v_i^*) by differentiating the profit function with respect to v_i, setting the derivative to 0, and solving for v_i^*. We derive the optimal value of content quality such that $v_1^* = v_2^* = \frac{qy}{2c(1-\phi^2)}$. We substitute the v_i value into π_i and show that $\pi_{i,S1}^{D*} = \frac{(q(1-2\phi) - 4c(1-\phi^2)(1+\phi)\alpha\delta)qy^2}{4c(1-\phi^2)^2}$.

Proof of Lemma 4:

Publisher i maximizes its total profit of $\frac{1}{(1-\phi^2)}(v_i - p_i - \phi(v_{i'} - p_{i'}))p_i + \frac{1}{(1-\phi^2)}(p_i - \phi p_{i'} + (\phi-1)\alpha\delta y)yq - cv_i^2$ where it decides on its content quality v_i and subscription fee p_i.

Differentiating the profit function with respect to p_i, setting the derivative to 0, and solving for p_i^*, we get $p_1^* = \frac{v_1 - \phi v_2 + \phi p_2 + yq}{2(1-\phi^2)}$. Differentiating the profit function with respect to v_i, setting the derivative to 0, and solving for v_i^*, we get $v_1^* = \frac{p_1}{2c(1-\phi^2)}$. Substituting the second result into the first one, we get that $p_1^* = \frac{p_2(\phi - 2\phi(1-\phi^2)c) + 2cyq(1-\phi^2)}{1-4c(1-\phi^2)^2}$. Hence, we show that $p_{1,S2}^{D*} = p_{2,S2}^{D*} = \frac{2qyc(1+\phi)}{2c(2-\phi)(\phi+1)-1}$ and $v_{1,S2}^{D*} = v_{2,S2}^{D*} = \frac{qy}{(\phi-1)(1+2c(\phi^2-\phi-2))}$.

We substitute the optimal content quality and subscription fee values into the profit function and get that $\pi_{i,S2}^{D*} = -qy^2\left(\frac{cq(4c(\phi-1)^3(\phi+1)+2\phi(\phi-1)+1)}{(\phi-1)^2(2c(\phi-2)(\phi+1)+1)^2} + \frac{\alpha\delta}{\phi+1}\right)$.

Proof of Proposition 2:

The proof is straightforward. We take the derivatives of v and p values under each strategy.

$\frac{\partial v_{S1}^{D*}}{\partial \phi} = \frac{qy\phi}{c(\phi^2-1)^2}$. This value is always positive.

$\frac{\partial v_{S2}^{D*}}{\partial \phi} = \frac{c(2+8\phi-6\phi^2)-1)qy}{(\phi-1)^2(1+2c(\phi-2)(\phi+1))^2}$. This value is always positive.

$\frac{\partial p_{S2}^{D*}}{\partial \phi} = \frac{2c(-2c(1+\phi)^2-1)qy}{(1+2c(\phi-2)(\phi+1))^2}$. This value is always positive, which proves (i).

$\frac{\partial v_{S1}^{D*}}{\partial c} = \frac{qy}{2c^2(\phi^2-1)}$. This value is always negative.

$\frac{\partial v_{S2}^{D*}}{\partial c} = -\frac{2qy(\phi-2)(\phi+1)}{(\phi-1)(1+2c(\phi-2)(\phi+1))^2}$. This value is always negative.

$\frac{\partial p_{S2}^{D*}}{\partial c} = -\frac{2qy(\phi+1)}{(1+2c(\phi-2)(\phi+1))^2}$. This value is always negative, which proves (ii).

Proof of Lemma 5:

In the asymmetric case, publishers follow different strategies. They make their decisions sequentially. Publisher 1 follows the content wall strategy where it does not offer the subscription option, and Publisher 2 follows the pay to avoid strategy where it offers the subscription option. Publisher 1 decides on its content quality v_1^{A*} without knowing Publisher 2's content quality. We take it as a constant ($v_2^A = \overline{v}$) at first. Next, Publisher 2 decides on its content quality v_2^{A*} and subscription fee p_2^{A*}. Publisher 1 maximizes its total profit of $\frac{1}{(1-\phi^2)}((v_i - \phi v_{i'}) + (\phi - 1)\alpha\delta y)yq - cv_i^2$ where it decides on the content quality v_1^{A*}. We find the optimal content quality (v_1^{A*}) by differentiating the profit function with respect to v_1^{A*}, setting the derivative to 0, and solving for v_1^{A*}. We derive the optimal value of content quality that $v_1^{A*} = \frac{qy}{2c(1-\phi^2)}$. We substitute the v_1^{A*} value into π_i and show that

$$\pi_1^{A*} = \frac{qy^2(4c(4c-1)\delta(\phi-1)^2 + 4cq(2\phi^2 + \phi - 1 - \phi^3))}{4c(1-4c)(\phi^2-1)^2}.$$

Publisher 2 maximizes its total profit of $\frac{1}{(1-\phi^2)}(v_i - p_i - \phi v_{i'})p_i + \frac{1}{(1-\phi^2)}(p_i + (\phi-1)\alpha\delta y)yq - cv_i^2$ where it decides on the content quality v_2^{A*} and subscription fee p_2^{A*}.

Differentiating the profit function with respect to p_2^A, setting the derivative to 0, and solving for p_2^A, we get $\frac{1}{4}\left(2v_2^A + qy\left(2 + \frac{\phi}{c(\phi^2-1)}\right)\right)$. Differentiating the profit function with respect to v_2^A, setting the derivative to 0, and solving for v_2^A, we get $-\frac{p_2^A}{2c(\phi^2-1)}$. Substituting the second result into the first one, we get that $p_2^A = \frac{qy(\phi+2c(\phi^2-1))-p_2^A}{4c(\phi^2-1)}$. Hence, we show that $p^{A*} = \frac{yq(2c(\phi^2-1)-\phi)}{(\phi^2-1)(4c-1)}$ and $v_2^{A*} = \frac{yq(2\phi+1-\phi^2)}{(1-\phi^2)(4c-1)}$.

We substitute the optimal content quality and subscription fee values into the profit function and get that $\pi_2^{A*} = \frac{qy^2(q(\phi+2c^2(\phi^2-1)^2-2c\phi(\phi(\phi-2)+2))-2c(4c-1)\delta(\phi-1)^2(\phi+1))}{2c(4c-1)(\phi^2-1)^2}$.

Proof of Proposition 3:

Using the optimal profits under each strategy drafted above, we find out the optimal strategy a duopolistic publisher follows in this proposition. Let $\Delta\pi = \pi_i^{D*}{}_{S2} - \pi_i^{D*}{}_{S1}$ where $\Delta\pi = qy^2\left(-\frac{\alpha\delta}{1+\phi} - \frac{cq(1+2(\phi-1)\phi+4c(\phi-1)^3(\phi+1))}{(\phi-1)^2(1+2c(\phi-2)(\phi+1))^2}\right) + \frac{qy^2(q(2\phi-1)-4c\alpha\delta(\phi-1)(\phi+1)^2)}{4c(\phi^2-1)^2}$. The publisher follows Strategy 2 when $\Delta\pi > 0$ and Strategy 1 when $\Delta\pi < 0$.

Assume that the contents are purely differentiated ($\phi = 0$).

$$\Delta\pi \xrightarrow{\phi\to 0} -qy^2\left(\frac{cq}{1-4c} + \alpha\delta\right) - \frac{(q-4c\alpha\delta)qy^2}{4c}$$

There are two solutions for c, and both solutions go to $\frac{1}{2}$. This shows that when $c > \frac{1}{2}$, the publisher follows the pay to avoid strategy as long as it is profitable to produce content. To find out what happens in the case that $c < \frac{1}{2}$, we check the value of $-\Delta\pi$. This function decreases with ϕ.

$\frac{\partial(-\Delta\pi)}{\partial\phi} = \frac{q\left(qy^2(1-\phi(3\phi-2)) - \frac{4c^2(\phi+1)^3(\phi+2c(1+4c(\phi-1)^3(\phi^3+1)+\phi(-5+\phi(3+\phi(2\phi-3)))))}{(1+2c(\phi-2)(\phi+1))^3}\right)}{2c(\phi^2-1)^3} < 0$, which proves (i).

We set the optimal profit functions for each case to 0 to find out the interval where the publisher's content production is nonprofitable. A publisher that follows Strategy 1 does not produce content when $c > \frac{q(2\phi-1)}{4\alpha\delta(\phi-1)(\phi+1)^2}$, and a publisher that follows Strategy 2 does not produce content when $c > \frac{K+L}{M}$.

Our assumption that $\alpha < -\frac{q(5+q+2\phi^2(q+3)-2\phi(5+q))}{4\delta(\phi-1(6-2q^2+\phi(2\phi(1+q^2)-7)))}$ ensures that the publisher produces content when it follows Strategy 2 as well. Due to this assumption, the restriction on $\pi_i^{D*}{}_{S1}$ is out of interest because the publisher follows Strategy 2 in the range that $c > \frac{K+L}{M}$. Hence, the publisher follows the pay to avoid strategy when $\frac{K+L}{M} > c > \frac{1}{2}$ and does not produce content when $\frac{K+L}{M} < c$, which proves (ii) and (iii).

Proof of Proposition 4:

In Lemma 4, we have shown the optimal profit of a duopolistic publisher:

$$\pi_{i,S2}^{D*} = -qy^2 \left(\frac{cq(4c(\phi-1)^3(\phi+1)+2\phi(\phi-1)+1)}{(\phi-1)^2(2c(\phi-2)(\phi+1)+1)^2} + \frac{\alpha\delta}{\phi+1} \right).$$

The publisher does not produce any content when its optimal profit is nonpositive. We set the profit function to 0 to find out the threshold. The threshold is $c > \frac{q(2\phi-1)}{4\alpha\delta(\phi-1)(\phi+1)^2}$. In this inequality, the publisher-related variables are the content production cost (c) and content substitutability (ϕ). In case the content production cost is greater than the threshold, the publisher either decreases the LHS or increases the RHS. This proposition focuses on the case when it is not possible to decrease the content production cost. In this case, we check the RHS exploring how ϕ changes it.

The value of $\frac{\partial\phi}{\partial RHS} = -\frac{(3-5\phi+4\phi^2)q}{4\alpha\delta(\phi-1)^2(\phi+1)^3}$ is always negative. It means higher ϕ values decrease the RHS, and in this case, content production is still nonpositive. This shows that when the publisher focuses on a topic, in other words, increases content differentiation, content production becomes positive.

Proof of Proposition 5:

A monopolistic publisher follows the content wall strategy when $c < \frac{1}{2}$. Think of the case when there are two publishers in the market. The duopolistic publishers follow the content wall strategy when content differentiation is high, and they follow the pay to avoid strategy when the content differentiation is low (see Corollary 3). Let's focus on the case in which the monopolistic publisher changes its strategy from content wall to pay to avoid. In the monopolistic market, its optimal content quality is $\frac{qy}{2c}$. In the duopolistic market, its content quality is $\frac{qy}{(\phi-1)(1+2c(\phi^2-\phi-2))}$. When $c < \frac{1}{2}$, the first value is always greater than the second value, showing that in this case competition decreases content quality. This proves *i*.

In all other cases, the monopolistic publisher keeps its strategy when there is a newcomer in the market. Its content quality when it follows the pay to avoid strategy in a monopoly is $\frac{yq}{4c-1}$. This value is smaller than $\frac{qy}{(\phi-1)(1+2c(\phi^2-\phi-2))}$ when $c > \frac{1}{2}$ where the publisher follows the pay to avoid strategy. A duopolistic publisher's content quality is $\frac{yq}{2c(1-\phi^2)}$ when it follows the content wall strategy. This value is greater than $\frac{qy}{2c}$ when $c < \frac{1}{2}$ where the publisher follows the content wall strategy. This proves *ii*.

Proof of Lemma 6:

The publisher maximizes its total profit of $(v-\alpha\delta y)y[(1-\alpha)g-\alpha h-y]-cv^2$ where it decides on the content quality v and the number of ads y. We find the optimal content quality (v^{E1*}) by differentiating the profit function with respect to v, setting the derivative to 0, and solving for v^{E1*}. From this we get $v^{E1*}=\frac{y((1-\alpha)g-\alpha h-y)}{2c}$. We find the optimal number of ads (y^{E1*}) by differentiating the profit function with respect to y, setting the derivative to 0, and solving for y^{E1*}. From this we get $y^{E1*}=\frac{\alpha\delta g-\alpha^2\delta(g+h)+v\mp\sqrt{3\alpha\delta((\alpha-1)g+\alpha h)v+(\alpha\delta g-\alpha^2\delta(g+h)+v)^2}}{3\alpha\delta}$. Substituting y^{E1*} into v^{E1*}, it yields two possible solutions: $v^{E1*}=0$ and $v^{E1*}=\alpha\delta g-\alpha^2\delta g-\alpha^2\delta h$. It is obvious that the profit is equal to 0 when there is no content quality. Hence, the second solution is a maximum. In this case

$$y^{E1*}=\frac{(1+\alpha-2\alpha^2)\delta g-2\alpha^2\delta h+\sqrt{\delta^2((1-\alpha)^2(1+\alpha+\alpha^2)g^2+(\alpha-1)\alpha^2(1+2\alpha)gh+\alpha^4h^2)}}{3\alpha\delta}$$

and

$$\pi_{S1}^{ME*}=-c((\alpha^2-1)\delta g+\alpha^2\delta h)^2-\frac{1}{27\alpha^2}$$

$$(d((\alpha-1)^2g+\alpha^2h)((\alpha^2+\alpha-2)+\alpha^2h)((\alpha-1)(2\alpha+1)g+2\alpha^2h)$$

$$+\frac{2(d^2((\alpha-1)^2(\alpha^2+\alpha+1)g^2+(\alpha-1)\alpha^2(1+2\alpha)gh+\alpha^4h^2))^{3/2}}{d^2}).$$

Proof of Lemma 7:

The publisher maximizes its total profit of $(v-p)p+(p-\alpha\delta y)y[(1-\alpha)g-\alpha h-y]-cv^2$ where it decides on the content quality v, subscription fee p, and number of ads y. We find the optimal content quality (v^{E2*}) by differentiating the profit function with respect to v, setting the derivative to 0, and solving for v^{E2*}. From this we get $v^{E2*}=\frac{p}{2c}$. We find the optimal number of ads (y^{E2*}) by differentiating the profit function with respect to y, setting the derivative to 0, and solving for y^{E2*}. From this we get $y^{E2*}=\frac{\alpha\delta g-\alpha^2\delta(g+h)\mp+\sqrt{3\alpha\delta((\alpha-1)g+\alpha h)p+(\alpha\delta g-\alpha^2\delta(g+h)+p)^2}}{3\alpha\delta}$. Lastly, we find the optimal subscription fee (p^{E2*}) by differentiating the profit function with respect to p, setting the derivative to 0, and solving for p^{E2*}. From this we get $v^{E2*}=\frac{v-y((\alpha-1)g+\alpha h+y)}{2}$. Substituting v^{E1*} and y^{E1*} into p^{E1*}, it yields three possible solutions: $p^{E1*}=0$, $p^{E1*}<0$, $p^{E1*}=A$. It is obvious that the profit is equal to 0 when the subscription fee is 0 or less than 0. Hence, the third solution is a maximum. In this case, $v^{E2*}=\frac{A}{2c}$ and $y^{E2*}=\frac{A+B+\sqrt{(A+B)^2-3AB}}{3\alpha\delta}$.

Proof of Corollary 1:

The number of users who subscribe is equal to $v^{E2*}-p^{E2*}$, and the number of users who who turn ad-blockers off is equal to $(1-\alpha)p^{E2*}+\alpha(p^{E2*}-\delta y^{E2*})$. We take the derivative of the numbers of users with respect to ad-seeing disutility of the users ($\alpha\delta$). From this we find that $\frac{v^{E2*}-p^{E2*}}{\alpha\delta}$ firstly increases then decreases and $\frac{(1-\alpha)p^{E2*}+\alpha(p^{E2*}-\delta y^{E2*})}{\alpha\delta}$ firstly decreases then increases. This also shows that the number of users who turn ad-blockers off increases when user ad-seeing disutility is high.

Proof of Proposition 6:

Let $\Delta\pi^E=\pi^{E*}_{S2}-\pi^{E*}_{S1}$. The publisher follows Strategy 2 when $\Delta\pi>0$ and Strategy 1 when $\Delta\pi<0$. $\Delta\pi^E$ takes positive values for the higher values of content production cost c, and it takes negative values for the lower values of c only when user ad-aversion takes moderate values.

Proof of Lemma 8:

Using the optimal discount value we presented before, we differentiate with respect to the variables to find out the effects of each variable on the discount value.

(i). The differentiation of e^* with respect to the discount effect of the purchasing probability (h) is:

$\frac{\partial e^*}{\partial h} = -\frac{p^W + p^M}{2h^2 - p^W + p^M}$

This equation takes always positive values since $p^W + p^M < 1$. Hence, higher discount effect on the purchasing probability increases the optimal discount rate.

(ii). The differentiation of e^* with respect to how active a customer is (q) is:

$\frac{\partial e^*}{\partial q} = \frac{d^2-1}{2}\left(-\frac{1}{q^2} + \frac{\alpha(\alpha-1)}{(1+d-\alpha q)^2}\right)$

This equation takes always positive values. Hence, the retailer offers a higher discount rate to a more active customer.

(iii). The differentiation of e^* with respect to the probability that the customer does not adopt the mobile app (α) is:

$\frac{\partial e^*}{\partial \alpha} = \frac{(d^2-1)(1+d-q)}{2(1+d-\alpha q)^2}$

This equation takes always positive values. Hence, the retailer offers a higher discount rate to a customer who is more likely to adopt the mobile app .

(iv). Lastly, the differentiation of e^* with respect to the customer's current purchasing probabilities over the web page and mobile app (p^W and p^M) are:

$\frac{\partial e^*}{\partial p^W} = \frac{\partial e^*}{\partial p^M} = -\frac{1}{2h(p^W + p^M - 1})^2$

This equation takes always negative values. Hence, the retailer offers a lower discount rate to a customer who already has a higher purchasing probabilities over the existing sales channels.

Proof of Proposition 7:

In this strategy, the customer takes advantage of a discount offered by the online retailer over the mobile app. We take into account that there is a probability that the customer adopts the mobile channel and purchase over it regularly. The adoption does not take place in the first period. After showing the customer's transactions for each period, we calculate her DET by summing her transactions over the time. Then, we find the optimal discount value (e^*) by differentiating the DET value with respect to e, setting the derivative to zero, and solving for e^*.

e^* is equal to $\frac{h+1}{2h} + \frac{d^2-1}{2q} + \frac{(1-\alpha)(d^2-1)}{2(\alpha q-d-1)} + \frac{1}{2h(p^W+p^M-1)}$. There is only one solution to this derivation. Hence, this value is the only value that e^* can take. We substitute it into the DET expression and find out that $DET^* = \dfrac{1}{4q(1+d-\alpha q)^2}\left(\frac{K}{h(1+d-q)(1-p^W-p^M)} + L\right)$

where

$K = (q(1+d-\alpha q)((p^W+p^M)(1-h)+h))^2 - (h(1-d^2)(1+d-q)(1-p^W-p^M))^2$

$L = 2(1+d)(q(1+d-\alpha q)(p^W(1+d)+p^M(1-d)) + h(1-p^W-p^M)(d-1)((d-1)(d+1)^2 - q(d-2)(d+1) - \alpha q^2))$.

Since there is only one value e^* cane take, this is the only value DET^* takes.

Proof of Lemma 9:

In this lemma, we showed how the discount effect on the purchasing probability (h) changes the DET of a customer. For this purpose, we differentiated the DET function with respect to h and set the derivative to zero to find out the boundaries. The derivation is as following:

$$\frac{\partial DET}{\partial h} = \frac{-\frac{(d-1)^2(d+1)^3(p^W+p^M-1)}{(1+d-\alpha q)^2} + \frac{(d-3)(d-1)(d+1)^2 q(p^W+p^M-1)}{(1+d-\alpha q)^2} + \frac{q^2\left(-\frac{((1+d)^2+\alpha^2 q^2-2\alpha(d+1)(d^2+2q-dq-1))(p^W+p^M-1)^2}{(1+d-\alpha q)^2} + \frac{(p^W+p^M)^2}{h^2}\right)}{(1+d-q)(p^W+p^M-1)}}{4q}$$

When we set the derivative to zero, h can take two values:

$$h = \frac{q(1+d-\alpha q)(p^W+p^M)}{\sqrt{(\alpha q^2+(d-2)(d+1)q-(d-1)(d+1)^2)^2(p^W+p^M-1)^2}}$$

and

$$h = \frac{q(\alpha q-d-1)(p^W+p^M)}{\sqrt{(\alpha q^2+(d-2)(d+1)q-(d-1)(d+1)^2)^2(p^W+p^M-1)^2}}$$

The values between the boundaries are negative. When h takes any value between the boundaries, higher h value decreases the DET. h takes positive values outside the boundaries. In these regions, higher h value increases the DET.

Proof of Lemma 10:

To be able to show which strategy the retailer follows, we simply find the regions that the DET when the retailer offers a discount c over the mobile app is higher than the $\overline{DET}$ when the retailer does not offer a discount. DET takes a larger value when $DET - \overline{DET}$ takes a positive value. For this purpose, we find the difference, set the difference to zero to find the boundaries. The difference between the transaction of two strategies is as follows:

$$DET - \overline{DET} = \frac{1}{4q(1+d-\alpha q)^2}\left(\tfrac{K}{h(1+d-q)(1-p^W-p^M)} + L\right) - \tfrac{(p^W+p^M)(1+d)}{1+d-q}$$

where

$K = (q(1+d-\alpha q)((p^W+p^M)(1-h)+h))^2 - (h(1-d^2)(1+d-q)(1-p^W-p^M))^2$

$L = 2(1+d)(q(1+d-\alpha q)(p^W(1+d)+p^M(1-d)) + h(1-p^W-p^M)(d-1)((d-1)(d+1)^2 - q(d-2)(d+1) - \alpha q^2))$

When we set the difference to zero, h can take two values:

$h = \frac{M+2\sqrt{N}}{O}$

and

$h = \frac{M-2\sqrt{N}}{O}$

where

$M = q(\alpha q - d - 1)(p^W + p^M - 1)(p^W(\alpha q^2 + (d+1)(d-2\alpha)q - (d-1)(d+1)^2 + ((d+1)^3 - (d+1)(d+2\alpha)q + \alpha q^2)p^M$

$N = (1+d)(1+d-q)q^2(1+d-\alpha q^2)(p^W+p^M-1)^2((\alpha-1)p^W q - dp^M(1+d) + (\alpha+d-1)p^M q)(p^W(\alpha q + d^2 - 1) - (1+d-\alpha q)p'$

$O = (\alpha q^2 + (d-2)(d+1)q - (d-1)(d+1)^2(p^W + p^M - 1)^2)$

When h takes a value between the boundaries, $DET - \overline{DET}$ takes a negative value and the retailer does not offer a discount over the mobile app. When h takes a value outside the boundaries, $DET - \overline{DET}$ takes a positive value and the retailer offers a discount over the mobile app.

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Curriculum Vitae

Gökhan Gecer

2016-2021 Ph.D. in Marketing, University of Mannheim, Business School

2013-2015 Master in Science, Industrial Engineering, Koc University

2008-2013 Bachelor in Industrial Engineering, TOBB University of Economics and Technology