Advertising Format and Content Provision on Revenue-Sharing Content Platforms

Yuansheng Wei

Sun Yat-sen University, China, weiysh25@mail.sysu.edu.cn

Lin Tian

Fudan University, Shanghai, China, tianlin@fudan.edu.cn

Baojun Jiang

Washington University in St. Louis, St. Louis, Missouri 63130, baojunjiang@wustl.edu

February 16, 2023

Abstract

The digital content market has grown dramatically in recent years. Many platforms (e.g., YouTube, Twitch, and Instagram) show ads when consumers watch the content on their platforms, and they share ad revenue with content creators to incentivize them to create and share content. These platforms often adopt either uniform advertising (UA) (i.e., they display the same number of ads irrespective of content quality) or differentiated advertising (DA) (i.e., they display the number of ads based on content quality). This paper shows that, regardless of the ad format, an increase in creator substitutability can increase the profits of the platform and the content creators and improve the consumer surplus. Moreover, the equilibrium ad revenue-sharing rate, content quality, and the number of ads shown for each content will be lower under DA than under UA. The platform's profit and the consumer surplus are also lower under DA than under UA. However, depending on the level of creator substitutability, the creators' profits can be higher or lower under UA. We have also analyzed an emerging ad format in which the platform allows content creators themselves to decide the number of ads on their content. Interestingly, we show that this new ad format can make the platform, the content creators, and the consumers worse off.

Key words: ad revenue sharing; ad format; content quality; ad number; competition

1. Introduction

Over the past two decades, the digital content industry has witnessed a boom. The latest statistics show that as of 2021, YouTube, the popular video-sharing platform, has 2.291 billion active users worldwide (Statista 2021). More than 720,000 pieces of new content are expected to be posted on YouTube per day (James 2019). Instagram, one of YouTube's direct competitors, is estimated to have 1.074 billion users worldwide in 2021 (Jasmine 2020). Rani and Kurt (2018) report that Instagram users spend an average of 53 minutes per day on the platform. Twitch, one of the fastest-growing streaming platforms, has 9.2 million active streamers each month; Twitch users view 71 million hours of content each day (Wise 2022).

Content platforms' enormous audience and reach are attractive for brands' marketing campaigns. Advertising has been the main revenue source for these content platforms. From 2018 to 2020, YouTube earned more than $34 billion in advertising revenue (Alexander 2020a). Similarly, Instagram earned $20 billion in advertising revenue in 2019 (Carman 2020a). Facebook reported total revenue of $86 billion in 2020, $84.2 billion of which came from advertising. Twitch takes 73% of the market share in streaming and gets $230 million in ad revenue (Matt 2020).

Since consumers contribute view counts by joining the platforms for content consumption, higher quality content spreads more effectively and improves consumer engagement with platforms as well as collaborating advertisers (Yoo et al. 2019). Platforms often incentivize content production and posting by offering ad revenue-sharing programs (Jain and Qian 2021). For example, YouTube keeps 45% of the revenue from ads shown on video content on its platform, and over $8 billion in ad revenue has been shared with YouTubers since 2006 (Alexander 2020a). Instagram introduced IGTV in 2018 and started sharing ad revenue with content creators in 2020 (Carman 2020b). WeChat Official Account

(also known as OA), one of the largest content platforms in China, shares 70% of daily ad revenue with content creators if they allow the platform to place ads in their original posts (e.g., articles or Mini Programs).[1] A similar ad revenue-sharing policy is also adopted by content platforms such as Twitch and TikTok (Lara 2020, Twitch 2021).

With the prevalence of content platforms and the adoption of ad revenue sharing, a key decision in platform operation is the advertising distribution choice. Content platforms have usually used one of the two advertising formats—a *uniform advertising (UA) format*, under which platforms show the same number of ads regardless of content qualities, and a *differentiated advertising (DA) format*, under which platforms show a different number of ads for content with different qualities. For example, Meta, formerly named Facebook, runs the uniform 6-second pre-roll ads on Facebook Watch.[2] Twitch runs uniform 30-second pre-roll ads in affiliates' content.[3] Viewers are exposed to the same amount of ads for different content on Twitch (Tara 2020). In contrast to Meta and Twitch, YouTube conditions video ads (e.g., Bumper Ads or Non Skippable Ads) on content performance; these ads can be up to 15 seconds long (Google 2021). Tencent Video, one of the most popular streaming sites in China, hosts independent creators' content and places differentiated ads on the content.[4] Similarly, differentiated ad placement is also adopted by Youku and iQIYI. Since content creators are incentivized by ad revenue sharing to produce high-quality content, a better understanding of the strategic role of ad formats has important implications for content creators and platforms. Therefore, content platforms that rely heavily on content creators' content contribution need to think carefully about the following questions: How does

---

[1] https://mp.weixin.qq.com/s/-lKACMbhYXhihxVxqFJLBA, accessed on February 2, 2023 (in Chinese).
[2] https://martech.org/facebook-announces-6-second-pre-roll-ad-test-new-mid-roll-ad-restrictions/, accessed on February 2, 2023.
[3] Twitch also offers 60-second unskippable mid-roll ads, which are independent with content qualities.
[4] Ad length on content creators' posted content can be up to 60 seconds long on the Tencent Video platform.

the advertising format affect content creation and content quality on a platform? Which advertising format (uniform advertising or differentiated advertising) is more profitable for the platform? Which advertising format will content creators prefer? For policymakers who care about welfare, it is also valuable to understand the impact of the platform's advertising strategy on consumer surplus and social welfare.

Under ad revenue sharing, the advertising format will directly influence the competitive dynamics among content creators on the platform. Another important factor affecting competition is the degree to which content creators are substitutable from the consumers' point of view. From the platform's perspective, increasing diversity or lower substitutability in content creators will increase the platform's value by providing consumers with different types of content and more touchpoints for interaction (Boudreau 2012, Hukal et al. 2020). High substitutability among content creators can lead to esthetic fatigue and drive consumers away from the platforms (Joei 2020). A survey by Bazaarvoice (2018) shows that 47% of consumers are fatigued by repetitive posts on content platforms and 27% are very concerned about dipping content qualities. So, will higher creator substitutability necessarily hurt the content platforms? Logically, higher substitutability or competition may make content creators more motivated to raise content quality, which could be beneficial to content platforms. For example, Paul (2015) suggests that, as competition increases, content creators need to invest more in content creation and raise their quality bars if they want to stand out from their competitors. He also recommends seven ways for content creators to increase content quality. Werner (2021) shows that top streamers on Twitch have used better graphics and/or have even created their own Twitch emotes to improve their streams' appearances. Such evidence suggests a strategic role of creator substitutability on platforms. Thus, in addition to studying content production, we are also interested in the impact of creator substitutability

on market outcomes. Despite the importance of this question, prior research focusing on the impact of creator competition in the content market has largely ignored the strategic roles of ad formats (uniform advertising or differentiated advertising) and advertising intensity (the number of ads displayed for content). Our work helps to fill this gap.

We construct an analytical model to address the aforementioned questions. In our model, two competing content creators produce and post content on a content platform. A representative consumer in the market can multi-consume content posted by substitutable creators to maximize his payoff. As the creator substitutability increases, the consumer tends to reduce the overall content consumption. The platform shares ad revenue with content creators by specifying an ad revenue-sharing rate. In our main analysis, we examine the impacts of creator substitutability on market outcomes under different ad formats. We examine the impacts of ad format on ad revenue-sharing rates, content qualities, and advertising intensities; we also investigate the market participants' preferences over different ad formats. For ease of exposition, in the remainder of this study, we use "UA" and "DA" to denote the uniform-advertising format and the differentiated-advertising format, respectively. Below, we highlight a few major findings.

First, regardless of the ad formats, one may intuit that an increase in creator substitutability would reduce all market participants' profits since increased creator substitutability tends to reduce the consumer's content consumption. However, our analysis shows that an increase in creator substitutability can increase both the content creators' profits and the consumer surplus under the UA and DA formats. This is because the anticipated reduction in content consumption gives the platform an incentive to share more ad revenue with the content creators to encourage high-quality content production. The higher fraction of ad revenue can make content creators better off, and high-quality

content will benefit the consumer. Moreover, our analysis shows that higher creator substitutability can also benefit the platform under both the UA and DA formats. The intuition lies in the fact that as creator substitutability increases, competition between the two content creators becomes more intense. To be competitive, content creators have more pressure to increase the quality of their content, which is beneficial to the platform.

Second, we find that the equilibrium ad revenue-sharing rate, content quality, and ad number will be lower under DA than under UA. Moreover, the platform's profit and the consumer surplus are also lower under DA than under UA. Under DA, the platform can set different numbers of ads for content of different qualities. As a result, the competition in content quality is weaker, and the content creators have less incentive to invest in content quality under DA than under UA. For this reason, the platform's profit is lower under DA than under UA, and the platform will set a lower revenue-sharing rate under DA than under UA.[5] The lower revenue-sharing rate leads to lower content quality, which leads to fewer ads for the content. Though fewer ads are shown, because of the lower content quality, the consumer surplus is lower under DA than under UA. Interestingly, we also find that the content creators' preferences between DA and UA are moderated by creator substitutability. The intuition lies in the tradeoff between the weaker content competition and the lower revenue-sharing rate under the DA format. More specifically, under DA, from the content creators' perspective, on the one hand, the competition in content quality is weaker; on the other hand, the platform will set a lower revenue-sharing rate. When creator substitutability is low, the benefit from the weakened content competition cannot cover the loss from the reduced revenue-sharing rate, and thus the content creators prefer the

---

[5] In our main model, we assume that the competing content creators are symmetric in content production efficiency. We have also examined the case in which the creators have asymmetric cost efficiency and find that the DA format will be preferred by the platform when the level of asymmetry in content production efficiency is relatively high. We have discussed the asymmetric model in the discussion section. For more details, please refer to part B of the Supplemental Materials file.

UA format. When creator substitutability is high, the benefit from the reduced content competition is more significant and can cover the loss from the reduced revenue-sharing rate, so the content creators would prefer the DA format.

In reality, some platforms (e.g., YouTube and Twitch) have made new attempts to compensate content creators by allowing the creators to choose the number of ads themselves. In a model extension, we enrich the main analysis by considering the emerging ad format, in which the content creators decide the number of ads on their content. For ease of exposition, we use "CA" to denote this ad format. Our analysis confirms the result in the previous analysis that an increase in creator substitutability can increase the content creators' profits and the consumer surplus. However, under CA, an increase in creator substitutability will make the platform worse off. Note that the CA format is more akin to the DA format. The only difference is that the platform chooses the ad number under DA whereas the content creators choose it under CA. In comparison with DA, the equilibrium ad revenue-sharing rate, content quality, and advertising intensity will be lower under CA. Moreover, the platform's profit is also lower under CA. When creator substitutability is low, the content creators' profits are lower, whereas the consumer surplus is higher under CA. In contrast, when creator substitutability is high, the content creators' profits are higher, but the consumer surplus is lower under CA. The underlying intuition of the comparison results between CA and DA hinges on the impact of the transfer of the advertising decision right on the competition between the content creators.

The rest of the paper is organized as follows. In the next section, we review the most related research. Section 3 describes the model setup. Section 4 presents the main analysis and results under uniform advertising and differentiated advertising. Section 5 considers the alternative case of creators-set advertising, where the content creators themselves choose the number of ads for their content. Section

6 provides further discussions about our model and results. Section 7 concludes the paper.

2. Literature Review

Our research contributes to the literature on ad-sponsored business models. It is common for media/content platforms to sell advertising space to advertisers. Research in this area has examined various perspectives such as the media firms' product provision (e.g., Steiner 1952, Doyle 1998, Athey et al. 2018), ad-intensity choice (e.g., Dukes 2004, Anderson and Coate 2005, Kind et al. 2007, 2009, Godes et al. 2009), and advertising contract design (e.g., Dukes and Gal-Or 2003, Peitz and Valletti 2008). For example, Gal-Or and Dukes (2003) examine the horizontal positioning of media firms and show that minimum differentiation can benefit media firms by increasing their negotiation power in the ad market. Godes et al. (2009) investigate how competition affects media firms' content prices and ad intensities. They show that media firms may charge higher content prices in a duopoly market than in a monopoly market because competition reduces the return from the ad market, which lowers the media firms' motivation to reduce content prices. Casadesus-Masanell and Zhu (2010) develop a sequential game to study ad-sponsored firms' strategic decisions on product quality. Our research has two fundamental differences from previous studies. First, prior research on ad strategy investigates the advertising level by emphasizing the interaction between media firms and advertisers and has largely neglected the critical role of independent content creators. Unlike these studies, our research focuses on the platform's ad revenue sharing with content creators and examines the impact of creator substitutability on their content provisions and the platform's compensation plan. Second, previous research on ad strategy has mainly focused on the advertising contract between media firms and advertisers. Little theoretical research has examined the impacts of ad formats (e.g., uniform advertising, differentiated advertising, or creators-set advertising). Our paper contributes to the literature by

examining the implications of ad formats on all participants' performances in the content market.

Our paper also relates to the literature on content production by content creators (e.g., Albuquerque et al. 2012, Boudreau 2012, Huang et al. 2015, 2019, Han et al. 2020, Hukal et al. 2020). Toubia and Stephen (2013) empirically examine users' content contributions to media platforms and find that image-related utility plays a more important role in incentivizing content posting than intrinsic utility. Stennek (2014) examines different content distribution choices and finds that exclusive distribution may motivate content providers to produce higher-quality products. D'Annunzio (2017) investigates the impact of vertical integration on the content providers' investments in premium content and shows that an independent provider is more likely to invest in content quality. Jiang et al. (2019) develop a content-acquisition model where consumers may subscribe to multiple distributors. They show that content creators will increase their content production when the content distributors are highly differentiated. Our research complements this stream of research in that we examine the effects of ad revenue sharing and different advertising formats on the content creators' efforts in content production. Sun and Zhu (2013) are among the first to look into content platforms' ad revenue sharing to show empirically that platforms' revenue-sharing plans lead to higher-quality content. A few recent theoretical studies (e.g., Jain and Qian 2021, Bhargava 2022) investigate the interaction between the platform's ad revenue sharing and the creators' content provision. Jain and Qian (2021) use a circular-city model to show that an increase in the number of content producers on the platform can lead to higher platform profits and better-quality content. Bhargava (2022) examines how the distribution of creator capabilities affects the market concentration of creators and shows that the platform's design can play a role. Relative to these papers, the key contribution of our study is to investigate the implications of different advertising formats in the context of ad revenue-sharing platform. Moreover, we incorporate decisions of both

content quality and advertising intensity (the number of ads to display for content) into our model and examine all participants' ad format preferences.[6]

This paper also contributes to the literature on price discrimination in two-sided markets. This literature primarily investigates the implications of price discrimination (e.g., Caillaud and Jullien 2003, McAfee and Schwartz 2004, Armstrong 2006, Jeon et al. 2016). Liu and Serfes (2013) show that price discrimination in a two-sided market may soften the competition between horizontally differentiated platforms. Carroni (2018) studies within-group price discrimination by competing media platforms and shows that conditioning subscription prices on past behaviors can hurt the platforms. Limited research has considered ad discrimination (or differentiated advertising) on content platforms. One exception is Lin (2020), who investigates how an ad-supported media platform price discriminates through versioning. He shows that price discrimination on one side of the market can increase the platform's incentive to discriminate on the other side of the market. We complement this literature by studying how different advertising formats (uniform advertising, differentiated advertising, and content creators-set advertising) on a content platform will affect content creators' productions and the advertising intensity for their content as well as firm profits and consumer surplus.

3. Model

We consider a digital content market consisting of two content creators (C_1 and C_2), who produce and post content (e.g., video, music, or game) on a content platform (P), where consumers can enjoy the content by viewing some ads.[7] One can think of the content creators as independent video producers

---

[6] Additionally, in contrast to Jain and Qian (2021), we have focused on a different competitive mechanism in the content market. In specific, in their model, the intensity of competition depends on the number of content creators. The more content creators are in the market, the more intense the competition will be, and also the more consumers will come to the platform (i.e., the market will expand). By contrast, in our model, the competition intensity is determined by substitutability between content creators on the platform. The more substitutable the creators are perceived, the more intense the competition will be, and the less the representative consumer will consume (i.e., the market will shrink).

[7] We have also analyzed a model with $N > 2$ content creators on the platform. Our key results from the main model remain qualitatively the same; the detailed analysis of this model is given in part C of the Supplemental Materials file.

producing different types of content, and the content platform as YouTube. Each content creator C_i ($i \in \{1,2\}$) decides her content quality q_i, which requires her to incur a cost of $C(q_i) = kq_i^2$, where k measures how efficiently creators can produce new content.[8] The platform will choose the number of ads d_i for each content creator's content; d_i can also be viewed as the total ad impressions or the ad frequency a consumer is exposed to over the duration of the content. We will also interchangeably refer to d_i as the advertising intensity for the content creator's content. In addition, the platform will choose what fraction $\alpha \in (0,1)$ of its ad revenue generated from the creator's content to pay the content creator. For example, Google pays independent content creators 55% of the ad revenue generated from their video content on the YouTube platform. One of China's largest video streaming platforms, Tencent Video pays content creators up to 80% of the ad revenue generated from their exclusive content posted. In the remainder of this paper, we refer to the fraction (i.e., α) of ad revenue that the platform pays content creators as the platform's ad revenue-sharing rate. We normalize the platform's operational cost and fixed cost to zero. We use the online video content industry as the main motivation for our model. However, our model can apply to other content markets where the platform sells ad spaces to advertisers and shares ad revenues with content creators to incentivize content production (e.g., Instagram and Tencent's WeChat Official Accounts Platform).

The consumer's utility from consuming content on the platform depends on three components: the platform's base value (v), the quality of the content (q_i), and the number of ads (d_i) shown with the content. In this paper, we use a representative consumer approach to model the market demand (e.g.,

---

[8] Note that our main model assumes that the two content creators are symmetric in content production efficiency (i.e., they have the same k). This assumption allows us to identify the effect of competition between content creators more clearly without convoluting the results with cost heterogeneities, ensuring that our results are driven solely by competition forces rather than cost asymmetry. We have also analyzed the case where the content creators are asymmetric in content production efficiency. The results are discussed in the discussion section. For details, please refer to part B of the Supplemental Materials file.

Godes et al. 2009, Kind et al. 2009). In particular, a representative consumer's utility from consuming

creator 1's content x_1 times and creator 2's content x_2 times is given by

$$U(x_1, x_2) = \sum_{i=1}^{2} x_i (v + \phi q_i - \beta d_i) - \frac{1}{2} \sum_{i=1}^{2} x_i^2 - \gamma x_1 x_2, \tag{1}$$

where $x_i \geq 0$ denotes the number or fraction of times the consumer consumes creator i's content (i.e.,

the amount or the "intensity" of the consumer's consumption of creator i's content), $\phi > 0$ represents

the consumer's marginal valuation for content quality, and $\beta > 0$ measures the consumer's disutility

for each ad impression. Let us examine the three terms of the utility function (1). Inside the first

summation, the term $v + \phi q_i - \beta d_i$ represents three components of the consumer's utility of *each*

consumption (e.g., each complete viewing) of creator i's content: v is the part of the consumer's

utility that depends on the platform's quality or service, ϕq_i is the part of the consumer's utility that

depends on the creator's content quality (q_i), and $-\beta d_i$ is the consumer's disutility from the ads shown

for creator i's content during each consumption. Thus, if the consumer consumes creator i's content

$x_i \geq 0$ times, we have $x_i (v + \phi q_i - \beta d_i)$ as part of the consumer's utility. However, the consumer

can become satiated as she consumes the same creator's content multiple times; so, to capture this, the

second summation term in (1) has a negative x_i^2 term such that as x_i increases, the consumer's

marginal utility from viewing creator i's content will decrease (e.g., due to satiation). Furthermore, the

consumer can also experience "satiation" when consuming both content creators' content; that is, the

consumer's consumption utility from one creator's content is negatively affected by the consumer's

consumption of the other creator's content, e.g., due to overlapping content or perspectives. The third

term in (1), $-\gamma x_1 x_2$, captures this utility interaction between the two creators' content. In essence, the

parameter $\gamma \in (0,1)$ captures the competition between the two content creators.[9] The higher γ is, the

---

[9] Note that $\gamma < 1$ is required for the second-order conditions to obtain a maximum (Ingene and Parry, 2004).

more substitutable the two creators are in the eyes of the consumer, and the more intense the competition between the two content creators. For example, two content creators posting product review videos will be perceived as more substitutable when both creators take male users' perspectives than when they have perspectives from different genders. Or, for commentary on political news, the creators will be perceived as more substitutable when they both have a Republican perspective than when one creator has a Republican perspective while the other has a Democrat perspective. Intuitively, as the substitutability between content creators increases (i.e., as γ is higher), the consumer tends to lower her consumption of a creator's content if she has already consumed the other creator's content. Thus, a higher γ implies that the content creators compete more intensely for the consumer's attention (consumption). One can intuitively think about creator substitutability as the horizontal (taste) differentiation between the creators (as in the earlier product review or political news examples). For the rest of the paper, the phrases "higher creator substitutability" and "more intense competition" are used interchangeably in our discussions.[10]

The representative-consumer approach to modeling demand implicitly reflects the fact that users on digital content platforms often consume content from substitutable content creators. For example, many consumers subscribe to more than one content creator in an area of interest on a platform such as YouTube. One can think of the representative consumer as consuming content to different extents depending on the platform's base value, the quality of the content, and the number of ads; the representative consumer's amount of consumption of the content represents the expected demand of the content. The utility framework (1) shows that the representative consumer can consume both content creators' content; it is a stylized, tractable model to capture the consumer's multi-homing (multiple

---

[10] We have also analyzed a model with complementarity between the content creators in part D of the Supplemental Materials file. Meanwhile, we have discussed the complementarity model in the discussion section.

consumptions of substitutable products) without explicitly modeling heterogeneous consumers' multi-homing behaviors.

Advertisers usually pay the platform based on the number of times their advertisements are shown (e.g., YouTube uses Cost Per View). In practice, the advertising revenue generated from a creator's content is typically proportional to the total impressions of the ads shown during consumers' consumption (i.e., viewing) of the creator's content. For example, advertising on YouTube costs are $0.01 to $0.03 per view on average. That means every time the consumer consumes a content with an ad, the platform can earn around $0.01 to $0.03.[11] Following Jain and Qian (2021), we assume that the platform's marginal ad revenue for each ad impression is a constant $m > 0$. Thus, the platform's total ad revenue (denoted by R_A) from all the content is an increasing linear function of the amount of content consumption on the platform: $R_A = m \sum_{i=1}^{2} x_i d_i$, where $x_i > 0$ is the number or fraction of times the consumer consumes creator i's content and d_i is the number of ads shown during each complete consumption of the content creator i's content. Such linear ad revenue has been widely used in the advertising literature (see Godes et al. 2009, Casadesus-Masanell and Zhu 2010, and Despotakis et al. 2020).

Figure 1　Timing of the Model

Ad revenue-sharing rate α　　　Content quality q_i　　　Number of Ads d_i

Stage 1　　　　　　　　Stage 2　　　　　　　Stage 3
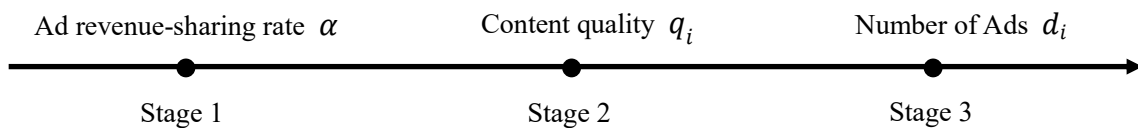
In practice, there are two commonly used types of ad formats on content platforms: (i) the uniform-advertising format (denoted by UA), under which the platform puts the same number of ads for all

---

[11] https://influencermarketinghub.com/how-much-do-youtube-ads-cost/, accessed on February 2, 2023.

content independent of quality; (ii) the differentiated-advertising format (denoted by DA), under which

the platform can choose different numbers of ads for different content based on quality. The platform

usually publicly commits to the advertising-format policy (i.e., whether it uses UA or DA). In other

words, the content creators take the platform's advertising policy as given when creating their content

(i.e., choosing their content quality levels). This is consistent with the practice given that the content

creators usually know how the platform's algorithm of ad displaying works before they join and decide

their respective content quality. For example, Google discloses its ad displaying strategy in YouTube's

help center.[12] The decision sequence under each ad format is shown in Figure 1. First, the platform sets

the ad revenue-sharing rate (α), i.e., the fraction of the ad revenue generated from the content creator's

content that will be paid to the creator. Second, each content creator decides her content quality (q_i) and

posts the content on the platform. Third, the platform chooses the number of ads (d_i) for each posted

content, and subsequently, the consumer chooses how much to consume each creator's content.

Note that we have assumed that the content creators choose their content qualities *before* the platform

chooses the ad intensity.[13] This is reasonable because even though the creators have good knowledge

of the platform's ad policy, they do not observe the exact number of ads that will be shown until after

they have created and uploaded their content. As is in practice, the platform will put ads on the creator's

content only sometime *after* the content has been uploaded and posted; typically, the platforms are able

to infer or measure the content quality posted on their platform very quickly and accurately through

multiple means, such as reviews and AI systems. For example, YouTube has adopted a combination of

---

human moderators and software to infer content quality.[14] TikTok also uses machine learning to evaluate the quality of each uploaded post.[15] The creators do not observe what ads or how many ads will be displayed at the time of creating the content. The platform's ads algorithm takes the creator's content as input to determine the ad intensity (based on the revealed quality of the content).

4. Analysis and Results

In this section, we analyze the equilibrium results. Section 4.1 examines the uniform advertising (UA) format. Section 4.2 considers the differentiated advertising (DA) format. Section 4.3 compares the two formats. A summary of the model notation is presented in Table 1.

Table 1 Model Notation

Notation	Explanation
C_i	Content creator $i = 1,2$
P	Platform
x_i	The consumer's amount (intensity) of consumption of creator i's content
q_i	Content creator i's content quality
d_i	Advertising intensity, i.e., the number of ads shown for content creator i's content (during each viewing)
v	The consumer's base consumption value from the platform
ϕ	The consumer's marginal valuation for content quality
β	The consumer's marginal disutility from viewing an ad
γ	Substitutability between the content creators
$U(x_1, x_2)$	The representative consumer's utility from consuming the two creators' content
m	Marginal ad revenue (per impression or viewing)
k	The creators' cost coefficient for content production
$\alpha \in (0,1)$	The platform's ad revenue-sharing rate (paid to the content creator)
$C(q_i)$	Creator i's production cost for content of quality q_i
π	Profit
CS	Consumer surplus
SW	Social welfare
UA	This superscript indicates the case of uniform advertising

---

[14] https://www.businessinsider.com/youtube-quality-content-and-engagement-2019-4, accessed on February 2, 2023.
[15] https://ranieri.agency/understanding-the-tiktok-algorithm, accessed on February 2, 2023.

^{DA}	This superscript indicates the case of differentiated advertising
^{CA}	This superscript indicates the case of content creators-set advertising

4.1. Uniform Advertising (UA)

We first investigate the uniform-advertising format, where the platform ex-ante sets the same number of ads for all content independent of quality. For example, Twitch uses uniform 30-second pre-roll advertising in affiliates' content (Tara 2020). Specifically, in our setting, after the content creators create and post their content, the platform will set the same number of ads for the content, i.e., $d_1 = d_2 = d$. From equation (1), the consumer's utility function simplifies to $U(x_1, x_2) = \sum_{i=1}^{2} x_i(v + \phi q_i - \beta d) - \frac{1}{2}\sum_{i=1}^{2} x_i^2 - \gamma x_1 x_2$. By solving $\frac{\partial U(x_1, x_2)}{\partial x_i} = 0$, the consumer's utility-maximizing amount of consumption for creator i's content, conditional on content quality (q_i) and the advertising intensity (d), is $x_i = \frac{1}{1-\gamma^2}[v(1-\gamma) + (\phi q_i - \beta d) - \gamma(\phi q_{i'} - \beta d)], i = \{1,2\}, i \neq i'$. The content creators and the platform maximize their profits as given below:

$$\pi_{C_i}(q_i) = \alpha m x_i d - k q_i^2, \tag{2}$$

$$\pi_P(\alpha, d) = (1 - \alpha)m(x_1 + x_2)d. \tag{3}$$

We use backward induction to solve the problem. The derivation of the equilibrium results is given in the Supplemental Materials file (*available upon request*). Our analysis shows that when content is very costly for content creators to produce (i.e., $k \geq \frac{m\phi^2}{2\beta(1-\gamma^2)}$), the platform under the uniform advertising format will not be able to profitably share ad revenues with creators to induce them to produce content on the platform. When content creators can produce content very efficiently (i.e., $k \leq \frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}$), the platform under the uniform advertising format will be able to share just enough ad revenue to induce the content creators to produce high-quality content to make zero equilibrium profit. These two extreme parameter regions do not reflect reality and are also not theoretically interesting. Thus, for non-trivial analysis, we focus on the case of $\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$ for the remainder

of this subsection, to ensure that all market participants earn positive payoffs under the uniform advertising format. We use a superscript UA to indicate the equilibrium results under uniform advertising. The equilibrium ad revenue-sharing rate, content qualities, and advertising intensity (the number of ads placed for the content) are given by

$$\alpha^{UA} = 2 - \frac{4k\beta(1-\gamma^2)}{m\phi^2},$$

$$q_1^{UA} = q_2^{UA} = q^{UA} = \frac{v[m\phi^2-2k\beta(1-\gamma^2)]}{\phi[4k\beta(1-\gamma^2)-m\phi^2]},$$

$$d^{UA} = \frac{kv(1-\gamma^2)}{4k\beta(1-\gamma^2)-m\phi^2}.$$

Plugging in α^{UA}, q^{UA}, and d^{UA}, we can simplify the platform's and the content creators' payoffs to

$$\pi_{C_1}^{UA} = \pi_{C_2}^{UA} = \pi_C^{UA} = \frac{kv^2[2k\beta(2-\gamma)(1-\gamma^2)-m\phi^2][m\phi^2-2k\beta(1-\gamma^2)]}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2},$$

and

$$\pi_P^{UA} = \frac{2k^2v^2\beta(1-\gamma)^2(1+\gamma)}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]}.$$

Following the extant literature (e.g., Singh and Vives 1984, Kind et al. 2009), the net utility $U(x_1, x_2)$ is the consumer surplus CS, and $U(x_1, x_2) + \pi_{C_1}^{UA} + \pi_{C_2}^{UA} + \pi_P^{UA}$ is the social welfare. One can show that the equilibrium consumer surplus and social welfare are given by

$$CS^{UA} = \frac{k^2v^2\beta^2(1-\gamma)^2(1+\gamma)}{[4k\beta(1-\gamma^2)-m\phi^2]^2},$$

and

$$SW^{UA} = \frac{kv^2\{\phi^2(1-\gamma^2)[\beta(1-\gamma)+2m(5-\gamma)]k\beta-8(1-\gamma^2)^2k^2\beta^2-2m^2\phi^4\}}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2}.$$

Creator substitutability (γ) plays an important role in the content market. Proposition 1 summarizes how creator substitutability affects the market outcome under uniform advertising (UA). The proof is given in the Online Appendix.

PROPOSITION 1. *Under the UA format, as creator substitutability (γ) increases,*

(a) the platform's optimal ad revenue-sharing rate increases; mathematically, $\frac{\partial \alpha^{UA}}{\partial \gamma} > 0$;

(b) each content creator's optimal content quality increases; mathematically, $\frac{\partial q^{UA}}{\partial \gamma} > 0$;

(c) the platform's optimal ad intensity increases; mathematically, $\frac{\partial d^{UA}}{\partial \gamma} > 0$;

(d) the platform's profit first decreases and then increases; mathematically, there exists $\gamma_1 > 0$

such that $\frac{\partial \pi_P^{UA}}{\partial \gamma} < 0$ *if* $\gamma < \gamma_1$ *and* $\frac{\partial \pi_P^{UA}}{\partial \gamma} > 0$ *if* $\gamma > \gamma_1$;

(e) each content creator's profit can increase or decrease; mathematically, there exists γ_2 *and* γ_3

such that $\frac{\partial \pi_C^{UA}}{\partial \gamma} > 0$ *when* $\gamma_2 < \gamma < \gamma_3$ *and* $\frac{\partial \pi_C^{UA}}{\partial \gamma} < 0$ *when* $\gamma < \gamma_2$ *or* $\gamma > \gamma_3$;

(f) the consumer surplus first decreases and then increases; mathematically, there exists $\gamma_4 > 0$

*such that* $\frac{\partial CS^{UA}}{\partial \gamma} < 0$ *if* $\gamma < \gamma_4$ *and* $\frac{\partial CS^{UA}}{\partial \gamma} > 0$ *if* $\gamma > \gamma_4$.

Proposition 1(a), 1(b), and 1(c) show that as creator substitutability (γ) increases, the optimal ad

revenue-sharing rate, content quality, and advertising intensity will increase. The intuition is as follows.

As the level of substitutability between content creators increases, the consumer tends to consume less

of their content. To mitigate the reduction in content consumption, the platform can either reduce the

number of ads shown for the content (i.e., advertising intensity) or share more ad revenue with content

creators to encourage them to increase the quality of their content. Under UA, since the platform sets

the same number of ads for all content, the two content creators compete for consumers in terms of

content quality *only*. As creator substitutability increases, the consumer will be less likely to consume

a creator's content if she has consumed the competing creator's content. Thus, competition between the

content creators becomes more intense, and the content creators will have more pressure to increase

their content quality to attract consumers because a creator with lower quality will lose a lot of

consumption to the competitor due to the high substitutability of their content. For this reason, as γ

increases, to mitigate the reduction in content consumption, the platform finds it more efficient to

incentivize high-quality content production than reduce the number of ads shown to the consumer. That

is, the platform will increase its revenue-sharing rate as creator substitutability increases. Since the content creators are motivated to produce higher-quality content, the platform will optimally show more ads for the content as creator substitutability increases.

Figure 2 Impacts of γ under UA

$$(v = 1, \beta = 1, m = 1, \phi = 1, k = 0.4)$$

(a)

(b)

(c)
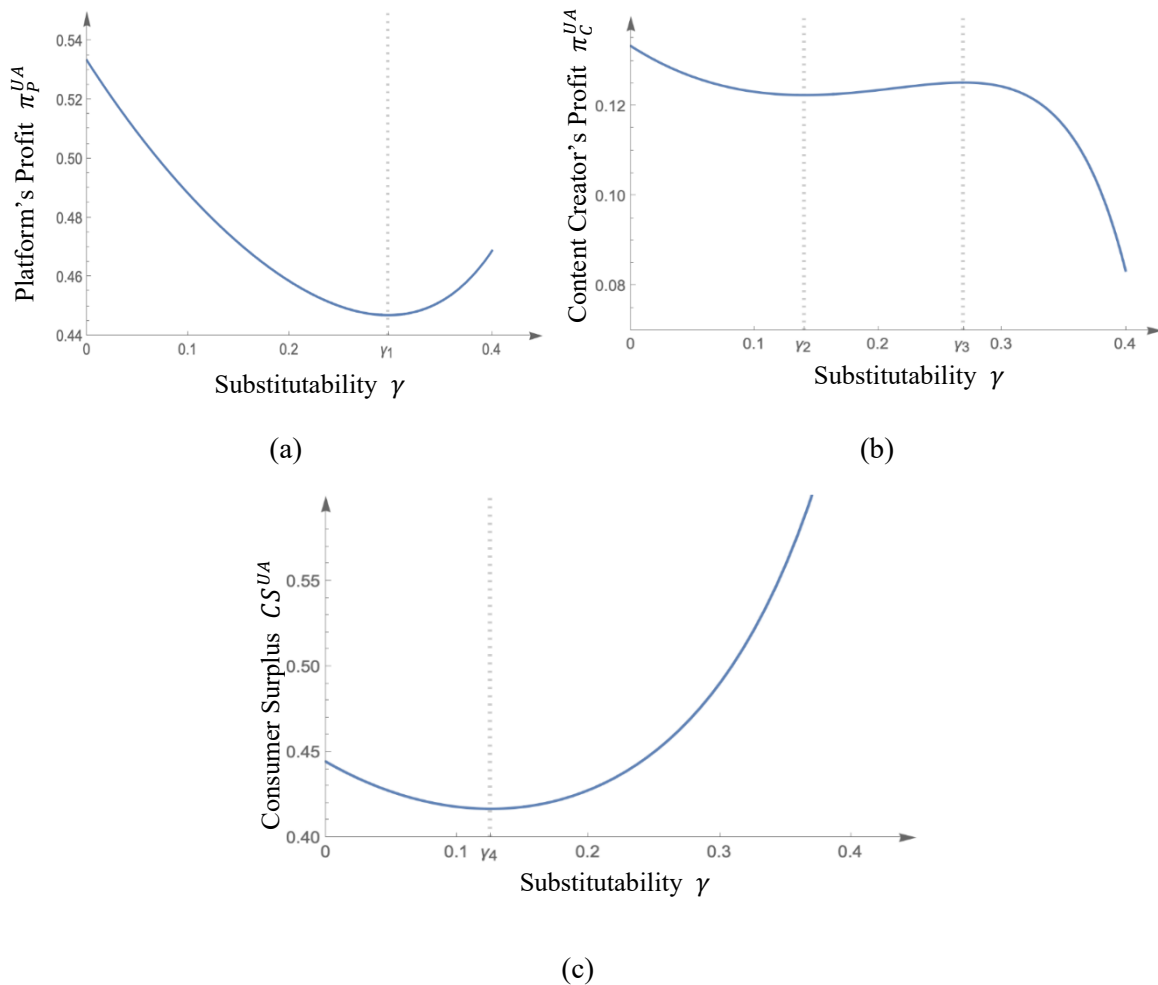
Proposition 1(d) demonstrates that the platform's profit may not necessarily be monotonic in γ. As Figure 2(a) shows, the net impact of creator substitutability on the platform's equilibrium profit exhibits a U-shape. Recall that as the substitutability between content creators increases, the consumer tends to consume less of their content. Thus, one may intuit that the platform will become worse off as the substitutability between content creators increases. However, as we have discussed, when the

substitutability between content creators increases, the content creators are more inclined to increase the quality of their content, which is beneficial to the platform. When creator substitutability is low, an increase in substitutability will significantly reduce the consumer's content consumption. But because creator substitutability is still relatively low, the content creators will not aggressively raise the content quality. So, overall, the negative effect of the reduced content consumption will dominate the positive effect of the increased content quality, making the platform worse off. By contrast, when creator substitutability is high, the impact of a marginal increase in substitutability on the overall content consumption will not be very significant, and the induced increase in content quality plays a more important role, making the platform better off.

Conventional wisdom might suggest that an increase in the substitutability between content creators will hurt the content creators due to intensified competition. However, Proposition 1(e) shows that the content creators can either benefit or hurt from increased substitutability between them. The intuition lies in the platform's strategic ad revenue-sharing decision. As shown in Proposition 1(a), as the substitutability between content creators increases, the platform will increase the revenue-sharing rate to share a higher fraction of ad revenue with the content creators. That is, an increase in substitutability has two opposing effects on the content creators—the negative effect of increased competition and the positive effect of a higher ad revenue-sharing rate from the platform. As illustrated in Figure 2(b), when the substitutability between content creators is in the middle region, the creators' loss from increased competition can be covered by their benefit from a higher revenue-sharing rate. Thus, the content creators can benefit from increased competition when γ is in the middle range. By contrast, when the substitutability between content creators is low or very high, the creators' loss from intensified competition will dominate their benefit from a higher revenue-sharing rate, leading to lower profits for

the content creators as γ increases.

As illustrated in Figure 2(c), Proposition 1(f) shows that the consumer surplus will first decrease and then increase as the substitutability between content creators increases. As γ increases and competition between content creators intensifies, on the one hand, the consumer tends to consume less of the creators' content; on the other hand, the content creators have incentives and are also motivated by the platform to produce higher-quality content. The former effect tends to reduce the consumer surplus, whereas the latter effect will increase the consumer surplus. When creator substitutability is low, the marginal impact of the increased substitutability on consumption is significant, while the content creators' incentives to increase content quality are relatively low. Consequently, as γ increases in the low range, the negative, direct effect on the consumer's overall content consumption will dominate the positive, strategic effect on content quality, resulting in lower consumer surplus. By contrast, when creator substitutability is already high, the direct effect of a marginal increase in substitutability on consumption is not as significant, and the strategic impact of increased content quality will dominate, leading to higher consumer surplus.

4.2. Differentiated Advertising (DA)

This subsection analyzes the differentiated-advertising format, under which the platform can set different numbers of ads for different content based on content quality. Such content-based advertising is common in practice. For example, YouTube conditions pre-roll video ads on content performance, and these ads can be up to 15 seconds long (Google 2021). We now examine how differentiated advertising will influence the interaction between the platform and the content creators.

Under DA, the platform can choose different advertising intensities (d_i, i.e., the number of ads shown for the content) based on the creator's content quality (q_i). From equation (1), the consumer's amount

of consumption for creator i's content is $x_i = \frac{1}{1-\gamma^2}[v(1-\gamma) + (\phi q_i - \beta d_i) - \gamma(\phi q_{i'} - \beta d_{i'})], i = \{1,2\}, i \neq i'$. The content creators and the platform maximize their respective profits:

$$\pi_{C_i}(q_i) = \alpha m x_i d_i - k q_i^2, \tag{4}$$

$$\pi_P(\alpha) = (1-\alpha)m(x_1 d_1 + x_2 d_2). \tag{5}$$

We solve the game by backward induction. Following the analysis under UA, we focus on the case where all market participants earn positive payoffs under the differentiated-advertising format. That is, the creators' content production efficiency k satisfies $\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$ for the remainder of this subsection. We use the superscript DA to indicate the subgame equilibrium outcome under differentiated advertising. The equilibrium ad revenue-sharing rate, content qualities, and advertising intensities are given by

$$\alpha^{DA} = 2 - \frac{8k\beta(1-\gamma^2)}{m\phi^2(2-\gamma)},$$

$$q_1^{DA} = q_2^{DA} = q^{DA} = \frac{v[m\phi^2(2-\gamma) - 4k\beta(1-\gamma^2)]}{\phi[8k\beta(1-\gamma^2) - m\phi^2(2-\gamma)]},$$

$$d_1^{DA} = d_2^{DA} = d^{DA} = \frac{2kv(1-\gamma^2)}{8k\beta(1-\gamma^2) - m\phi^2(2-\gamma)}.$$

Substitution of the above solutions into (4) and (5) allows us to simplify the platform's and the content creators' profits to

$$\pi_{C_1}^{DA} = \pi_{C_2}^{DA} = \pi_C^{DA} = \frac{kv^2[m\phi^2(2-\gamma) - 4k\beta(1-\gamma^2)][4k\beta(1-\gamma^2)(4-3\gamma) - m\phi^2(2-\gamma)^2]}{\phi^2(2-\gamma)[8k\beta(1-\gamma^2) - m\phi^2(2-\gamma)]^2},$$

and

$$\pi_P^{DA} = \frac{8k^2v^2\beta(1-\gamma)^2(1+\gamma)}{\phi^2(2-\gamma)[8k\beta(1-\gamma^2) - m\phi^2(2-\gamma)]}.$$

The consumer surplus and social welfare are given by

$$CS^{DA} = \frac{4k^2v^2\beta^2(1-\gamma)^2(1+\gamma)}{[8k\beta(1-\gamma^2) - m\phi^2(2-\gamma)]^2},$$

and

$$SW^{DA} = \frac{2kv^2\{2\phi^2(1-\gamma^2)[\beta(1-\gamma) + 2m(5-3\gamma)]k\beta - 16(1-\gamma^2)^2 k^2\beta^2 - m^2\phi^4(2-\gamma)^2\}}{\phi^2[8k\beta(1-\gamma^2) - m\phi^2(2-\gamma)]^2}.$$

One can see that the substitutability (γ) between content creators also plays an important role under

the DA format. Proposition 2 summarizes the impacts of γ on the equilibrium outcome under DA.

Figure 3 provides an illustration of how γ affects the platform's and the content creators' equilibrium

profits and the consumer surplus.

PROPOSITION 2. *Under the DA format, as creator substitutability (γ) increases,*

(a) the platform's optimal ad revenue-sharing rate first decreases and then increases;

mathematically, $\frac{\partial \alpha^{DA}}{\partial \gamma} < 0$ if $\gamma < 2 - \sqrt{3}$ and $\frac{\partial \alpha^{DA}}{\partial \gamma} > 0$ if $\gamma > 2 - \sqrt{3}$;

(b) each content creator's optimal content quality first decreases and then increases; mathematically,

$\frac{\partial q^{DA}}{\partial \gamma} < 0$ if $\gamma < 2 - \sqrt{3}$ and $\frac{\partial q^{DA}}{\partial \gamma} > 0$ if $\gamma > 2 - \sqrt{3}$;

(c) the platform's optimal ad intensity first decreases and then increases; mathematically, $\frac{\partial d^{DA}}{\partial \gamma} <$

0 if $\gamma < 2 - \sqrt{3}$ and $\frac{\partial d^{DA}}{\partial \gamma} > 0$ if $\gamma > 2 - \sqrt{3}$;

(d) the platform's profit first decreases and then increases; mathematically, there exists $\gamma_5 > 0$

such that $\frac{\partial \pi_P^{DA}}{\partial \gamma} < 0$ if $\gamma < \gamma_5$ and $\frac{\partial \pi_P^{DA}}{\partial \gamma} > 0$ if $\gamma > \gamma_5$;

(e) each content creator's profit can decrease or increase; mathematically, when $k < \frac{m\phi^2}{4\beta}$, there

exists γ_6 such that $\frac{\partial \pi_C^{DA}}{\partial \gamma} > 0$ if $\gamma < \gamma_6$ and $\frac{\partial \pi_C^{DA}}{\partial \gamma} < 0$ if $\gamma > \gamma_6$; when $k > \frac{m\phi^2}{4\beta}$, there exists

γ_7 and γ_8 such that $\frac{\partial \pi_C^{DA}}{\partial \gamma} > 0$ if $\gamma_7 < \gamma < \gamma_8$ and $\frac{\partial \pi_C^{DA}}{\partial \gamma} < 0$ if $\gamma < \gamma_7$ or $\gamma > \gamma_8$;

(f) the consumer surplus first decreases and then increases; mathematically, there exists $\gamma_9 > 0$

such that $\frac{\partial CS^{DA}}{\partial \gamma} < 0$ if $\gamma < \gamma_9$ and $\frac{\partial CS^{DA}}{\partial \gamma} > 0$ if $\gamma > \gamma_9$.

Proposition 2(a), 2(b), and 2(c) show that the optimal ad revenue-sharing rate, content quality, and

advertising intensity under DA exhibit a U-shaped relationship with creator substitutability. These

results differ from those under UA (see Proposition 1(a), 1(b), and 1(c)). If the two content creators

become more substitutable (i.e., as γ increases), the consumer tends to reduce the overall consumption of content, and the platform can mitigate the consumption reduction by either reducing the number of ads (advertising intensity) or sharing more ad revenue with the content creators to encourage high-quality content production. Under UA, the platform sets the same number of ads for all content regardless of quality, and the two content creators can compete for the consumer's consumption solely by increasing content quality. If a creator has lower content quality than the competitor, the consumer will shift some consumption to the competitor's content, which will reduce the creator's profit from shared advertising revenue. By contrast, under DA, since the platform can set different numbers of ads for content with different quality levels, the two creators do not have to compete as aggressively on quality as they do under UA. Under DA, each content creator knows that if she creates lower quality than her competitor, she will not lose as much consumption as she will under UA because the platform will have an incentive to lower the advertising intensity (the number of ads displayed) for lower quality content. Thus, the DA format tends to weaken the creators' competition in content quality relative to the UA format. So, as γ increases, the platform's best response under DA is not always to raise the revenue-sharing rate anymore; rather, it may want to reduce the advertising intensity. When creator substitutability (γ) is low, the competition between the content creators is not high, and their incentives to increase content quality are relatively low. As creator substitutability increases, to mitigate the consumer's reduction in content consumption, the platform will find it more efficient to reduce the number of ads for the content than to raise the revenue-sharing rate to incentivize high-quality content production. Moreover, the platform will actually *reduce* the revenue-sharing rate to compensate for lowered advertising intensity. The decreased ad revenue-sharing rate in turn weakens the content creators' incentive to invest in content quality. By contrast, when creator substitutability is high, quality

competition is intense, and the platform will find it more effective to raise the revenue-sharing rate to incentivize content creators to increase content quality rather than to reduce the number of ads to appease the consumer. The increased content quality, in turn, enables the platform to show more ads for the content.

Proposition 2(d) shows that the platform's profit will first decrease and then increase as creator substitutability increases. The result is qualitatively the same as that under the UA format (see Proposition 1 (d)). As we have analyzed in Proposition 1(d), an increase in the substitutability between content creators can exert two effects on the platform's profit. On the one hand, it tends to reduce the consumer's total content consumption; on the other hand, the content creators are more inclined to increase the quality of their content. When creator substitutability is low, the first negative effect dominates the second positive effect, and the increased creator substitutability reduces the platform's profit. When the substitutability between content creators is high, the second positive effect becomes very prominent and improves the platform's profit as the creators' substitutability increases.

Proposition 2(e) shows that as the content creators' substitutability (γ) increases, their profits can either decrease or increase. The intuition hinges on the tradeoff between the direct, negative effect of an increase in creator substitutability and its strategic effect on the platform's ad revenue-sharing decision. As in the UA format, we find that the content creators can gain from the platform's strategically increased revenue-sharing rate (see Proposition 2(a)), making them better off overall. Moreover, as illustrated in Figure 3(b), as γ increases, even when the platform strategically reduces the revenue-sharing rate, the content creators can still benefit from increased creator substitutability. This result complements the finding under UA and only happens when the creators are very efficient in content production (i.e., when $k < \frac{m\phi^2}{4\beta}$). This is because the decreased revenue-sharing rate can

moderate content competition between creators. In particular, when the creators are very efficient in content production, they will compete heavily on content quality. In that case, a lower revenue-sharing rate will significantly reduce the creators' incentive for high-quality content production, which not only offsets the impact of the increased substitutability but also saves a lot of costs for content creators. It turns out that the creators' saved costs can cover their loss from the lowered revenue-sharing rate, leading to higher profits for the content creators as γ increases.

Figure 3 Impacts of γ under DA

$$(v = 1, \beta = 1, m = 1, \phi = 1)$$

(a) $k = 0.4$

(I) $k = 0.248$
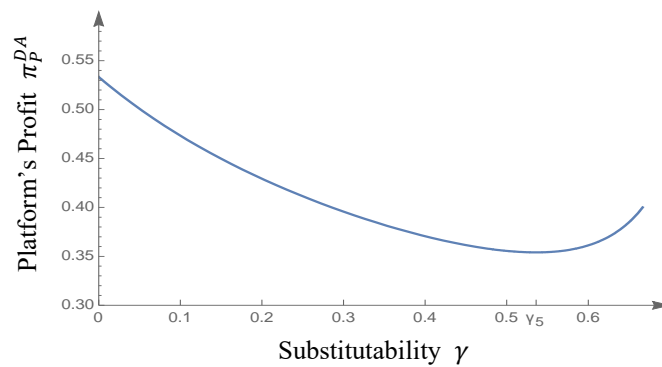
(II) $k = 0.4$
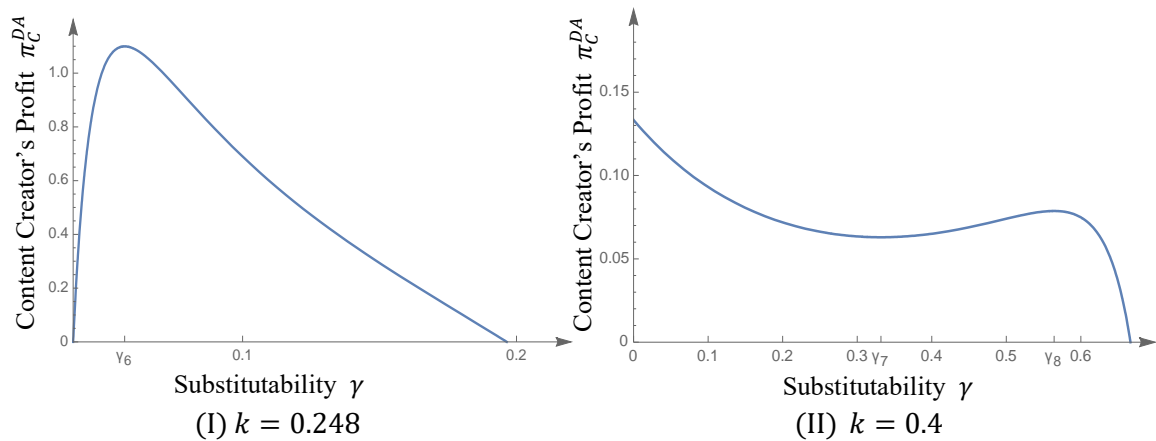
(b)

(c) $k = 0.4$

Proposition 2(f) shows that, under DA, the consumer surplus first decreases and then increases as the substitutability between content creators increases. Though the consumer tends to reduce content consumption as creator substitutabilit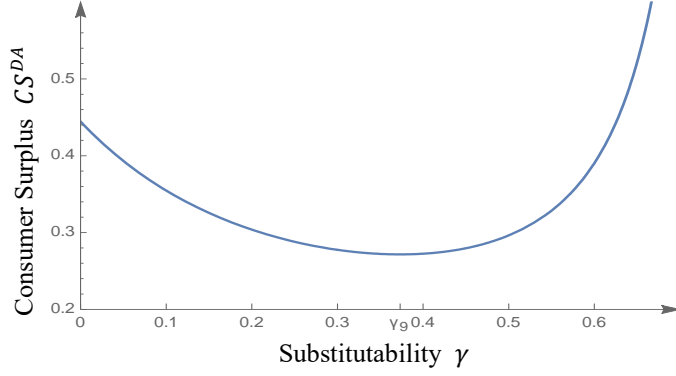y increases, the content creators will have more pressure to raise content quality, and the platform may also increase its ad revenue-sharing rate to encourage the creators to increase their content quality. When creator substitutability is low, the platform lowers its revenue-sharing rate in response to increased creator substitutability, which induces the creators to decrease content quality. Thus, the increased creator substitutability and lower content quality levels will reduce the consumer surplus. By contrast, when creator substitutability is high, an incremental increase in the substitutability will induce the platform to raise its revenue-sharing rate, which further incentivizes the content creators to increase content quality. For the consumer, the increased consumption value from increased content quality can offset the reduction in utility from increased substitutability between content creators, thus increasing the consumer surplus.

4.3. Comparison between DA and UA

We now compare the equilibrium outcomes under DA and UA formats. Our analysis has shown that when content is very costly for content creators to produce (i.e., $k \geq \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$), the platform under DA will not be able to profitably share ad revenues with creators to induce them to produce content on the

platform. When content creators can produce content very efficiently (i.e., $k \leq \frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}$), the

platform under UA will be able to share just enough ad revenue to induce the content creators to produce

high-quality content to make zero equilibrium profit. For non-trivial analysis, we focus on the case of

$\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$ for the remainder of this section, to ensure that all market participants

earn positive payoffs under both UA and DA formats. Proposition 3 presents the comparison of the

equilibrium revenue-sharing rates, content qualities, and advertising intensities.

PROPOSITION 3. $\alpha^{DA} < \alpha^{UA}$, $q^{DA} < q^{UA}$, and $d^{DA} < d^{UA}$.

Proposition 3 shows that the equilibrium ad revenue-sharing rate, content quality, and advertising

intensity will be lower under DA than those under UA. Note that DA reduces quality competition

relative to UA even though, in equilibrium, the two content creators choose the same quality for their

content. Let us examine why DA helps reduce content quality competition relative to UA. As explained

before, under UA, the platform sets the same number of ads for all content regardless of quality, and

the two content creators can use only quality to compete for the consumer's consumption. In that case,

a creator has an incentive to increase her content quality to exceed the competitor's quality or avoid

being undercut in quality because, since the same number of ads are shown regardless of content quality,

the consumption of the creator's content will be low if she has lower quality than the competitor. To

increase the consumer's consumption of her content, the creator can only increase her content quality

even when it will have to incur a high production cost. By contrast, under DA, the content creators do

not have to compete only on quality because the platform will reduce the advertising intensity (i.e., it

will show a smaller number of ads) for lower-quality content. The creator knows that under DA, she

can reduce content quality to save some cost without losing as much consumption from the consumer

as under UA because the platform will find it optimal to lower the number of ads for the lower-quality

content. In essence, the advertising intensity is the "price" for the creator's content that the consumer has to pay. Hence, the content creators have less incentive to invest in content quality under DA than that under UA. In other words, DA can help alleviate the quality competition between the two content creators. For this reason, the platform will choose a lower revenue-sharing rate under DA than under UA. The lower revenue-sharing rate further leads to lower content quality. Because of the lower content quality, the platform shows fewer ads for content under DA than under UA.

Proposition 4 summarizes the market participants' preferences between DA and UA. The results are illustrated in Figure 4.

PROPOSITION 4.

(a) $\pi_P^{DA} < \pi_P^{UA}$.

(b) There exists $\hat{\gamma}_1$ such that $\pi_C^{DA} < \pi_C^{UA}$ if $\gamma < \hat{\gamma}_1$ and $\pi_C^{DA} > \pi_C^{UA}$ if $\gamma > \hat{\gamma}_1$.

(c) $CS^{DA} < CS^{UA}$.

Proposition 4(a) and 4(c) show that the platform's equilibrium profit and the consumer surplus are lower under DA than under UA. The intuition also lies in the fact that content creators have a weaker incentive to invest in content quality and create lower-quality content under DA than under UA. One might wonder why in reality, some platforms choose DA over UA, while our main model predicts DA is less profitable for the platform than UA. Note that we have assumed that the content creators have symmetric cost efficiency in their content production (i.e., they have the same k). If one considers a model with asymmetric content creators, the platform may find DA more profitable than UA if the creators have asymmetric costs (k). We will shed more light on the asymmetric model in the discussion section.

Proposition 4(b) shows that each content creator's equilibrium profit under DA can be higher or lower

than that under UA. On the one hand, under DA, the platform can show different numbers of ads for content of different quality, which mitigates quality competition between the two content creators. On the other hand, under DA, the platform will set a lower revenue-sharing rate than under UA. When creator substitutability is low, content-quality competition is not fierce, in which case the content creators' gain from the reduced competition is dominated by the loss from the lower revenue-sharing rate, resulting in lower equilibrium profits for content creators under DA than under UA. By contrast, if creator substitutability is high, quality competition between the content creators is very fierce, in which case the creators' gain from the reduced competition by DA can cover the loss from the lowered revenue-sharing rate, making the content creators better off under DA than under UA.

Figure 4 Comparison between DA and UA

$$(v = 1, \beta = 1, m = 1, \phi = 1)$$
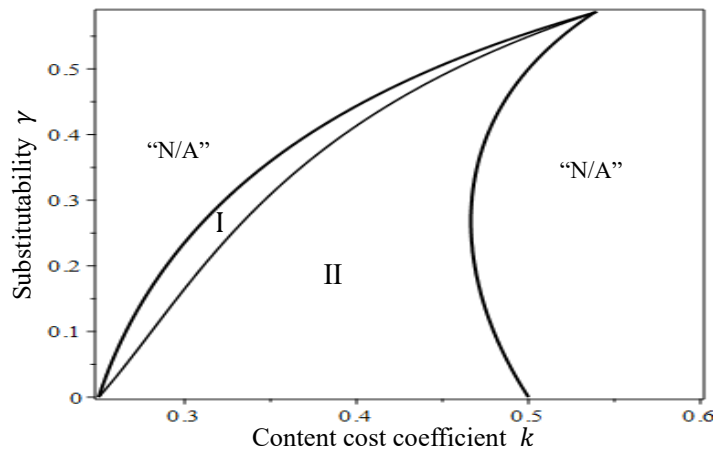
Notes: In Region I, $\pi_P^{UA} > \pi_P^{DA}$, $\pi_C^{UA} < \pi_C^{DA}$, $CS^{UA} > CS^{DA}$.
In Region II, $\pi_P^{UA} > \pi_P^{DA}$, $\pi_C^{UA} > \pi_C^{DA}$, $CS^{UA} > CS^{DA}$.

Proposition 4 shows that compared with UA, DA can lead to an all-lose outcome for the platform, the content creators, and the consumer (see Region II in Figure 4). This result suggests that when considering DA vs. UA, the content platforms and the content creators should think about the strategic effects of the advertising-format decision. While differentiated advertising sounds flexible, sometimes the uniform advertising format may not be a bad idea.

5. Creators-Set Advertising (CA)

Thus far, we have explored the two scenarios (UA an DA) where the platform determines the number of ads displayed for content on the platform. In practice, a content platform may consider allowing content creators themselves to choose the number of ads shown for their content. For example, YouTube has implemented the "partner-sold ads" program since 2010, which basically allows a creator to sell ads directly (Alexander 2020b). One may wonder how this emerging ad format affects the market outcome. We now analyze the scenario in which the content creators set the number of ads to display for their content. For ease of exposition, we use "CA" to denote this *creators-set advertising* format.

The game proceeds in three stages. First, the platform sets the ad revenue-sharing rate α. Second, the content creators determine their respective content quality q_i. Third, the content creators simultaneously choose the number of ads d_i for their respective content. We solve the game by backward induction. The derivation of the equilibrium results is given in the Supplemental Materials file. Following the main analysis, we focus on the case where all market participants earn positive payoffs under CA. That is, the creators' content production efficiency k satisfies $\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$ when we present the equilibrium results and examine the impacts of creator substitutability. We use a superscript *CA* to indicate the equilibrium results for this creators-set advertising scenario. The equilibrium ad revenue-sharing rate, content qualities, and advertising intensities (the number of ads shown for the content) are given by

$$\alpha^{CA} = 2 - \frac{k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}{m\phi^2(2-\gamma^2)},$$

$$q_1^{CA} = q_2^{CA} = q^{CA} = \frac{v[2m\phi^2(2-\gamma^2)-k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)]}{2\phi[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]},$$

$$d_1^{CA} = d_2^{CA} = d^{CA} = \frac{kv(2+\gamma)(2-\gamma)(1+\gamma)(1-\gamma)}{2[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]}.$$

The platform's and the content creators' profits are

$$\pi_{C_1}^{CA} = \pi_{C_2}^{CA} = \pi_C^{CA} = \frac{kv^2[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-2m\phi^2(2-\gamma^2)][2m\phi^2(2-\gamma^2)^2-k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)]}{4\phi^2(2-\gamma^2)[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^2},$$

and

$$\pi_P^{CA} = \frac{k^2v^2\beta(2+\gamma)^2(2-\gamma)^2(1+\gamma)(1-\gamma)}{2\phi^2(2-\gamma^2)[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]}.$$

The consumer surplus and social welfare are given by

$$CS^{CA} = \frac{k^2v^2\beta^2(1+\gamma)(2+\gamma)^2(2-\gamma)^2}{4[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^2},$$

and

$$SW^{CA} = \frac{kv^2\{\phi^2(2-\gamma)^2(1+\gamma)(2+\gamma)[\beta(2+\gamma)+2m(10-\gamma-5\gamma^2)]k\beta-2(2-\gamma)^4(1+\gamma)^2(2+\gamma)^2k^2\beta^2-8m^2\phi^4(2-\gamma^2)^2\}}{4\phi^2[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^2}.$$

Note that each content creator can determine the number of ads to show for her own content, and the two creators can potentially choose different numbers of ads. In this sense, the CA format is more similar to the aforementioned differentiated advertising (DA) format. The only difference is that the ad decision-maker is the platform under DA but the content creators under CA. We will shed light on the intuition of the CA results using the DA format for comparison.

Let us first examine the impact of creator substitutability. Proposition 5 summarizes the results under CA. Figure 5 illustrates the equilibrium profits (of the platform and the content creators) and the consumer surplus as a function of the substitutability between content creators.

PROPOSITION 5. *Under the CA format, as creator substitutability (γ) increases,*

(a) the platform's optimal ad revenue-sharing rate decreases; mathematically, $\frac{\partial \alpha^{CA}}{\partial \gamma} < 0$;

(b) each content creator's optimal content quality decreases; mathematically, $\frac{\partial q^{CA}}{\partial \gamma} < 0$;

(c) the optimal ad intensity decreases; mathematically, $\frac{\partial d^{CA}}{\partial \gamma} < 0$;

(d) the platform's profit decreases; mathematically, $\frac{\partial \pi_p^{CA}}{\partial \gamma} < 0$;

(e) each content creator's profit can decrease or increase; mathematically, when $k < \frac{m\phi^2}{4\beta}$, there

exists γ_{10} *such that* $\frac{\partial \pi_c^{CA}}{\partial \gamma} > 0$ *if* $\gamma < \gamma_{10}$ *and* $\frac{\partial \pi_c^{CA}}{\partial \gamma} < 0$ *if* $\gamma > \gamma_{10}$; *when* $k > \frac{m\phi^2}{4\beta}$,

$\frac{\partial \pi_c^{CA}}{\partial \gamma} < 0$;

(f) the consumer surplus can decrease or increase; mathematically, there exists γ_{11} *and* γ_{12} *such*

that $\frac{\partial CS^{CA}}{\partial \gamma} > 0$ *when* $\gamma_{11} < \gamma < \gamma_{12}$ *and* $\frac{\partial CS^{CA}}{\partial \gamma} < 0$ *when* $\gamma < \gamma_{11}$ *or* $\gamma > \gamma_{12}$.

First, Proposition 5(a) shows that as creator substitutability (γ) increases, the platform reduces its ad

revenue-sharing rate. This result differs from the result under DA (see Proposition 2(a)), where, as the

creator substitutability increases, the platform can mitigate this consumer's consumption-decreasing

tendency by *increasing* the revenue-sharing rate to encourage the content creators to increase content

quality. Proposition 2(a) shows that under DA, such a response is beneficial to the platform in certain

situations. By contrast, Proposition 5(a) shows that under CA, the platform will actually *reduce* its

revenue-sharing rate when creator substitutability increases. The CA format enables the content creators

to set the number of ads directly, which will moderate the competition in content quality even more than

the DA format, under which it is the platform that sets differentiated advertising based on the platform's

profit incentive rather than the content creators' incentives. Consequently, a higher revenue-sharing rate

cannot compel content creators to invest in quality as much as it can under the DA format. As a result,

the platform under CA will no longer find it optimal to raise the revenue-sharing rate. Rather, the

platform will reduce the revenue-sharing rate to offset the reduction in content consumption as creator

substitutability increases. Moreover, Proposition 5(b) and 5(c) show that as creator substitutability

increases, the decreased revenue-sharing rate weakens the creators' motivation to invest in content

production, which, in turn, decreases the number of ads the creators will show for their content.

Proposition 5(d) further shows that as γ increases, the platform's increased revenue margin cannot

fully offset the loss of reduced content consumption induced by increased creator substitutability and
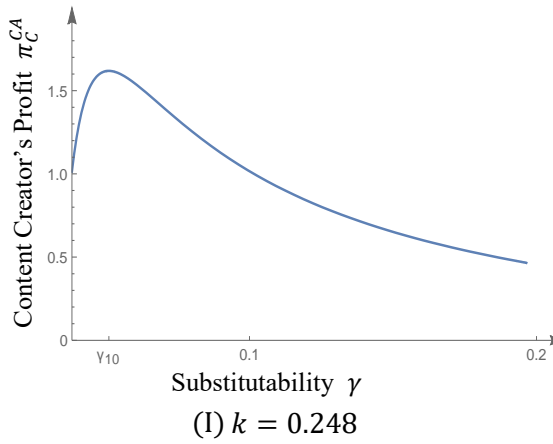
lower content quality, making the platform worse off.

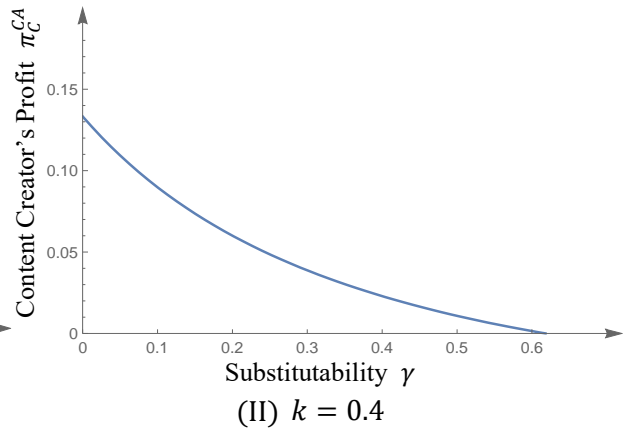**Figure 5 Impacts of γ under CA**

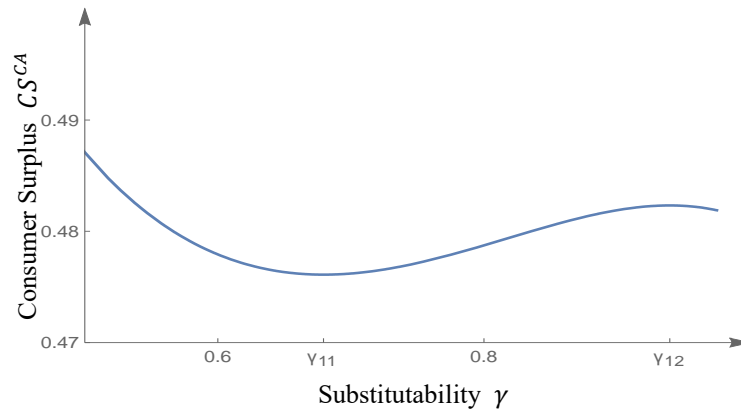$$(v = 1, \beta = 1, m = 1, \phi = 1)$$
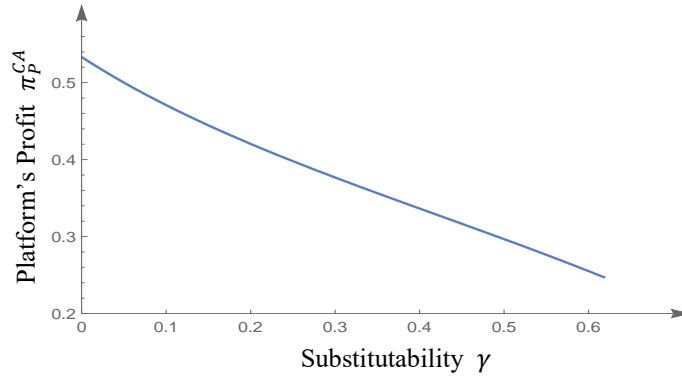
(a) $k = 0.4$

(I) $k = 0.248$

(II) $k = 0.4$

(b)

(c) $k = 0.34$

Proposition 5(e) shows that each content creator's profit can increase or decrease as creator substitutability increases. The intuition hinges on the tradeoff between the direct, negative effect of an increase in creator substitutability and its strategic effect on the platform's ad revenue-sharing decision. As γ increases, the platform reduces its ad revenue-sharing rate. As we have discussed in Proposition 2(e), the lowered revenue-sharing rate can moderate content competition and therefore save some production costs for content creators. When the creators are efficient in content production and creator substitutability is low, the saved costs can offset the impact of the increased substitutability and cover the loss from the lowered revenue-sharing rate, making the creators better off as γ increases. By contrast, when the creators are not efficient in content production, the saved costs can no longer overturn the impacts of the increased substitutability and the lowered revenue-sharing rate, leading to lower profits for creators as γ increases.

Proposition 5(f) shows that as creator substitutability increases, the consumer surplus will either decrease or increase. The intuition hinges on the following tradeoff. As creator substitutability increases, first, both content quality and the overall content consumption decrease; second, content creators will place fewer ads for their content. When γ is very low, content competition between the two creators is weak. In such a situation, content creators' incentives to reduce the advertising intensity are low; hence the first negative effect dominates, and thus an increase in creator substitutability decreases the consumer surplus. When γ is in the middle range, the content creators' incentives to reduce advertising intensity will be relatively high. In such a situation, the second positive effect dominates; thus, an increase in creator substitutability increases the consumer surplus. When γ is very high, an increase in creator substitutability significantly decreases the consumer's total content consumption. In this case, the consumer's benefit from fewer ads will be covered by the loss from reduced content consumption.

Thus, an increase in creator substitutability will reduce the consumer surplus when γ is high.

Next, we compare the equilibrium outcomes under CA and DA formats. Following the main analysis, we focus on the parameter conditions under which the cost coefficient k of content production satisfies $\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$ such that both the platform and the content creators earn positive equilibrium profits under both CA and DA formats. Proposition 6 provides a comparison of the equilibrium ad revenue-sharing rates, content qualities, and advertising intensities.

PROPOSITION 6. $\alpha^{CA} < \alpha^{DA}$, $q^{CA} < q^{DA}$, and $d^{CA} < d^{DA}$.

Proposition 6 shows that the equilibrium ad revenue-sharing rate, content quality, and advertising intensity are lower under CA than under DA. Note that under CA, the content creators can set the number of ads themselves and use both advertising intensity and content quality to compete for the consumer's consumption. In comparison with DA under which the platform decides the number of ads for all content, the content creators have more flexibility in setting ad numbers under CA. When it is costly to improve content quality, it will be optimal for the creators to reduce the advertising intensity to attract consumers rather than to do so by producing very high content quality. Note that under DA, the platform sets the advertising intensity based on the platform's total profits rather than the creator's profit. With CA, the creators can fully flexibly reduce the advertising intensity to attract consumers rather than relying on the platform, i.e., CA gives the creators a direct "price" lever to attract consumers in addition to content quality. Thus, the content creators have less pressure to produce high content quality under CA than under DA. As a result, the platform will choose a lower revenue-sharing rate under CA than under DA, the content creators will invest less in content quality, and fewer ads will be shown for content under CA than under DA.

As illustrated in Figure 6, the market participants' preferences between CA and DA depend on the

substitutability between content creators. Proposition 7 summarizes the comparison results of the profits (of the platform and the content creators) and the consumer surplus.

PROPOSITION 7.

(a) $\pi_P^{CA} < \pi_P^{DA}$.

(b) There exists $\hat{\gamma}_2$ such that $\pi_C^{CA} < \pi_C^{DA}$ if $\gamma < \hat{\gamma}_2$ and $\pi_C^{CA} > \pi_C^{DA}$ if $\gamma > \hat{\gamma}_2$.

(c) There exists $\hat{\gamma}_3(< \hat{\gamma}_2)$ such that $CS^{CA} > CS^{DA}$ if $\gamma < \hat{\gamma}_3$ and $CS^{CA} < CS^{DA}$ if $\gamma > \hat{\gamma}_3$.

Proposition 7(a) shows that the platform's equilibrium profit is lower under CA than under DA. This is because the content creators have less incentive to invest in content quality and the equilibrium content quality is lower under CA than under DA. Proposition 7(b) shows that the content creators' preferences between CA and DA are moderated by the substitutability between content creators. Contrary to the conventional wisdom that the content creators should prefer holding the decision right for the advertising intensity, we find that the content creators' profits can be lower under CA than under DA when creator substitutability is not very high (e.g., when $\gamma < \hat{\gamma}_2$). To understand this result, note that the platform will share a lower fraction of ad revenue with the content creators under CA than under DA. When creator substitutability is not very high, content competition between the two content creators is not very intense, so the creators' benefit from holding the decision right for the advertising intensity is not significant enough to cover the loss induced by the lowered revenue-sharing rate, thus making the content creators' profits lower under CA than under DA.

Proposition 7(c) shows that the consumer surplus can be higher or lower under CA than under DA. Under CA, on the one hand, the content quality is lower; on the other hand, fewer ads will be shown for the content. When creator substitutability is low, CA reduces the content quality to a lesser extent than it induces lower advertising intensity (fewer ads for the content), so the consumer surplus is higher

under CA than under DA. By contrast, when creator substitutability is high, CA will reduce the content quality more than it increases the benefit of fewer ads to the consumer, thus making the consumer surplus lower under CA than under DA.

Figure 6 Comparison between CA and DA

$$(v = 1, \beta = 1, m = 1, \phi = 1)$$
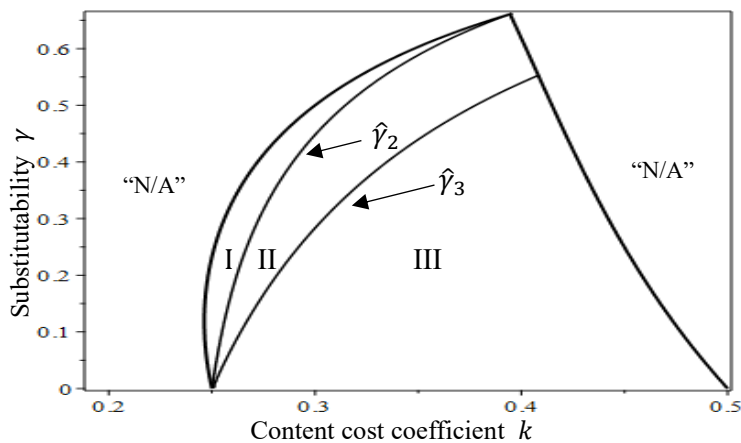
Notes: In Region I, $\pi_P^{CA} < \pi_P^{DA}$, $\pi_C^{CA} > \pi_C^{DA}$, $CS^{CA} < CS^{DA}$.

In Region II, $\pi_P^{CA} < \pi_P^{DA}$, $\pi_C^{CA} < \pi_C^{DA}$, $CS^{CA} < CS^{DA}$.

In Region III, $\pi_P^{CA} < \pi_P^{DA}$, $\pi_C^{CA} < \pi_C^{DA}$, $CS^{CA} > CS^{DA}$.

Proposition 7 shows that compared with DA, CA can lead to an all-lose outcome for the platform, the content creators, and the consumer (in Region II in Figure 6, where $\hat{\gamma}_3 < \gamma < \hat{\gamma}_2$). This result has important managerial implications for the content market. As observed in practice, some platforms (e.g., YouTube and Twitch) have allowed content creators to determine the advertising intensity for their own content. Our results suggest that this might benefit the platform or the creators if their strategic decisions regarding ad revenue sharing or content quality are considered. Our results also provide some testable hypotheses for future empirical research in this area. For example, our results suggest that platforms with CA tend to have lower content quality and less advertising intensity than those with DA.

6. Discussions

This section provides further discussions about our model and results. First, our main model assumes

that there are only two content creators in the market. In practice, a platform usually deals with a large number of content creators. In part C of the Supplemental Materials file, we have first analyzed a model with $N > 2$ creators. We demonstrate that the impacts of ad format on the creators' incentives to invest in content quality remain the same as those in the main model; thus, our main results are qualitatively the same as those in the main model. Furthermore, we have also analyzed a model in which the content creators are heterogeneous in their entry costs. Specifically, we assume that there are $\bar{N}$ potential creators in the content market and the content creators' entry costs are uniformly distributed over $[0, \bar{C}]$. A creator joins the platform only if the creator can obtain a non-negative profit. Our analysis shows that the main results regarding the platform's ad format preference remain qualitatively the same as those in the main model.

Second, our main model has assumed that the content creators are symmetric in content production efficiency. In reality, content creators may have very asymmetric cost efficiency. To check the robustness and boundary of our findings, we have analyzed a model with asymmetric content creators (the detailed analysis is given in part B of the Supplemental Materials file). We find that our results hold qualitatively the same when the two content creators are not too asymmetric in content production efficiency. For example, the platform still prefers the UA format to the DA format. However, when the asymmetric level in content production efficiency between content creators is relatively high, we observe that the platform's preferences towards ad formats can change qualitatively. In that case, the platform would prefer DA to UA. This may explain why in reality, some platforms choose DA over UA, while our main model (i.e., the symmetric model) predicts that DA is less profitable for the platform than UA. Note that when the level of asymmetry in content production efficiency is low, the two creators are comparable to each other. Since the creators' competition in content quality is stronger under UA

than under DA, the platform prefers UA to DA. In contrast, when the production efficiency of the two content creators is very asymmetric, the increased quality competition for creators under UA relative to DA is not very significant. Meanwhile, because under UA the same number of ads are shown for all content regardless of quality, the more efficient creator has less incentive to produce high-quality content under UA than under DA since she does not expect to obtain high enough compensation from displaying ads under UA. In other words, the DA format provides the more efficient content creator with stronger motivation to invest in content quality than the UA format. We do find that the more efficient content creator will produce higher-quality content under DA than under UA when the cost asymmetry between the content creators is relatively high. Moreover, as the cost asymmetry between the content creators increases, the platform will be more dependent on the more efficient creator's content creation; thus, the platform would prefer DA to UA when the asymmetry in production efficiency between the creators is high.

Third, we have assumed that the content creators on the platform are substitutable to each other in our main model. In part D of the Supplemental Materials file, we study a new model with complementarity between the content creators. In the new model, the representative consumer's net utility can be rewritten as $U(x_i, q_i, d_i) = \sum_{i=1}^{n}(x_i(v + \phi q_i - \beta d_i) - \frac{1}{2}x_i^2) + \gamma \sum_{i \neq i'}^{n} x_i x_{i'}$, by replacing γ in the main model with $-\gamma$, where $\gamma \in (0,1)$. The higher γ is, the more complementary the creators are in the eyes of the consumer. Other aspects of the model are the same as those in our main model. Since creator complementarity entails opposite forces than creator substitutability, the new model has yielded several novel findings that are different from those in the main model. *First*, regardless of the ad formats (UA or DA), the optimal ad revenue-sharing rate, content quality, ad intensity, and all participants' payoffs (i.e., the platform's profit, the creators' profits, and consumer

surplus) will always increase in creator complementarity. To understand these results, note that as creator complementarity increases, the platform has a stronger incentive to compensate the creators for content creation. The content creators respond to the increased ad revenue-sharing rate by increasing their content qualities. The increase in content quality, in turn, enables the platform to display more ads. As a result, as creator complementarity increases, the consumer's increased demand for content makes both the platform and the creators better off. Higher content quality and higher content consumption will lead to higher consumer surplus. *Second*, we find that the equilibrium ad revenue-sharing rate, content quality, and the number of ads shown for each content will be lower under UA than under DA. This result arises because the content creators have more incentive to produce high-quality content under DA than under UA since they expect to obtain differentiated compensation from ads under DA. So, the platform tends to share more ad revenue with the content creators to motivate content production under DA than under UA. The higher-quality content, in turn, enables the platform to show more ads for the content under DA than under UA. *Third*, we show that all participants' payoffs are higher under DA than those under UA. The intuition is that content creators have a stronger incentive to invest in content quality under DA than under UA. The higher-quality content leads to more content consumption and higher payoffs under DA than under UA. Moreover, we have also compared the DA format with the CA format. We find that all participants prefer DA over CA. For content creators, it is because the content competition vanishes in the complementarity model, and the creators' benefit from holding the decision right for advertising intensity will be negligible. In this case, the loss due to the lower ad revenue-sharing rate makes the content creators' profits under CA lower than those under DA. Meanwhile, the content creators will have a stronger incentive to invest in content quality under DA than under CA; the benefit from high content quality will dominate, making the consumer surplus higher

under DA than under CA.

7. Conclusion

Online platforms (e.g., YouTube, Instagram, and Twitch) host content posted by independent content creators and earn ad revenue by displaying ads on the content. These platforms offer a share of ad revenue to content creators to incentivize content production. The platforms can set the advertising in two different ways—one is the uniform-advertising format (UA), under which platforms place the same number of ads in different content; the other is the differentiated-advertising format (DA), under which platforms set different numbers of ads in content of different qualities. In this paper, we study the implications of different ad formats on content production, the number of ads, and market participants' payoffs. Our work differs from previous studies that have ignored the important roles of ad formats and focused primarily on either the number of ads or content-creation decisions. As far as we know, our study is among the first to examine how the advertising format on content platforms can influence content production and adverting intensity in the context of ad revenue-sharing platforms. This allows us to uncover the strategic interaction between ad format and content production in the content market.

Our analysis shows several interesting results that provide useful managerial insights into platform operations in the content market. First, in contrast to the conventional wisdom that creator substitutability on the media platform will hurt all market participants, we show that an increase in creator substitutability can increase the content creators' profits and the consumer surplus under both UA and DA formats. Because as creator substitutability increases, the platform has an incentive to share more ad revenue with the content creators to encourage high-quality content production. We also find that an increase in creator substitutability can benefit the platform under both UA and DA formats because as creator substitutability increases, the content creators are more inclined to increase the

quality of their content. Our findings suggest that platforms with more homogeneous content creators can share more ad revenue to encourage high-quality content production to compensate for the negative effect of a high degree of creator substitutability. Platforms in such situations may also want to facilitate the production of high-quality content. YouTube, for example, has implemented a training program named "YouTube Creator Academy" to help content creators produce standard but high-quality content.[16] Twitch has also launched the so-called "Twitch Creator Camp" to share tips with creators to improve their streaming.[17]

Second, we find that the equilibrium ad revenue-sharing rate, content quality, and advertising intensity will be lower under DA than under UA, and the platform's profit and the consumer surplus are also lower under DA than under UA. Moreover, when creator substitutability is low (high), the content creators' profits are lower (higher) under DA than under UA. These findings provide useful prescriptions for content platform operations. For example, in some situations, platforms should adopt the UA format rather than the DA format, as Meta and Twitch do.

Third, we have also investigated the emerging ad format where the platform allows the content creators to determine the number of ads for their own content (i.e., the CA format). Our analysis shows that under CA, higher creator substitutability can increase the content creators' profits and the consumer surplus but will make the platform worse off. Meanwhile, the equilibrium ad revenue-sharing rate, content quality, and advertising intensity are lower under CA than under DA, and the platform's profit is lower under CA than under DA. Moreover, depending on the substitutability between content creators, both the content creators' profits and the consumer surplus can be higher or lower under CA than under

---

[16] https://newsinitiative.withgoogle.com/resources/lessons/youtube-creator-academy-improve-your-youtube-skills/, accessed on February 2, 2023.

[17] https://blog.twitch.tv/en/2018/07/24/twitch-creator-camp-do-what-you-do-best-even-better-3381c64136c8/, accessed on February 2, 2023.

DA. These findings suggest that platforms may want to restrain the adoption of the emerging CA format and that the CA format is not necessarily beneficial to content creators and society if the strategic effect of CA on ad revenue-sharing and content quality is considered.

We conclude the paper with some potential directions for future research. First, we model a representative consumer's content consumption in the main analysis. The fixed number of consumers on the platform cannot capture the impact of the generation of consumer traffic to the platform. It would be interesting to investigate all participants' preferences over different ad formats by considering the effect of content quality on market expansion. Second, we have assumed that the platform is able to infer and measure the content quality posted on the platform. In practice, the content creators may be better informed than the platform about the content quality. Future research can study the impacts of quality information asymmetry. In particular, the platform may have an incentive to screen different types of creators by offering content creators the option to self-select into one ad revenue-sharing contract (i.e., providing content creators the choice to choose from UA, DA, and CA). It would be interesting to investigate whether and how such self-selection contracts would affect market outcomes. Third, in our model, the size of the total potential market (i.e., $\frac{2v}{1+\gamma}$) shrinks when creator substitutability (i.e., γ) increases. In the content market, the total market potential may not change dramatically with increased competition between content creators on the platform. It may be interesting to explore the case where the size of the total potential market is independent of the creator substitutability. Fourth, we have assumed that the platform carries and puts ads on content posted by third-party content creators. As the content market grows, content platforms may themselves produce some original content and display ads for their content. For example, YouTube has recently unlocked a batch of its original shows

and allows viewers to watch them with ads.[18] It would be interesting to investigate the impact of the interaction between the platform's original content and the third-party's content on the market outcomes (i.e., content qualities, ad strategies, and profits). Fifth, our main model assumes that the platforms specify a uniform revenue-sharing rate to all content creators. Anecdotal evidence suggests that streamers on Twitch may receive conditional ad revenue shares on their popularity.[19] It would be interesting to examine the impact of differentiated ad revenue-sharing rates on the creators' content production efforts and the participants' performances. Lastly, the booming content market has witnessed fierce competition among revenue-sharing content platforms. It would be interesting to analyze the competition between content platforms. Such an analysis would help us understand how platform competition affects content production and the platforms' profits. It might also be useful to incorporate the content creators' multi-homing in the context of platform competition.

Acknowledgments

References

Albuquerque P, Pavlidis P, Chatow U, Chen KY, Jamal Z (2012) Evaluating promotional activities in an online two-sided market of user-generated content. *Mark. Sci.* 31(3):406–432.

Alexander J (2020a) Creators finally know how much money YouTube makes, and they want more of it. *The Verge*. Retrieved (March 5, 2021), https://www.theverge.com/2020/2/4/21121370/youtube-advertising-revenue-creators-demonetization-earnings-google.

Alexander J (2020b) YouTube is experimenting with letting creators sell ads directly to brands. *The*

---

[18] https://teneightymagazine.com/2020/06/02/6-youtube-originals-series-you-need-to-watch/, accessed on February 2, 2023.

[19] https://www.quora.com/What-is-the-revenue-share-between-Twitch-and-streamers-for-users-that-subscribe-to-a-streamers-channel-for-4-99, accessed on February 2, 2023.

Verge. Retrieved (March 19, 2021), https://www.theverge.com/2020/2/27/21156289/youtube-ads-creators-demonetization-brands-adpocalypse-alternative-monetization-sponsorship.

Anderson SP, Coate S (2005) Market provision of broadcasting: A welfare analysis. *Rev. Econ. Stud.* 72(4):947–972.

Armstrong M (2006) Competition in two-sided markets. *RAND J. Econ.* 37(3):668–691.

Athey S, Calvano E, Gans JS (2018) The impact of consumer multi-homing on advertising markets and media competition. *Manage. Sci.* 64(4):1574–1590.

Bazaarvoice (2018) Content called out; 47% of consumers fatigued by repetitive influencers. *Bazaarvoice*. Retrieved (April 14, 2021), https://www.bazaarvoice.com/press/content-called-out-47-of-consumers-fatigued-by-repetitive-influencers/.

Bhargava HK (2022) The creator economy: Managing ecosystem supply, revenue-sharing, and platform design. *Manage. Sci.* 68(7):5233–5251.

Boudreau KJ (2012) Let a thousand flowers bloom? An early look at large numbers of software app developers and patterns of innovation. *Organ. Sci.* 23(5):1409–1427.

Cai G (George), Dai Y, Zhou SX (2012) Exclusive channels and revenue sharing in a complementary goods market. *Mark. Sci.* 31(1):172–187.

Caillaud B, Jullien B (2003) Chicken & egg: Competition among intermediation service providers. *RAND J. Econ.*:309–328.

Carman A (2020a) Instagram brought in $20 billion in ad revenue last year, more than a quarter of Facebook's earnings. *The Verge*. Retrieved (March 5, 2021), https://www.theverge.com/2020/2/4/21122956/instagram-ad-revenue-earnings-amount-facebook.

Carman A (2020b) Instagram will share revenue with creators for the first time through ads in IGTV. *The Verge*. Retrieved (March 5, 2021), https://www.theverge.com/2020/5/27/21271009/instagram-ads-igtv-live-badges-test-update-creators.

Carroni E (2018) Poaching in media: Harm to subscribers? *J. Econ. Manag. Strateg.* 27(2):221–236.

Casadesus-Masanell R, Zhu F (2010) Strategies to fight ad-sponsored rivals. *Manage. Sci.* 56(9):1484–1499.

D'Annunzio A (2017) Vertical integration in the tv market: Exclusive provision and program quality. *Int. J. Ind. Organ.* 53:114–144.

Doyle C (1998) Programming in a competitive broadcasting market: Entry, welfare and regulation. *Inf. Econ. Policy* 10(1):23–39.

Dukes A (2004) The advertising market in a product oligopoly. *J. Ind. Econ.* 52(3):327–348.

Dukes A, Gal-Or E (2003) Negotiations and exclusivity contracts for advertising. *Mark. Sci.* 22(2):222–245.

Gal-Or E, Dukes A (2003) Minimum differentiation in commercial media markets. *J. Econ. Manag. Strateg.* 12(3):291–325.

Godes D, Ofek E, Sarvary M (2009) Content vs. Advertising: The impact of competition on media firm strategy. *Mark. Sci.* 28(1):20–35.

Google (2021) Non-skippable ad campaigns. *Google*. Retrieved (March 30, 2021), https://support.google.com/displayvideo/answer/9224914?hl=en&ref_topic=6190068.

Han Y, Lappas T, Sabnis G (2020) The importance of interactions between content characteristics and creator characteristics for studying virality in social media. *Inf. Syst. Res.* 31(2):576–588.

Huang N, Burtch G, Gu B, Hong Y, Liang C, Wang K, Fu D, Yang B (2019) Motivating user-generated content with performance feedback: Evidence from randomized field experiments. *Manage. Sci.* 65(1):327–345.

Huang Y, Singh PV, Ghose A (2015) A structural model of employee behavioral dynamics in enterprise social media. *Manage. Sci.* 61(12):2825–2844.

Hukal P, Henfridsson O, Shaikh M, Parker G (2020) Platform signaling for generating platform content. *MIS Q. Manag. Inf. Syst.* 44(3):1177–1206.

Ingene CA, Parry ME (2004) *Mathematical models of distribution channels* (Springer).

Jain S, Qian K (2021) Compensating online content producers : A theoretical analysis. *Manage. Sci.* 67(11):7075–7090.

James H (2019) More than 500 hours of content are now being uploaded to YouTube every minute. *Tubefilter*. Retrieved (March 29, 2021), https://www.tubefilter.com/2019/05/07/number-hours-video-uploaded-to-youtube-per-minute/.

Jasmine E (2020) Global Instagram users 2020. *eMarketer*. Retrieved (March 29, 2021), https://www.emarketer.com/content/global-instagram-users-2020.

Jeon DS, Kim BC, Menicucci D (2016) Second-degree price discrimination by a two-sided monopoly platform. *CEPR Discuss. Pap. No. DP11488, Available SSRN https//ssrn.com/abstract=2834825*.

Jiang B, Tian L, Zhou B (2019) Competition of content acquisition and distribution under consumer multipurchase. *J. Mark. Res.* 56(6):1066–1084.

Joei C (2020) Influencer fatigue: Are we done with influencers? *Linkfluence*. Retrieved (April 7, 2021), https://www.linkfluence.com/blog/influencer-fatigue#C.

Johan S (2014) Exclusive quality–why exclusive distribution may benefit the TV-viewers. *Inf. Econ. Policy* 26:42–57.

Kind HJ, Nilssen T, Sørgard LW (2007) Competition for viewers and advertisers in a TV oligopoly. *J. Media Econ.* 20(3):211–233.

Kind HJ, Nilssen T, Sørgard LW (2009) Business models for media firms : Does competition matter for how they raise revenue? *Mark. Sci.* 28(6):1112–1128.

Lara O (2020) TikTok is testing a "shop now" button for influencer videos. *Digiday*. Retrieved (March 30, 2021), https://digiday.com/marketing/tiktok-is-testing-a-shop-now-button-for-influencer-videos/.

Lin S (2020) Two-sided price discrimination by media platforms. *Mark. Sci.* 39(2):317–338.

Liu Q, Serfes K (2013) Price discrimination in two-sided markets. *J. Econ. Manag. Strateg.* 22(4):768–786.

Matt P (2020) Report: Amazon's Twitch not meeting ad revenue expectations. *Forbes*. Retrieved (March 30, 2021), https://www.forbes.com/sites/mattperez/2020/01/08/report-amazons-twitch-not-meeting-ad-revenue-expectations/?sh=2bc6b58d7164.

McAfee RP, Schwartz M (2004) Opportunism in multilateral vertical contracting: Nondiscrimination, exclusivity, and uniformity: Reply. *Am. Econ. Rev.* 94(3):802–805.

Paul S (2015) 7 ways to improve your content quality as competition increases. *SmartBug*. Retrieved (September 9, 2021), https://www.smartbugmedia.com/blog/7-ways-to-improve-your-content-quality-as-competition-increases.

Peitz M, Valletti TM (2008) Content and advertising in the media: Pay-tv versus free-to-air. *Int. J. Ind. Organ.* 26(4):949–965.

Rani M, Kurt W (2018) People spend almost as much time on Instagram as they do on Facebook - Vox. *Recode*. Retrieved (March 29, 2021), https://www.vox.com/2018/6/25/17501224/instagram-facebook-snapchat-time-spent-growth-data.

Singh N, Vives X (1984) Price and quantity competition in a differentiated duopoly. *RAND J. Econ.*

15(4):546–554.

Statista (2021) Most popular social networks worldwide as of January 2021, ranked by number of active users. *Statista*. Retrieved (March 29, 2021), https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/.

Steiner P (1952) Program patterns and preferences, and the workability of competition in radio broadcasting. *Q. J. Econ.* 66(2):194–223.

Sun M, Zhu F (2013) Ad revenue and content commercialization: Evidence from blogs. *Manage. Sci.* 59(10):2314–2331.

Tara J (2020) A guide to twitch advertising 101. *Tinuiti*. Retrieved (March 30, 2021), https://tinuiti.com/blog/news/twitch-ads/.

Toubia O, Stephen AT (2013) Intrinsic vs. image-related utility in social media: Why do people contribute content to Twitter? *Mark. Sci.* 32(3):368–392.

Twitch (2021) Joining the affiliate program. *Twitch*. Retrieved (March 30, 2021), https://help.twitch.tv/s/article/joining-the-affiliate-program?language=en_US#revenue.

Werner G (2021) How to get more viewers on Twitch. *Influ. Mark.* Retrieved (September 9, 2021), https://influencermarketinghub.com/how-to-get-more-viewers-on-twitch/.

Wise J (2022) Twitch statistics 2022: How many people use twitch? *Earthweb*. Retrieved (September 16, 2022), https://earthweb.com/twitch-statistics/.

Yoo E, Gu B, Rabinovich E (2019) Diffusion on social media platforms: A point process model for interaction among similar content. *J. Manag. Inf. Syst.* 36(4):1105–1141.

Online Appendix

This Online Appendix presents the proofs of Propositions 1~7 in the main paper. Due to space constraint, other detailed analyses that have been omitted in the main paper are given in the Supplemental Materials file (*available upon request*). In specific, Part A of the Supplemental Materials file presents the equilibrium analysis of the main model. Part B examines a model where the content creators are asymmetric in content production efficiency. Part C analyzes an extended model with $N > 2$ content creators. Part D considers complementarity between the two content creators. Part E analyzes a model in which the content creators determine content quality *after* the ad intensity for their (anticipated) content has been chosen and committed by the platform. Part F investigates a model in which the content creators have better (private) information, regarding their costs of content creation, than the platform.

PROOF OF PROPOSITION 1. (a) We first investigate how α^{UA} changes with γ. Taking derivative gives $\frac{\partial \alpha^{UA}}{\partial \gamma} = \frac{8k\beta\gamma}{m\phi^2} > 0$. That is, α^{UA} increases in γ.

(b) Next, we examine how q^{UA} changes with γ. Taking derivative gives $\frac{\partial q^{UA}}{\partial \gamma} = \frac{4kv\beta\gamma m\phi}{[4k\beta(1-\gamma^2)-m\phi^2]^2} > 0$. That is, q^{UA} increases in γ.

(c) Next, we investigate the impact of γ on d^{UA}. Taking derivative gives $\frac{\partial d^{UA}}{\partial \gamma} = \frac{2kv\gamma m\phi^2}{[4k\beta(1-\gamma^2)-m\phi^2]^2} > 0$. That is, d^{UA} increases in γ.

(d) We then investigate the impact of γ on π_P^{UA}. Taking derivative gives $\frac{\partial \pi_P^{UA}}{\partial \gamma} = \frac{2k^2v^2\beta(1-\gamma)[m\phi^2(1+3\gamma)-4k\beta(1-\gamma^2)(1+\gamma)]}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2} = \frac{2k^2v^2\beta(1-\gamma)}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2} f_1(\gamma)$, where $f_1(\gamma) = m\phi^2(1+3\gamma) - 4k\beta(1-\gamma^2)(1+\gamma)$ and $\frac{\partial f_1(\gamma)}{\partial \gamma} = 3m\phi^2 + 4k\beta(1+\gamma)(3\gamma-1)$. Note that $\frac{\partial f_1(\gamma)}{\partial \gamma}$ increases in m. Conditional on $\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$ (i.e., $\frac{2k\beta(1-\gamma^2)}{\phi^2} < m < \frac{2k\beta(1-\gamma^2)(2-\gamma)}{\phi^2}$), we

have $\frac{\partial f_1(\gamma)}{\partial \gamma} > \frac{\partial f_1(\gamma)}{\partial \gamma}\big|_{m=\frac{2k\beta(1-\gamma^2)}{\phi^2}} = 2k\beta(1+\gamma)(1+3\gamma) > 0.$ [1] That is, $f_1(\gamma)$ increases in γ. One

can show $f_1(\gamma)|_{\gamma=0} = m\phi^2 - 4k\beta < 0$ and $f_1(\gamma)|_{\gamma=1} = 4m\phi^2 > 0$. Hence, there exists a threshold

value $\gamma_1 > 0$ such that $f_1(\gamma) < 0$ (i.e., $\frac{\partial \pi_P^{UA}}{\partial \gamma} < 0$) when $\gamma < \gamma_1$ and $f_1(\gamma) > 0$ (i.e., $\frac{\partial \pi_P^{UA}}{\partial \gamma} > 0$)

when $\gamma > \gamma_1$. Therefore, we obtain that π_P^{UA} first decreases and then increases in γ.

(e) We then examine the impact of γ on π_C^{UA}. Differentiating π_C^{UA} gives $\frac{\partial \pi_C^{UA}}{\partial \gamma} =$

$\frac{2k^2v^2\beta(1+\gamma)}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^3} f_2(\gamma)$, where $f_2(\gamma) = m^2\phi^4(1-3\gamma) - 2m\phi^2 k\beta(3 - 7\gamma + \gamma^2 + 3\gamma^3) +$

$8k^2\beta^2(1-\gamma)^3(1+\gamma)^2$. Note that $\frac{\partial f_2(\gamma)}{\partial \gamma} = -8k^2\beta^2(1-\gamma)^2(1+\gamma)(1+5\gamma) + 2k\beta(1+\gamma)(7 -$

$9\gamma)m\phi^2 - 3m^2\phi^4$ and $\frac{\partial^2 f_2(\gamma)}{\partial \gamma^2} = -4k\beta[m\phi^2(1+9\gamma) + 8k\beta(1-\gamma)(1-2\gamma-5\gamma^2)]$. One can

show that $\frac{\partial^2 f_2(\gamma)}{\partial \gamma^2} < 0$ when $k < \frac{m\phi^2(1+9\gamma)}{8k\beta(1-\gamma)(5\gamma^2+2\gamma-1)}$ and $\frac{\partial^2 f_2(\gamma)}{\partial \gamma^2} > 0$ when $k > \frac{m\phi^2(1+9\gamma)}{8k\beta(1-\gamma)(5\gamma^2+2\gamma-1)}$.

We depict the following analysis into two cases. First, given $k < \frac{m\phi^2(1+9\gamma)}{8k\beta(1-\gamma)(5\gamma^2+2\gamma-1)}$, $\frac{\partial f_2(\gamma)}{\partial \gamma}$ decreases

in γ. Conditional on $\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$, one can show that $\frac{\partial f_2(\gamma)}{\partial \gamma}|_{\gamma=0} = -8k^2\beta^2 +$

$14k\beta m\phi^2 - 3m^2\phi^4 > 0$ and $\frac{\partial f_2(\gamma)}{\partial \gamma}|_{\gamma=1} = -8k\beta m\phi^2 - 3m^2\phi^4 < 0$. It indicates that $f_2(\gamma)$ first

increases and then decreases in γ. Further, one can also show that $f_2(\gamma)|_{\gamma=0} = -(m\phi^2 -$

$2k\beta)(4k\beta - m\phi^2) < 0$ and $f_2(\gamma)|_{\gamma=1} = -2m^2\phi^4 < 0$, and there can happen $f_2(\gamma) > 0$. Hence,

there exist thresholds γ_2 and γ_3 such that $f_2(\gamma) > 0$ (i.e., $\frac{\partial \pi_C^{UA}}{\partial \gamma} > 0$) when $\gamma_2 < \gamma < \gamma_3$ and

$f_2(\gamma) < 0$ (i.e., $\frac{\partial \pi_C^{UA}}{\partial \gamma} < 0$) when $\gamma < \gamma_2$ or $\gamma > \gamma_3$. Second, given $k > \frac{m\phi^2(1+9\gamma)}{8k\beta(1-\gamma)(5\gamma^2+2\gamma-1)}$, $\frac{\partial f_2(\gamma)}{\partial \gamma}$

increases in γ. Following the first step, one can verify that $\frac{\partial f_2(\gamma)}{\partial \gamma} < 0$ and $f_2(\gamma)$ decreases in γ. One

can also obtain that $f_2(\gamma)|_{\gamma=0} > 0$ and $f_2(\gamma)|_{\gamma=1} < 0$. It indicates that $f_2(\gamma) > 0$ when γ is small

(and $f_2(\gamma) < 0$ when γ is large). By summarizing the above results, we get that π_C^{UA} can increase

or decrease in γ.

---

[1] Note that $\pi_C^{UA} \leq 0$ when $k \leq \frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}$ or $k \geq \frac{m\phi^2}{2\beta(1-\gamma^2)}$. Hence under UA, for non-trivial analysis, we have focused

on the case of $\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$ to ensure that all market participants earn positive profit.

(f) We now examine the impact of γ on CS^{UA}. Taking derivative gives $\frac{\partial CS^{UA}}{\partial \gamma} =$

$\frac{k^2 v^2 \beta^2 (1-\gamma)}{[4k\beta(1-\gamma^2)-m\phi^2]^3} f_3(\gamma)$, where $f_3(\gamma) = m\phi^2(1+3\gamma) - 4k\beta(1-\gamma)^2(1+\gamma)$. Note that $\frac{\partial f_3(\gamma)}{\partial \gamma} =$

$3m\phi^2 + 4k\beta(1-\gamma)(1+3\gamma) > 0$, i.e., $f_3(\gamma)$ increases in γ. Conditional on $\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k <$

$\frac{m\phi^2}{2\beta(1-\gamma^2)}$, we have $f_3(\gamma)|_{\gamma=0} = m\phi^2 - 4k\beta < 2k\beta(1-\gamma^2)(2-\gamma) - 4k\beta < 0$ and $f_3(\gamma)|_{\gamma=1} =$

$4m\phi^2 > 0$. Hence, there exists a threshold value γ_4 such that $f_3(\gamma) < 0$ (i.e., $\frac{\partial CS^{UA}}{\partial \gamma} < 0$) when $\gamma <$

γ_4 and $f_3(\gamma) > 0$ (i.e., $\frac{\partial CS^{UA}}{\partial \gamma} > 0$) when $\gamma > \gamma_4$. Therefore, we get that CS^{UA} first decreases and

then increases in γ. This completes the proof of Proposition 1. $\square$

PROOF OF PROPOSITION 2. (a) We first examine the impact of γ on α^{DA}. Taking derivative gives

$\frac{\partial \alpha^{DA}}{\partial \gamma} = -\frac{8k\beta(1-4\gamma+\gamma^2)}{m\phi^2(2-\gamma)^2}$. One can verify that $\frac{\partial \alpha^{DA}}{\partial \gamma} < 0$ when $\gamma < 2 - \sqrt{3}$ and $\frac{\partial \alpha^{DA}}{\partial \gamma} > 0$ when $\gamma >$

$2 - \sqrt{3}$. Therefore, we get that α^{DA} first decreases and then increases in γ.

(b) Next, we investigate how q^{DA} changes with γ. Taking derivative gives $\frac{\partial q^{DA}}{\partial \gamma} =$

$-\frac{4kv\beta m\phi(1-4\gamma+\gamma^2)}{[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2}$. One can verify that $\frac{\partial q^{DA}}{\partial \gamma} < 0$ when $\gamma < 2 - \sqrt{3}$ and $\frac{\partial q^{DA}}{\partial \gamma} > 0$ when $\gamma >$

$2 - \sqrt{3}$. Therefore, we get that q^{DA} first decreases and then increases in γ.

(c) Next, we investigate the impact of γ on d^{DA}. Taking derivative gives $\frac{\partial d^{DA}}{\partial \gamma} =$

$-\frac{2kvm\phi^2(1-4\gamma+\gamma^2)}{[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2}$. One can verify that $\frac{\partial d^{DA}}{\partial \gamma} < 0$ when $\gamma < 2 - \sqrt{3}$ and $\frac{\partial d^{DA}}{\partial \gamma} > 0$ when $\gamma >$

$2 - \sqrt{3}$. Therefore, we get that d^{DA} first decreases and then increases in γ.

(d) We then analyze how π_P^{DA} changes with γ. Taking derivative gives $\frac{\partial \pi_P^{DA}}{\partial \gamma} =$

$\frac{8k^2 v^2 \beta(1-\gamma)}{\phi^2(2-\gamma)^2[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2} f_4(\gamma)$, where $f_4(\gamma) = m\phi^2\gamma(5-\gamma)(2-\gamma) - 8k\beta(1-\gamma)(1+\gamma)^2$.

Note that $\frac{\partial f_4(\gamma)}{\partial \gamma} = -8k\beta(1+\gamma)(1-3\gamma) + m\phi^2(10-14\gamma+3\gamma^2)$. Conditional on

$\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$, one can show that $\frac{\partial f_4(\gamma)}{\partial \gamma} > 0$.[2] That is, $f_4(\gamma)$ increases in γ. Note

---

[2] Note that $\pi_C^{DA} \leq 0$ when $k \leq \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)}$ or $k \geq \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$. Hence under DA, for non-trivial analysis, we have focused on the case of $\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$ to ensure that all market participants earn positive profits.

also $f_4(\gamma)|_{\gamma=0} = -8k\beta < 0$ and $f_4(\gamma)|_{\gamma=1} = 4m\phi^2 > 0$. Hence, there exists a threshold value γ_5 such that $f_4(\gamma) < 0$ (i.e., $\frac{\partial \pi_P^{DA}}{\partial \gamma} < 0$) when $\gamma < \gamma_5$ and $f_4(\gamma) > 0$ (i.e., $\frac{\partial \pi_P^{DA}}{\partial \gamma} > 0$) when $\gamma > \gamma_5$. Therefore, we get that π_P^{DA} first decreases and then increases in γ.

(e) We then examine how π_C^{DA} changes with γ. Differentiating π_C^{DA} gives $\frac{\partial \pi_C^{DA}}{\partial \gamma} = \frac{16k^2v^2\beta}{\phi^2(2-\gamma)^2[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^3} f_5(\gamma)$, where $f_5(\gamma) = 16k^2\beta^2(1-\gamma^2)^3 - 2m\phi^2k\beta(2-\gamma)(1-\gamma)(1+\gamma)(5-9\gamma+3\gamma^2-\gamma^3) + m^2\phi^4(2-\gamma)^2(1-2\gamma)$. Conditional on $\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$, one can show that $\frac{\partial^5 f_5(\gamma)}{\partial \gamma^5} = -240k\beta[(5-6\gamma)m\phi^2 + 48k\beta\gamma] < 0$. That is, $\frac{\partial^4 f_5(\gamma)}{\partial \gamma^4}$ decreases in γ. Note that $\frac{\partial^4 f_5(\gamma)}{\partial \gamma^4}|_{\gamma=0} = 96k\beta(7m\phi^2 + 12k\beta) > 0$ and $\frac{\partial^4 f_5(\gamma)}{\partial \gamma^4}|_{\gamma=1} = -192k\beta(24k\beta - m\phi^2) < 0$. Hence, $\frac{\partial^3 f_5(\gamma)}{\partial \gamma^3}$ first increases and then decreases in γ. Following the similar steps, one can get that $\frac{\partial^2 f_5(\gamma)}{\partial \gamma^2}$ decreases in γ or first decreases and then increases and then decreases in γ. Further, $\frac{\partial f_5(\gamma)}{\partial \gamma}$ increases in γ or first decreases and then increases in γ or first increases and then decreases and then increases in γ. Moreover, one can show that $f_5(\gamma)$ first increases and then decreases in γ. Given the impact of γ on $f_5(\gamma)$, we depict the following analysis into two cases. First, given $k < \frac{m\phi^2}{4\beta}$, we have $f_5(\gamma)|_{\gamma=0} = 4(m\phi^2 - k\beta)(m\phi^2 - 4k\beta) > 0$ and $f_5(\gamma)|_{\gamma=1} = -m^2\phi^4 < 0$. Hence, there exists a threshold value γ_6 such that $f_5(\gamma) > 0$ (i.e., $\frac{\partial \pi_C^{DA}}{\partial \gamma} > 0$) if $\gamma < \gamma_6$ and $f_5(\gamma) < 0$ (i.e., $\frac{\partial \pi_C^{DA}}{\partial \gamma} < 0$) if $\gamma > \gamma_6$. Second, given $k > \frac{m\phi^2}{4\beta}$, conditional on $\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$, we can get that $f_5(\gamma)|_{\gamma=0} = 4(m\phi^2 - k\beta)(m\phi^2 - 4k\beta) < 0$ and $f_5(\gamma)|_{\gamma=1} = -m^2\phi^4 < 0$, and there can happen $f_5(\gamma) > 0$. Hence, there exist thresholds γ_7 and γ_8 such that $f_5(\gamma) > 0$ (i.e., $\frac{\partial \pi_C^{DA}}{\partial \gamma} > 0$) when $\gamma_7 < \gamma < \gamma_8$ and $f_5(\gamma) < 0$ (i.e., $\frac{\partial \pi_C^{DA}}{\partial \gamma} < 0$) when $\gamma < \gamma_7$ or $\gamma > \gamma_8$. By summarizing the above results, we get that π_C^{DA} can decrease or increase in γ.

(f) Finally, we examine the impact of γ on CS^{DA}. Taking derivative gives $\frac{\partial CS^{DA}}{\partial \gamma} = \frac{4k^2v^2\beta^2(1-\gamma)}{[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^3} f_6(\gamma)$, where $f_6(\gamma) = m\phi^2\gamma(5-\gamma) - 8k\beta(1-\gamma)^2(1+\gamma)$ and $\frac{\partial f_6(\gamma)}{\partial \gamma} =$

$8k\beta(1 + 2\gamma - 3\gamma^2) + m\phi^2(5 - 2\gamma)$. Note that $\frac{\partial f_6(\gamma)}{\partial \gamma}$ increases in k . Conditional on

$\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$, we have $\frac{\partial f_6(\gamma)}{\partial \gamma} > \frac{\partial f_6(\gamma)}{\partial \gamma}\big|_{k=\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)}} = \frac{m\phi^2(28+13\gamma-39\gamma^2+12\gamma^3)}{(1+\gamma)(4-3\gamma)} >$

0 . Hence, $f_6(\gamma)$ increases in γ . Further, one can show that $f_6(\gamma)\big|_{\gamma=0} = -8k\beta < 0$ and

$f_6(\gamma)\big|_{\gamma=1} = 4m\phi^2 > 0$. Hence, there exists a threshold value γ_9 such that $f_6(\gamma) < 0$ (i.e., $\frac{\partial CS^{DA}}{\partial \gamma} <$

0) when $\gamma < \gamma_9$ and $f_6(\gamma) > 0$ (i.e., $\frac{\partial CS^{DA}}{\partial \gamma} > 0$) when $\gamma > \gamma_9$. Therefore, we obtain that CS^{DA}

first decreases and then increases in γ. This completes the proof of Proposition 2. □

PROOF OF PROPOSITION 3. First, we compare α^{DA} with α^{UA}, where $\alpha^{DA} = 2 - \frac{8k\beta(1-\gamma^2)}{m\phi^2(2-\gamma)}$ and

$\alpha^{UA} = 2 - \frac{4k\beta(1-\gamma^2)}{m\phi^2}$. Plugging in, we have $\alpha^{DA} - \alpha^{UA} = -\frac{4k\beta\gamma(1-\gamma^2)}{m\phi^2(2-\gamma)} < 0$.

Second, we compare q^{DA} with q^{UA}, where $q^{DA} = \frac{v[m\phi^2(2-\gamma)-4k\beta(1-\gamma^2)]}{\phi[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]}$ and $q^{UA} =$

$\frac{v[m\phi^2-2k\beta(1-\gamma^2)]}{\phi[4k\beta(1-\gamma^2)-m\phi^2]}$. Plugging in, we have $q^{DA} - q^{UA} = -\frac{2kv\beta m\phi\gamma(1-\gamma^2)}{[4k\beta(1-\gamma^2)-m\phi^2][8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]} < 0$.

Third, we compare d^{DA} with d^{UA}, where $d^{DA} = \frac{2kv(1-\gamma^2)}{8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)}$ and $d^{UA} = \frac{kv(1-\gamma^2)}{4k\beta(1-\gamma^2)-m\phi^2}$.

Plugging in, we obtain $d^{DA} - d^{UA} = -\frac{kvm\phi^2\gamma(1-\gamma^2)}{[4k\beta(1-\gamma^2)-m\phi^2][8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]} < 0$. This completes the

proof of Proposition 3. □

PROOF OF PROPOSITION 4. (a) First, we compare π_P^{DA} with π_P^{UA}, where $\pi_P^{DA} =$

$\frac{8k^2v^2\beta(1-\gamma)^2(1+\gamma)}{\phi^2(2-\gamma)[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]}$ and $\pi_P^{UA} = \frac{2k^2v^2\beta(1-\gamma)^2(1+\gamma)}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]}$. Plugging in, we have $\pi_P^{DA} - \pi_P^{UA} =$

$\frac{2k^2v^2\beta\gamma(1-\gamma)^2(1+\gamma)[8k\beta(1-\gamma^2)-m\phi^2(4-\gamma)]}{\phi^2(2-\gamma)[4k\beta(1-\gamma^2)-m\phi^2][8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]}$. One can easily show that when $k < \frac{m\phi^2(4-\gamma)}{8\beta(1-\gamma^2)}$, $\pi_P^{DA} -$

$\pi_P^{UA} < 0$ (and when $k > \frac{m\phi^2(4-\gamma)}{8\beta(1-\gamma^2)}$, $\pi_P^{DA} - \pi_P^{UA} > 0$). Note that $\frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)} - \frac{m\phi^2(4-\gamma)}{8\beta(1-\gamma^2)} =$

$-\frac{m\phi^2\gamma}{8\beta(1-\gamma^2)} < 0$, conditional on $\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$, there is $\pi_P^{DA} - \pi_P^{UA} < 0$. Therefore,

we obtain π_P^{DA} is lower than π_P^{UA}.

(b) Second, we compare π_C^{DA} with π_C^{UA} , where $\pi_C^{DA} =$

$\frac{kv^2[m\phi^2(2-\gamma)-4k\beta(1-\gamma^2)][4k\beta(1-\gamma^2)(4-3\gamma)-m\phi^2(2-\gamma)^2]}{\phi^2(2-\gamma)[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2}$ and $\pi_C^{UA} =$

$\frac{kv^2[2k\beta(2-\gamma)(1-\gamma^2)-m\phi^2][m\phi^2-2k\beta(1-\gamma^2)]}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2}$. Plugging in π_C^{DA} and π_C^{UA}, one can obtain that $\pi_C^{DA} -$

$\pi_C^{UA} = \frac{2k^2v^2\beta\phi^2\gamma(1-\gamma)(1+\gamma)}{\phi^4(2-\gamma)[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2[4k\beta(1-\gamma^2)-m\phi^2]^2}f_7(\gamma)$, where $f_7(\gamma) = -128k^3\beta^3(1-\gamma)^4(1+\gamma)^3 + 32k^2\beta^2m\phi^2(\gamma^2-4\gamma+2)(1-\gamma^2)^2 + 2k\beta m^2\phi^4(1-\gamma)(1+\gamma)(\gamma^3-12\gamma^2+24\gamma-4) - m^3\phi^6\gamma(3-\gamma)(2-\gamma)$. Conditional on $\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$ (i.e., $\frac{4k\beta(1-\gamma^2)}{2-\gamma} < m\phi^2 < 2k\beta(1-\gamma^2)(2-\gamma)$), we get that $\frac{\partial^3 f_7(\gamma)}{\partial\gamma^3} = -6(m\phi^2)^3 - 12k\beta(23-48\gamma+10\gamma^2)(m\phi^2)^2 + 768k^2\beta^2(2-10\gamma^2+5\gamma^3)m\phi^2 - 768k^3\beta^3(1-\gamma)(3+15\gamma-15\gamma^2-35\gamma^3) < 0$. That is, $\frac{\partial^2 f_7(\gamma)}{\partial\gamma^2}$ decreases in γ. Further, one can show that $\frac{\partial^2 f_7(\gamma)}{\partial\gamma^2}\big|_{\gamma=0} = 768k^3\beta^3 - 192k^2\beta^2m\phi^2 - 32k\beta m^2\phi^4 + 10m^3\phi^6 > 0$ and $\frac{\partial^2 f_7(\gamma)}{\partial\gamma^2}\big|_{\gamma=2-\sqrt{2}} = 2[5760(53\sqrt{2}-75)k^3\beta^3 + 32(265-184\sqrt{2})m\phi^2k^2\beta^2 + 2(86-79\sqrt{2})m^2\phi^4k\beta + (3\sqrt{2}-1)m^3\phi^6] < 0$. [3] Hence, $\frac{\partial f_7(\gamma)}{\partial\gamma}$ first increases and then decreases in γ. Following the similar steps, one can get that $f_7(\gamma)$ first increases and then decreases in γ. Further, one can show that $f_7(\gamma)|_{\gamma=0} < 0$ and $f_7(\gamma)|_{\gamma=2-\sqrt{2}} = 128(1033\sqrt{2}-1461)k^3\beta^3 + 4(60-41\sqrt{2})m^2\phi^4k\beta - 2m^3\phi^6 > 0$. Hence, there exists a cutoff point $\hat{\gamma}_1$ such that $f_7(\gamma) < 0$ (i.e., $\pi_C^{DA} < \pi_C^{UA}$) when $\gamma < \hat{\gamma}_1$ and $f_7(\gamma) > 0$ (i.e., $\pi_C^{DA} > \pi_C^{DA}$) when $\gamma > \hat{\gamma}_1$. Therefore, we obtain that π_C^{DA} is lower (higher) than π_C^{UA} when γ is low (high).

(c) Third, we compare CS^{DA} with CS^{UA}, where $CS^{DA} = \frac{4k^2v^2\beta^2(1-\gamma)^2(1+\gamma)}{[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2}$ and $CS^{UA} = \frac{k^2v^2\beta^2(1-\gamma)^2(1+\gamma)}{[4k\beta(1-\gamma^2)-m\phi^2]^2}$. Plugging in, $CS^{DA} - CS^{UA} = \frac{k^2v^2\beta^2m\phi^2\gamma(1-\gamma)^2(1+\gamma)[m\phi^2(4-\gamma)-16k\beta(1-\gamma^2)]}{[4k\beta(1-\gamma^2)-m\phi^2]^2[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2}$. One can easily show that when $k > \frac{m\phi^2(4-\gamma)}{16\beta(1-\gamma^2)}$, $CS^{DA} - CS^{UA} < 0$ (and when $k < \frac{m\phi^2(4-\gamma)}{16\beta(1-\gamma^2)}$, $CS^{DA} - CS^{UA} > 0$). Note that $\frac{m\phi^2(4-\gamma)}{16\beta(1-\gamma^2)} - \frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} = \frac{m\phi^2\gamma(\gamma-6)}{16\beta(1-\gamma^2)(2-\gamma)} < 0$, conditional on $\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$, there is $CS^{DA} - CS^{UA} < 0$. Therefore, we get that CS^{DA} is lower than CS^{UA}. This ends the proof of Proposition 4. □

PROOF OF PROPOSITION 5. (a) We first examine the impact of γ on α^{CA}. Taking derivative gives

---

[3] Recall that when comparing DA with UA, for non-trivial analysis, we have focused on the case of $\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$, which can hold only if $0 < \gamma < 2 - \sqrt{2}$. Hence, we use $\gamma = 0$ and $\gamma = 2 - \sqrt{2}$ as the two boundary points here.

$\frac{\partial \alpha^{CA}}{\partial \gamma} = \frac{k\beta(2-\gamma)[\gamma^2(2+\gamma)(1-2\gamma)+2\gamma-4]}{m\phi^2(2-\gamma^2)^2} < -\frac{4k\beta(2-\gamma)(1-\gamma)}{m\phi^2(2-\gamma^2)^2} < 0$. That is, α^{CA} decreases in γ.

(b) Next, we investigate how q^{CA} changes with γ. Taking derivative gives $\frac{\partial q^{CA}}{\partial \gamma} = -\frac{kv\beta m\phi(2-\gamma)(4-2\gamma-2\gamma^2+3\gamma^3+2\gamma^4)}{2[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^2} < 0$. That is, q^{CA} decreases in γ.

(c) Next, we investigate the impact of γ on d^{CA}. Taking derivative gives $\frac{\partial d^{CA}}{\partial \gamma} = \frac{kv}{2[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^2}g_1(k)$, where $g_1(k) = 2m\phi^2\gamma(6-4\gamma^2+\gamma^4) - k\beta(4+4\gamma-\gamma^2-\gamma^3)^2$. Note that $g_1(k)$ decreases in k. Conditional on $\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$, one can verify that $g_1(k) < g_1(k)|_{k=\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)}} < 0$. That is, $\frac{\partial d^{CA}}{\partial \gamma} < 0$. Therefore, we get that d^{CA} decreases in γ.

(d) We then investigate the impact of γ on π_P^{CA}. Differentiating π_P^{CA} gives $\frac{\partial \pi_P^{CA}}{\partial \gamma} = \frac{k^2v^2\beta(2-\gamma)(2+\gamma)}{2\phi^2(2-\gamma^2)^2[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^2}g_2(k)$, where $g_2(k) = 2m\phi^2\gamma(8-8\gamma^2+4\gamma^4-\gamma^6) - k\beta(2-\gamma)^3(1+\gamma)^2(2+\gamma)(2+\gamma^2)$. Note that $g_2(k)$ decreases in k. Conditional on $\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$, one can show that $g_2(k) < g_2(k)|_{k=\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)}} = -\frac{2m\phi^2(2+\gamma)(2-\gamma^2)(4-8\gamma+4\gamma^2+6\gamma^3-5\gamma^4-2\gamma^5+2\gamma^6)}{4-\gamma-2\gamma^2} < 0$.[4] Therefore, there is $\frac{\partial \pi_P^{CA}}{\partial \gamma} < 0$, i.e., π_P^{CA} decreases in γ.

(e) We then examine the impact of γ on π_C^{CA}. Taking derivative gives $\frac{\partial \pi_C^{CA}}{\partial \gamma} = \frac{k^2v^2\beta(2-\gamma)^2(1+\gamma)}{4\phi^2(2-\gamma^2)^2[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^3}f_8(\gamma)$, where $f_8(\gamma) = k^2\beta^2(2-\gamma)^4(1+\gamma)^2(2+\gamma)^3(2+\gamma^2) - m\phi^2k\beta(2-\gamma)(2+\gamma)(2-\gamma^2)[40+16\gamma-10\gamma^2+\gamma^3(2+\gamma)(11-\gamma-4\gamma^2)] + 4m^2\phi^4(2-\gamma^2)^2(4+2\gamma^3+\gamma^4)$. We depict the following analysis into two cases. First, given $k < \frac{m\phi^2}{4\beta}$, we have $\frac{\partial^2 f_8(\gamma)}{\partial \gamma^2} = -2k^2\beta^2(2-\gamma)^2(2+\gamma)(8+88\gamma+82\gamma^2+112\gamma^3+28\gamma^4-110\gamma^5-55\gamma^6) + 8k\beta m\phi^2(80-60\gamma-258\gamma^2+470\gamma^3+360\gamma^4-399\gamma^5-231\gamma^6+81\gamma^7+45\gamma^8) -$

---

[4] Note that $\pi_C^{CA} \leq 0$ when $k \leq \frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)}$ or $k \geq \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$. Hence under CA, for non-trivial analysis, we have focused on the case of $\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$ to ensure that all market participants earn positive profits.

$16m^2\phi^4(8 - 12\gamma - 24\gamma^2 + 40\gamma^3 + 30\gamma^4 - 21\gamma^5 - 14\gamma^6) > 0$. That is, $\frac{\partial f_8(\gamma)}{\partial \gamma}$ increases in γ .

Conditional on $\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)} < k < \min(\frac{m\phi^2}{4\beta}, \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)})$, we can show that

$\frac{\partial f_8(\gamma)}{\partial \gamma}|_{\gamma=0} = 128k\beta(3k\beta - m\phi^2) < 0$ and $\frac{\partial f_8(\gamma)}{\partial \gamma}|_{\gamma=\tilde{\gamma}} > 0$.[5] It indicates that $f_8(\gamma)$ first decreases

and then increases in γ. Further, we can verify that $f_8(\gamma)|_{\gamma=0} = 64(k\beta - m\phi^2)(4k\beta - m\phi^2) > 0$

and $f_8(\gamma)|_{\gamma=\tilde{\gamma}} < 0$. Hence, there exists a threshold value γ_{10} such that $f_8(\gamma) > 0$ (i.e., $\frac{\partial \pi_C^{CA}}{\partial \gamma} > 0$)

when $\gamma < \gamma_{10}$ and $f_8(\gamma) < 0$ (i.e., $\frac{\partial \pi_C^{CA}}{\partial \gamma} < 0$) when $\gamma > \gamma_{10}$. Second, given $k > \frac{m\phi^2}{4\beta}$, conditional

on $\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$, one can verify that $f_8(\gamma) < 0$ (i.e., $\frac{\partial \pi_C^{CA}}{\partial \gamma} <$

0). By summarizing the above results, we get that π_C^{CA} can decrease or increase in γ.

(f) Finally, we examine the impact of γ on CS^{CA}. Differentiating CS^{CA} gives $\frac{\partial CS^{CA}}{\partial \gamma} =$

$\frac{k^2v^2\beta^2[3k\beta\gamma(1+\gamma)(4-\gamma^2)^3 - m\phi^2(2-\gamma)(2+\gamma)(8+8\gamma+2\gamma^2+\gamma^4)]}{4[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma) - m\phi^2(2-\gamma^2)]^3} = \frac{k^2v^2\beta^2}{4[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma) - m\phi^2(2-\gamma^2)]^3} f_9(\gamma)$,

where $f_9(\gamma) = 3k\beta\gamma(1+\gamma)(4-\gamma^2)^3 - m\phi^2(2-\gamma)(2+\gamma)(8 + 8\gamma + 2\gamma^2 + \gamma^4)$. Note that

$\frac{\partial f_9(\gamma)}{\partial \gamma} = 3k\beta(4-\gamma^2)^2(4 + 8\gamma - 7\gamma^2 - 8\gamma^3) - 2m\phi^2(4 - 3\gamma^2)(4 + \gamma^3)$ and $\frac{\partial^2 f_9(\gamma)}{\partial \gamma^2} = 6k\beta(2 - $

$\gamma)(2+\gamma)(16 - 36\gamma - 68\gamma^2 + 21\gamma^3 + 28\gamma^4) + 6m\phi^2\gamma(8 - 4\gamma + 5\gamma^3)$. One can show that

$\frac{\partial^2 f_9(\gamma)}{\partial \gamma^2} < 0$ when $k > \frac{m\phi^2\gamma(8-4\gamma+5\gamma^3)}{k\beta(2-\gamma)(2+\gamma)(-16+36\gamma+68\gamma^2-21\gamma^3-28\gamma^4)}$ and $\frac{\partial^2 f_9(\gamma)}{\partial \gamma^2} > 0$ when $k < $

$\frac{m\phi^2\gamma(8-4\gamma+5\gamma^3)}{k\beta(2-\gamma)(2+\gamma)(-16+36\gamma+68\gamma^2-21\gamma^3-28\gamma^4)}$. We depict the following analysis into two cases. First, given

$k < \frac{m\phi^2\gamma(8-4\gamma+5\gamma^3)}{k\beta(2-\gamma)(2+\gamma)(-16+36\gamma+68\gamma^2-21\gamma^3-28\gamma^4)}$, $\frac{\partial f_9(\gamma)}{\partial \gamma}$ increases in γ . Conditional on

$\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$, one can show that $\frac{\partial f_9(\gamma)}{\partial \gamma} > 0$. That is, $f_9(\gamma)$

increases in γ. Further, one can also show that $f_9(\gamma) < 0$ in the feasible region. Hence, CS^{CA} can

decrease in γ. Second, given $k > \frac{m\phi^2\gamma(8-4\gamma+5\gamma^3)}{k\beta(2-\gamma)(2+\gamma)(-16+36\gamma+68\gamma^2-21\gamma^3-28\gamma^4)}$, $\frac{\partial f_9(\gamma)}{\partial \gamma}$ decreases in γ.

Conditional on $\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$, one can show that $\frac{\partial f_9(\gamma)}{\partial \gamma}|_{\gamma=0} >$

---

[5] Note that $\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)} < k < \min(\frac{m\phi^2}{4\beta}, \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)})$ can hold only if $0 < \gamma < \tilde{\gamma}$, where $\tilde{\gamma}$ is the unique solution within zero to one of the equation $8(2-\gamma^2)^2 - (2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2) = 0$.

0 and $\frac{\partial f_9(\gamma)}{\partial \gamma}|_{\gamma=1} < 0$. It indicates that $f_9(\gamma)$ first increases and then decreases in γ. Following the first step, one can get that $f_9(\gamma)|_{\gamma=0} < 0$ and $f_9(\gamma)|_{\gamma=1} < 0$, and there can happen $f_9(\gamma) > 0$. That is, there exist thresholds γ_{11} and γ_{12} such that $f_9(\gamma) > 0$ (i.e., $\frac{\partial CS^{CA}}{\partial \gamma} > 0$) when $\gamma_{11} < \gamma < \gamma_{12}$ and $f_9(\gamma) < 0$ (i.e., $\frac{\partial CS^{CA}}{\partial \gamma} < 0$) when $\gamma < \gamma_{11}$ or $\gamma > \gamma_{12}$. By summarizing the above results, we get that CS^{CA} can decrease or increase in γ. This ends the proof of Proposition 5. □

PROOF OF PROPOSITION 6. We first compare α^{CA} with α^{DA}, where $\alpha^{CA} = 2 - \frac{k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}{m\phi^2(2-\gamma^2)}$ and $\alpha^{DA} = 2 - \frac{8k\beta(1-\gamma^2)}{m\phi^2(2-\gamma)}$. Plugging in, we have $\alpha^{CA} - \alpha^{DA} = -\frac{k\beta\gamma^2(1+\gamma)(8-\gamma(4+\gamma))}{m\phi^2(2-\gamma)(2-\gamma^2)} < 0$.

Second, we compare q^{CA} with q^{DA}, where $q^{CA} = \frac{v[2m\phi^2(2-\gamma^2)-k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)]}{2\phi[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]}$ and $q^{DA} = \frac{v[m\phi^2(2-\gamma)-4k\beta(1-\gamma^2)]}{\phi[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]}$. Plugging in q^{CA} and q^{DA}, one can show that $q^{CA} - q^{DA} = -\frac{kv\beta m\phi\gamma^2(1+\gamma)[8-\gamma(4+\gamma)]}{2[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)][k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]} < 0$.

Finally, we compare d^{CA} with d^{DA}, where $d^{CA} = \frac{kv(2+\gamma)(2-\gamma)(1+\gamma)(1-\gamma)}{2[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]}$ and $d^{DA} = \frac{2kv(1-\gamma^2)}{8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)}$. Plugging in, we have $d^{CA} - d^{DA} = \frac{kv\gamma(1-\gamma^2)[m\phi^2(4-\gamma(2+\gamma))-4k\beta(2-\gamma)(1+\gamma)(2+\gamma)]}{[2k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-2m\phi^2(2-\gamma^2)][8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]}$. One can easily show that when $k > \frac{m\phi^2[4-\gamma(2+\gamma)]}{4\beta(2-\gamma)(1+\gamma)(2+\gamma)}$, $d^{CA} - d^{DA} < 0$ (and when $k < \frac{m\phi^2[4-\gamma(2+\gamma)]}{4\beta(2-\gamma)(1+\gamma)(2+\gamma)}$, $d^{CA} - d^{DA} > 0$). Note that $\frac{m\phi^2[4-\gamma(2+\gamma)]}{4\beta(2-\gamma)(1+\gamma)(2+\gamma)} - \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} = -\frac{m\phi^2\gamma(1+\gamma)(2\gamma^3+3\gamma^2-22\gamma+20)}{4\beta(2-\gamma)(2+\gamma)(1+\gamma)(1-\gamma^2)(4-3\gamma)} < 0$, conditional on $\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$, there is $d^{CA} < d^{DA}$.[6] This completes the proof of Proposition 6. □

PROOF OF PROPOSITION 7. (a) We first compare π_P^{CA} with π_P^{DA}, where $\pi_P^{CA} = \frac{k^2v^2\beta(2+\gamma)^2(2-\gamma)^2(1+\gamma)(1-\gamma)}{2\phi^2(2-\gamma^2)[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]}$ and $\pi_P^{DA} = \frac{8k^2v^2\beta(1-\gamma)^2(1+\gamma)}{\phi^2(2-\gamma)[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]}$. Plugging in, we have $\pi_P^{CA} - \pi_P^{DA} = \frac{k^2v^2\beta\phi^2\gamma^2(1-\gamma^2)[8k\beta(2-\gamma)^2(1-\gamma)(1+\gamma)(2+\gamma)-m\phi^2(48-32\gamma-20\gamma^2+12\gamma^3+\gamma^4)]}{2\phi^4(2-\gamma^2)(2-\gamma)[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)][8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]}$. One can

---

[6] Recall that when comparing CA with DA, for non-trivial analysis, we have assumed $\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$, which can hold only if $0 < \gamma < \hat{\gamma}$, where $\hat{\gamma}$ is the unique solution within zero to one of the equation $\gamma^5 + 18\gamma^4 - 48\gamma^3 + 64\gamma - 32 = 0$. Hence, we use $\gamma = 0$ and $\gamma = \hat{\gamma}$ as the two boundary points here.

show that when $k < \frac{m\phi^2(48-32\gamma-20\gamma^2+12\gamma^3+\gamma^4)}{8\beta(2-\gamma)^2(1-\gamma)(1+\gamma)(2+\gamma)}$, $\pi_P^{CA} - \pi_P^{DA} < 0$ (and when $k > \frac{m\phi^2(48-32\gamma-20\gamma^2+12\gamma^3+\gamma^4)}{8\beta(2-\gamma)^2(1-\gamma)(1+\gamma)(2+\gamma)}$, $\pi_P^{CA} - \pi_P^{DA} > 0$). Note that $\frac{m\phi^2(48-32\gamma-20\gamma^2+12\gamma^3+\gamma^4)}{8\beta(2-\gamma)^2(1-\gamma)(1+\gamma)(2+\gamma)} - \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)} = \frac{16-\gamma^2[4+(4-\gamma)\gamma]}{8\beta(2-\gamma)^2(1-\gamma)(1+\gamma)(2+\gamma)} > 0$, conditional on $\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$, there is $\pi_P^{CA} - \pi_P^{DA} < 0$. Therefore, we obtain that π_P^{CA} is lower than π_P^{DA}.

(b) Second, we compare π_C^{CA} with π_C^{DA}, where $\pi_C^{CA} = \frac{kv^2[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-2m\phi^2(2-\gamma^2)][2m\phi^2(2-\gamma^2)^2-k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)]}{4\phi^2(2-\gamma^2)[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^2}$ and $\pi_C^{DA} = \frac{kv^2[m\phi^2(2-\gamma)-4k\beta(1-\gamma^2)][4k\beta(1-\gamma^2)(4-3\gamma)-m\phi^2(2-\gamma)^2]}{\phi^2(2-\gamma)[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2}$. By repeating the proof of Proposition 4(b), one can derive that there exists a threshold value $\hat{\gamma}_2$ such that $\pi_C^{CA} < \pi_C^{DA}$ when $\gamma < \hat{\gamma}_2$ and $\pi_C^{CA} > \pi_C^{DA}$ when $\gamma > \hat{\gamma}_2$. Because the detailed deriving process is very tedious, we omit the proof steps here (available upon request).

(c) Third, we compare CS^{CA} with CS^{DA}, where $CS^{CA} = \frac{k^2v^2\beta^2(1+\gamma)(2+\gamma)^2(2-\gamma)^2}{4[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^2}$ and $CS^{DA} = \frac{4k^2v^2\beta^2(1-\gamma)^2(1+\gamma)}{[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2}$. Plugging in CS^{CA} and CS^{DA}, one can show that $CS^{CA} - CS^{DA} = \frac{k^2v^2\beta^2\gamma(1+\gamma)[4k\beta(1-\gamma^2)(4-\gamma)(2-\gamma)(2+\gamma)-m\phi^2(16-12\gamma-6\gamma^2+5\gamma^3)]}{4[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^2[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2} f_{10}(\gamma)$, where $f_{10}(\gamma) = 4k\beta(2+\gamma)(2-\gamma)(1-\gamma^2) - m\phi^2(4+2\gamma-3\gamma^2)$ and $\frac{\partial f_{10}(\gamma)}{\partial \gamma} = -8k\beta\gamma(5-2\gamma^2) - 2m\phi^2(1-3\gamma)$. Note that $\frac{\partial f_{10}(\gamma)}{\partial \gamma}$ decreases in k. Conditional on $\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$, we have $\frac{\partial f_{10}(\gamma)}{\partial \gamma} < \frac{\partial f_{10}(\gamma)}{\partial \gamma}\big|_{k=\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)}} = -\frac{2m\phi^2(4+5\gamma-15\gamma^2+12\gamma^3-\gamma^4-2\gamma^5)}{(1-\gamma)(1+\gamma)(4-3\gamma)} < 0$. That is, $f_{10}(\gamma)$ decreases in γ. Further, one can show that $f_{10}(\gamma)\big|_{\gamma=0} = 16k\beta - 4m\phi^2 > 0$ and $f_{10}(\gamma)\big|_{\gamma=\hat{\gamma}} < 0$. Hence, there exists a threshold value $\hat{\gamma}_3$ such that $CS^{CA} > CS^{DA}$ (i.e., $f_{10}(\gamma) > 0$) when $\gamma < \hat{\gamma}_3$ and $CS^{CA} < CS^{DA}$ (i.e., $f_{10}(\gamma) < 0$) when $\gamma > \hat{\gamma}_3$. Therefore, we get that CS^{CA} is higher (lower) than CS^{DA} when γ is low (high). This ends the proof of Proposition 7. □

Supplemental materials for review purpose for manuscript

"Advertising Format and Content Provision on Revenue-Sharing Content Platforms"

In this reviewer supplement, Part A presents the equilibrium analysis of the main model. Part B examines a model where the content creators are asymmetric in content production efficiency. Part C analyzes an extended model with $N > 2$ content creators. Part D considers complementarity between the two content creators. Part E analyzes a model in which the content creators determine content quality *after* the ad intensity for their (anticipated) content has been chosen and committed by the platform. Part F investigates a model in which the content creators have better (private) information, regarding their costs of content creation, than the platform.

Part A: Analysis of the Main Model

In this part, we present the equilibrium analysis of the main model. In specific, we analyze the equilibrium results under the UA format, the DA format, and the CA format, respectively. Backward induction is applied to derive the equilibrium results.

1.1. Uniform Advertising (UA)

Under the UA format, first, solving the platform's problem on the advertising intensity gives $d = \frac{2v + (q_1 + q_2)\phi}{4\beta}$. Second, substituting d into π_{C_i} and solving the content creators' problems, we have

$q_i = \frac{vm\phi\alpha}{4k\beta(1-\gamma^2) - m\phi^2\alpha}$ and $\pi_{C_i} = \frac{kv^2\alpha m[4k\beta(1-\gamma)^2(1+\gamma) - m\phi^2\alpha]}{[m\phi^2\alpha - 4k\beta(1-\gamma^2)]^2}$. When $\alpha > \frac{4k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2}$, one can

show that $\pi_{C_i} < 0$. In consequence, the content creators will not join the platform. To ensure that the content creators will join the platform, the platform's problem on the ad revenue-sharing rate can be rewritten as

$$\max_{\alpha} \pi_P(\alpha) = \frac{8k^2v^2m\beta(1-\alpha)(1-\gamma)^2(1+\gamma)}{[4k\beta(1-\gamma^2) - m\phi^2\alpha]^2},$$

$$s.t. \begin{cases} \alpha \geq 0, \\ \alpha \leq 1, \\ \pi_{C_i} \geq 0. \end{cases}$$

The objective function $\pi_P(\alpha)$ is concave in α. Note that the third constraint $\pi_{C_i} \geq 0$ is equal to

$\alpha \leq \frac{4k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2}$. Define the Lagrangian $L^{UA} = \frac{8k^2v^2m\beta(1-\alpha^{UA})(1-\gamma)^2(1+\gamma)}{[4k\beta(1-\gamma^2)-m\phi^2\alpha^{UA}]^2} + \lambda_1\alpha^{UA} + \lambda_2(1-$

$\alpha^{UA}) + \lambda_3(\frac{4k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2} - \alpha^{UA})$, where λ_1, λ_2, and λ_3 are the Lagrange multipliers. The Kuhn-

Tucker conditions are

$$\begin{cases} \frac{\partial L^{UA}}{\partial \alpha^{UA}} = \frac{8k^2v^2m\beta(1-\gamma)^2(1+\gamma)[m\phi^2(2-\alpha^{UA})-4k\beta(1-\gamma^2)]}{[4k\beta(1-\gamma^2)-m\phi^2\alpha^{UA}]^3} + \lambda_1 - \lambda_2 - \lambda_3 = 0, \\ \lambda_1\alpha^{UA} = 0, \\ \lambda_2(1-\alpha^{UA}) = 0, \\ \lambda_3\left(\frac{4k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2} - \alpha^{UA}\right) = 0, \\ \lambda_1, \lambda_2, \lambda_3 \geq 0. \end{cases}$$

Case 1. If $\alpha^{UA} = 0$. Then $\lambda_2 = 0$ and $\lambda_3 = 0$. Solving the first-order condition gives $\lambda_1 =$

$\frac{v^2m(2k\beta(1-\gamma^2)-m\phi^2)}{4k\beta^2(1-\gamma)(1+\gamma)^2}$. Nonnegativity conditions require $k \geq \frac{m\phi^2}{2\beta(1-\gamma^2)}$.

Case 2. If $\alpha^{UA} = 1$. Then $\lambda_1 = 0$ and $\lambda_3 = 0$. Solving the first-order condition gives $\lambda_2 =$

$-\frac{8k^2v^2m\beta(1-\gamma)^2(1+\gamma)}{(4k\beta(1-\gamma^2)-m\phi^2)^2} < 0$, which cannot happen.

Case 3. If $\alpha^{UA} = \frac{4k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2}$. Then $\lambda_1 = 0$ and $\lambda_2 = 0$. Solving the first-order condition gives

$\lambda_3 = \frac{v^2m(m\phi^2-2k\beta(1-\gamma^2)(2-\gamma))}{4k\beta^2\gamma^3(1-\gamma)(1+\gamma)^2}$. Nonnegativity conditions require $k \leq \frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}$.

Case 4. If $\alpha^{UA} \neq 0$, 1 and $\frac{4k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2}$. Then $\lambda_1 = 0$, $\lambda_2 = 0$ and $\lambda_3 = 0$. Solving the first-

order condition gives $\alpha^{UA} = 2 - \frac{4k\beta(1-\gamma^2)}{m\phi^2}$. We need the condition $\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$

(i.e., $\alpha^{UA} > 0$, $1 - \alpha^{UA} > 0$ and $\frac{4k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2} - \alpha^{UA} > 0$) to hold for this case to be valid.

By summarizing the above results, we get the equilibrium ad revenue-sharing rate as follows:

$$\alpha^{UA} = \begin{cases} \frac{4k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2} & k \leq \frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}, \\ 2 - \frac{4k\beta(1-\gamma^2)}{m\phi^2} & \frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}, \\ 0 & k \geq \frac{m\phi^2}{2\beta(1-\gamma^2)}. \end{cases}$$

The equilibrium content quality is

$$q^{UA} = \begin{cases} \dfrac{v(1-\gamma)}{\phi\gamma} & k \leq \dfrac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}, \\[2mm] \dfrac{v[m\phi^2-2k\beta(1-\gamma^2)]}{\phi[4k\beta(1-\gamma^2)-m\phi^2]} & \dfrac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \\[2mm] 0 & k \geq \dfrac{m\phi^2}{2\beta(1-\gamma^2)}. \end{cases}$$

The equilibrium advertising intensity is

$$d^{UA} = \begin{cases} \dfrac{v}{2\beta\gamma} & k \leq \dfrac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}, \\[2mm] \dfrac{kv(1-\gamma^2)}{4k\beta(1-\gamma^2)-m\phi^2} & \dfrac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \\[2mm] \dfrac{v}{2\beta} & k \geq \dfrac{m\phi^2}{2\beta(1-\gamma^2)}. \end{cases}$$

Plugging in α^{UA}, q^{UA}, and d^{UA}, the platform's and the content creators' profits are

$$\pi_P^{UA} = \begin{cases} \dfrac{v^2 m}{2\beta\gamma^2(1+\gamma)} - \dfrac{2kv^2(1-\gamma)^2}{\phi^2\gamma^2} & k \leq \dfrac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}, \\[2mm] \dfrac{2k^2v^2\beta(1-\gamma)^2(1+\gamma)}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]} & \dfrac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \\[2mm] \dfrac{v^2 m}{2\beta(1+\gamma)} & k \geq \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \end{cases}$$

and

$$\pi_C^{UA} = \begin{cases} 0 & k \leq \dfrac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}, \\[2mm] \dfrac{kv^2[2k\beta(2-\gamma)(1-\gamma^2)-m\phi^2][m\phi^2-2k\beta(1-\gamma^2)]}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2} & \dfrac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \\[2mm] 0 & k \geq \dfrac{m\phi^2}{2\beta(1-\gamma^2)}. \end{cases}$$

Moreover, the consumer surplus CS^{UA} and the social welfare SW^{UA} are

$$CS^{UA} = \begin{cases} \dfrac{v^2}{4\gamma^2(1+\gamma)} & k \leq \dfrac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}, \\[2mm] \dfrac{k^2v^2\beta^2(1-\gamma)^2(1+\gamma)}{[4k\beta(1-\gamma^2)-m\phi^2]^2} & \dfrac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \\[2mm] \dfrac{v^2}{4(1+\gamma)} & k \geq \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \end{cases}$$

and

$$SW^{UA} = \begin{cases} \dfrac{v^2}{4\gamma^2}\left[\dfrac{\beta+2m}{\beta(1+\gamma)} - \dfrac{8k(1-\gamma)^2}{\phi^2}\right] & k \leq \dfrac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}, \\[2mm] \dfrac{kv^2\{\phi^2(1-\gamma^2)[\beta(1-\gamma)+2m(5-\gamma)]k\beta-8(1-\gamma^2)^2k^2\beta^2-2m^2\phi^4\}}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2} & \dfrac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \\[2mm] \dfrac{v^2(\beta+2m)}{4\beta(1+\gamma)} & k \geq \dfrac{m\phi^2}{2\beta(1-\gamma^2)}. \end{cases}$$

For ease of reference, we summarize the above equilibrium results in Table A1. Note that the content

creators obtain positive profits only when their content production efficiency is in the middle region,

i.e., $\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$.

Table A1 Equilibrium Results under UA

	$k \in (0, \frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}]$	$k \in (\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)}, \frac{m\phi^2}{2\beta(1-\gamma^2)})$	$k \in [\frac{m\phi^2}{2\beta(1-\gamma^2)}, +\infty)$
α^{UA}	$\frac{4k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2}$	$2 - \frac{4k\beta(1-\gamma^2)}{m\phi^2}$	0
q^{UA}	$\frac{v(1-\gamma)}{\phi\gamma}$	$\frac{v[m\phi^2-2k\beta(1-\gamma^2)]}{\phi[4k\beta(1-\gamma^2)-m\phi^2]}$	0
d^{UA}	$\frac{v}{2\beta\gamma}$	$\frac{kv(1-\gamma^2)}{4k\beta(1-\gamma^2)-m\phi^2}$	$\frac{v}{2\beta}$
π_C^{UA}	0	$\frac{kv^2[2k\beta(2-\gamma)(1-\gamma^2)-m\phi^2][m\phi^2-2k\beta(1-\gamma^2)]}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2}$	0
π_P^{UA}	$\frac{v^2m}{2\beta\gamma^2(1+\gamma)} - \frac{2kv^2(1-\gamma)^2}{\phi^2\gamma^2}$	$\frac{2k^2v^2\beta(1-\gamma)^2(1+\gamma)}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]}$	$\frac{v^2m}{2\beta(1+\gamma)}$
CS^{UA}	$\frac{v^2}{4\gamma^2(1+\gamma)}$	$\frac{k^2v^2\beta^2(1-\gamma)^2(1+\gamma)}{[4k\beta(1-\gamma^2)-m\phi^2]^2}$	$\frac{v^2}{4(1+\gamma)}$
SW^{UA}	$\frac{v^2}{4\gamma^2}[\frac{\beta+2m}{\beta(1+\gamma)} - \frac{8k(1-\gamma)^2}{\phi^2}]$	$\frac{kv^2\{\phi^2(1-\gamma^2)[\beta(1-\gamma)+2m(5-\gamma)]k\beta-8(1-\gamma^2)^2k^2\beta^2-2m^2\phi^4\}}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2}$	$\frac{v^2(\beta+2m)}{4\beta(1+\gamma)}$

1.2. Differentiated Advertising (DA)

Under the DA format, first, solving the platform's problem on the advertising intensity obtains $d_i = \frac{v+\phi q_i}{2\beta}$. Second, substituting d_i into π_{C_i} and solving the content creators' problems on content qualities, we have $q_i = \frac{vm\phi\alpha(2-\gamma)}{8k\beta(1-\gamma^2)-m\phi^2\alpha(2-\gamma)}$ and $\pi_{C_i} = \frac{kv^2m\alpha[16k\beta(1-\gamma)^2(1+\gamma)-m\phi^2\alpha(2-\gamma)^2]}{[8k\beta(1-\gamma^2)-m\phi^2\alpha(2-\gamma)]^2}$. When $\alpha > \frac{16k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2(2-\gamma)^2}$, one can show that $\pi_{C_i} < 0$. In consequence, the content creators will not join the platform. To ensure that the content creators will join the platform, the platform's problem on the ad revenue-sharing rate can be rewritten as

$$\max_{\alpha} \pi_P(\alpha) = \frac{32k^2v^2m\beta(1-\alpha)(1-\gamma)^2(1+\gamma)}{[8k\beta(1-\gamma^2)-m\phi^2\alpha(2-\gamma)]^2},$$

$$s.t. \begin{cases} \alpha \geq 0, \\ \alpha \leq 1, \\ \pi_{C_i} \geq 0. \end{cases}$$

The objective function $\pi_P(\alpha)$ is concave in α. Note that the third constraint $\pi_{C_i} \geq 0$ is equal to $\alpha \leq \frac{16k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2(2-\gamma)^2}$. Define the Lagrangian $L^{DA} = \frac{32k^2v^2m\beta(1-\alpha^{DA})(1-\gamma)^2(1+\gamma)}{[8k\beta(1-\gamma^2)-m\phi^2\alpha^{DA}(2-\gamma)]^2} + \lambda_1\alpha^{DA} + \lambda_2(1 -$

$\alpha^{DA}) + \lambda_3 \left(\frac{16k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2(2-\gamma)^2} - \alpha^{DA} \right)$, where λ_1, λ_2, and λ_3 are the Lagrange multipliers. The Kuhn-

Tucker conditions are

$$
\begin{cases}
\frac{\partial L^{DA}}{\partial \alpha^{DA}} = 0, \\
\lambda_1 \alpha^{DA} = 0, \\
\lambda_2(1 - \alpha^{DA}) = 0, \\
\lambda_3 \left(\frac{16k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2(2-\gamma)^2} - \alpha^{DA} \right) = 0, \\
\lambda_1, \lambda_2, \lambda_3 \geq 0.
\end{cases}
$$

Follow the derivation under the UA format, the equilibrium ad revenue-sharing rate can be given by

$$
\alpha^{DA} = \begin{cases}
\frac{16k\beta(1-\gamma^2)(1-\gamma)}{m\phi^2(2-\gamma)^2} & k \leq \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)}, \\
2 - \frac{8k\beta(1-\gamma^2)}{m\phi^2(2-\gamma)} & \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}, \\
0 & k \geq \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}.
\end{cases}
$$

The equilibrium content quality is

$$
q^{DA} = \begin{cases}
\frac{2v(1-\gamma)}{\phi\gamma} & k \leq \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)}, \\
\frac{v[m\phi^2(2-\gamma)-4k\beta(1-\gamma^2)]}{\phi[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]} & \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}, \\
0 & k \geq \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}.
\end{cases}
$$

The equilibrium advertising intensity is

$$
d^{DA} = \begin{cases}
\frac{v(2-\gamma)}{2\beta\gamma} & k \leq \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)}, \\
\frac{2kv(1-\gamma^2)}{8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)} & \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}, \\
\frac{v}{2\beta} & k \geq \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}.
\end{cases}
$$

Plugging in α^{DA}, q^{DA}, and d^{DA}, the platform's and the content creators' profits are

$$
\pi_P^{DA} = \begin{cases}
\frac{v^2 m(2-\gamma)^2}{2\beta\gamma^2(1+\gamma)} - \frac{8kv^2(1-\gamma)^2}{\phi^2\gamma^2} & k \leq \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)}, \\
\frac{8k^2v^2\beta(1-\gamma)^2(1+\gamma)}{\phi^2(2-\gamma)[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]} & \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}, \\
\frac{v^2 m}{2\beta(1+\gamma)} & k \geq \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)},
\end{cases}
$$

and

$$\pi_C^{DA} = \begin{cases} 0 & k \le \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)}, \\ \frac{kv^2[m\phi^2(2-\gamma)-4k\beta(1-\gamma^2)][4k\beta(1-\gamma^2)(4-3\gamma)-m\phi^2(2-\gamma)^2]}{\phi^2(2-\gamma)[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2} & \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}, \\ 0 & k \ge \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}. \end{cases}$$

The consumer surplus CS^{DA} and the social welfare SW^{DA} are

$$CS^{DA} = \begin{cases} \frac{v^2(2-\gamma)^2}{4\gamma^2(1+\gamma)} & k \le \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)}, \\ \frac{4k^2v^2\beta^2(1-\gamma)^2(1+\gamma)}{[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2} & \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}, \\ \frac{v^2}{4(1+\gamma)} & k \ge \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}, \end{cases}$$

and

$$SW^{DA} = \begin{cases} \frac{v^2}{4\gamma^2}\left[\frac{(2-\gamma)^2(\beta+2m)}{\beta(1+\gamma)} - \frac{32k(1-\gamma)^2}{\phi^2}\right] & k \le \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)}, \\ \frac{2kv^2\{2\phi^2(1-\gamma^2)[\beta(1-\gamma)+2m(5-3\gamma)]k\beta-16(1-\gamma^2)^2k^2\beta^2-m^2\phi^4(2-\gamma)^2\}}{\phi^2[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2} & \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}, \\ \frac{v^2(\beta+2m)}{4\beta(1+\gamma)} & k \ge \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}. \end{cases}$$

For ease of reference, we summarize the above equilibrium results in Table A2. Note that the content creators obtain positive profits only when their content production efficiency is in the middle region, i.e., $\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$.

Table A2 Equilibrium Results under DA

	$k \in (0, \frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)}]$	$k \in (\frac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)}, \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)})$	$k \in [\frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}, +\infty)$
α^{DA}	$\frac{16k\beta(1-\gamma^2)(1-\gamma)}{m\phi^2(2-\gamma)^2}$	$2 - \frac{8k\beta(1-\gamma^2)}{m\phi^2(2-\gamma)}$	0
q^{DA}	$\frac{2v(1-\gamma)}{\phi\gamma}$	$\frac{v[m\phi^2(2-\gamma)-4k\beta(1-\gamma^2)]}{\phi[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]}$	0
d^{DA}	$\frac{v(2-\gamma)}{2\beta\gamma}$	$\frac{2kv(1-\gamma^2)}{8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)}$	$\frac{v}{2\beta}$
π_C^{DA}	0	$\frac{kv^2[m\phi^2(2-\gamma)-4k\beta(1-\gamma^2)][4k\beta(1-\gamma^2)(4-3\gamma)-m\phi^2(2-\gamma)^2]}{\phi^2(2-\gamma)[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2}$	0
π_P^{DA}	$\frac{v^2m(2-\gamma)^2}{2\beta\gamma^2(1+\gamma)} - \frac{8kv^2(1-\gamma)^2}{\phi^2\gamma^2}$	$\frac{8k^2v^2\beta^2(1-\gamma)^2(1+\gamma)}{\phi^2(2-\gamma)[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]}$	$\frac{v^2m}{2\beta(1+\gamma)}$
CS^{DA}	$\frac{v^2(2-\gamma)^2}{4\gamma^2(1+\gamma)}$	$\frac{4k^2v^2\beta^2(1-\gamma)^2(1+\gamma)}{[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2}$	$\frac{v^2}{4(1+\gamma)}$
SW^{DA}	$\frac{v^2}{4\gamma^2}[\frac{(2-\gamma)^2(\beta+2m)}{\beta(1+\gamma)} - \frac{32k(1-\gamma)^2}{\phi^2}]$	$\frac{2kv^2\{2\phi^2(1-\gamma^2)[\beta(1-\gamma)+2m(5-3\gamma)]k\beta-16(1-\gamma^2)^2k^2\beta^2-m^2\phi^4(2-\gamma)^2\}}{\phi^2[8k\beta(1-\gamma^2)-m\phi^2(2-\gamma)]^2}$	$\frac{v^2(\beta+2m)}{4\beta(1+\gamma)}$

Note that, as we have discussed in the main paper, when comparing the DA format with the UA

format, we focus on the interesting case of $\frac{m\phi^2}{2\beta(1-\gamma^2)(2-\gamma)} < k < \frac{m\phi^2(2-\gamma)}{4\beta(1-\gamma^2)}$, under which the content

creators obtain positive profits under both the UA format and the DA format.

1.3. Creators-Set Advertising (CA)

Under the CA format, first, solving the content creators' problems on the advertising intensity gives

$d_i = \frac{v(2-\gamma-\gamma^2)+(2-\gamma^2)\phi q_i-\gamma\phi q_{3-i}}{\beta(4-\gamma^2)}$. Second, solving the content creators' problems on content qualities

gives $q_i = \frac{vm\phi\alpha(2-\gamma^2)}{k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2\alpha(2-\gamma^2)}$. Third, substituting d_i and q_i into π_{C_i}, we obtain $\pi_{C_i} =$

$\frac{kv^2m\alpha[k\beta(4-\gamma^2)^2(1-\gamma^2)-m\phi^2\alpha(2-\gamma^2)^2]}{[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2\alpha(2-\gamma^2)]^2}$. When $\alpha > \frac{k\beta(4-\gamma^2)^2(1-\gamma^2)}{m\phi^2(2-\gamma^2)^2}$, one can show that $\pi_{C_i} < 0$. In

consequence, the content creators will not join the platform. To ensure that the content creators will join

the platform, the platform's problem on the ad revenue-sharing rate can be rewritten as

$$\max_{\alpha} \pi_P(\alpha) = \frac{2k^2v^2m\beta(1-\alpha)(4-\gamma^2)^2(1-\gamma^2)}{[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2\alpha(2-\gamma^2)]^2},$$

$$s.t. \begin{cases} \alpha \geq 0, \\ \alpha \leq 1, \\ \pi_{C_i} \geq 0. \end{cases}$$

The objective function $\pi_P(\alpha)$ is concave in α. Note that the third constraint $\pi_{C_i} \geq 0$ is equal to

$\alpha \leq \frac{k\beta(4-\gamma^2)^2(1-\gamma^2)}{m\phi^2(2-\gamma^2)^2}$. Define the Lagrangian $L^{CA} = \frac{2k^2v^2m\beta(1-\alpha^{CA})(4-\gamma^2)^2(1-\gamma^2)}{[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2\alpha^{CA}(2-\gamma^2)]^2} + \lambda_1\alpha^{CA} +$

$\lambda_2(1-\alpha^{CA}) + \lambda_3\left(\frac{k\beta(4-\gamma^2)^2(1-\gamma^2)}{m\phi^2(2-\gamma^2)^2} - \alpha^{CA}\right)$, where λ_1, λ_2, and λ_3 are the Lagrange multipliers. The

rest derivation is the same as those under the UA format, we omit the detailed analysis here. The

equilibrium results are provided in Table A3. Note that the content creators obtain positive profits only

when their content production efficiency is in the middle region, i.e., $\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)} < k <$

$\frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$.

Table A3 Equilibrium Results under CA

$k \in (0, \frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)}]$	$k \in$	$k \in [\frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}, +\infty)$
	$(\frac{2m\phi^2(2-\gamma^2)^2}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)}, \frac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)})$	

α^{CA}	$\dfrac{k\beta(4-\gamma^2)^2(1-\gamma^2)}{m\phi^2(2-\gamma^2)^2}$	$2 - \dfrac{k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}{m\phi^2(2-\gamma^2)}$	0
q^{CA}	$\dfrac{v(1-\gamma)(2+\gamma)}{\phi\gamma}$	$\dfrac{v[2m\phi^2(2-\gamma^2)-k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)]}{2\phi[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]}$	0
d^{CA}	$\dfrac{v(1-\gamma)(2-\gamma^2)}{\beta(2-\gamma)\gamma}$	$\dfrac{kv(2+\gamma)(2-\gamma)(1+\gamma)(1-\gamma)}{2[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]}$	$\dfrac{v(1-\gamma)}{\beta(2-\gamma)}$
π_C^{CA}	0	$\dfrac{kv^2[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-2m\phi^2(2-\gamma^2)][2m\phi^2(2-\gamma^2)^2-k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)(4-\gamma-2\gamma^2)]}{4\phi^2(2-\gamma^2)[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^2}$	0
π_P^{CA}	$\dfrac{2v^2(1-\gamma)[m\phi^2(2-\gamma^2)^2-k\beta(4-\gamma^2)^2(1-\gamma^2)]}{\beta\phi^2\gamma^2(2-\gamma)^2(1+\gamma)}$	$\dfrac{k^2v^2\beta(2+\gamma)^2(2-\gamma)^2(1+\gamma)(1-\gamma)}{2\phi^2(2-\gamma^2)[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]}$	$\dfrac{2v^2m(1-\gamma)}{\beta(2-\gamma)^2(1+\gamma)}$
CS^{CA}	$\dfrac{v^2(2-\gamma^2)^2}{\gamma^2(2-\gamma)^2(1+\gamma)}$	$\dfrac{k^2v^2\beta^2(1+\gamma)(4-\gamma^2)^2}{4[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^2}$	$\dfrac{v^2}{(2-\gamma)^2(1+\gamma)}$
SW^{CA}	$\dfrac{v^2}{\gamma^2}\left\{\dfrac{(2-\gamma^2)^2[\beta+2m(1-\gamma)]}{\beta(2-\gamma)^2(1+\gamma)} - \dfrac{2k(2+\gamma)^2(1-\gamma)^2}{\phi^2}\right\}$	$\dfrac{kv^2[\phi^2(2-\gamma^2)(1+\gamma)(2+\gamma)[\beta(2+\gamma)+2m(10-\gamma-5\gamma^2)]k\beta-2k^2\beta^2(2-\gamma)^4(1+\gamma)^2(2+\gamma)^2-8m^2\phi^4(2-\gamma^2)^2]}{4\phi^2[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2(2-\gamma^2)]^2}$	$\dfrac{v^2[\beta+2m(1-\gamma)]}{\beta(2-\gamma)^2(1+\gamma)}$

In the analysis of the comparison between the CA format and the DA format, we focus on the interesting case of $\dfrac{m\phi^2(2-\gamma)^2}{4\beta(1-\gamma^2)(4-3\gamma)} < k < \dfrac{2m\phi^2(2-\gamma^2)}{\beta(2-\gamma)^2(1+\gamma)(2+\gamma)}$, where the content creators obtain positive profits under both the CA format and the DA format.

Part B: Asymmetric Content Production Efficiency

In the main paper, we have assumed that the content creators are symmetric in content production efficiency (i.e., $k_1 = k_2 = k$). In reality, some creators may have advantage in content production over others. In this part, we analyze the model in which one content creator is more efficient in content production than the other content creator. Without loss of generality, we assume $k_1 = 1$ and $k_2 = k < k_1$. Other aspects of the model are the same as those in the main model. Next, we present the equilibrium outcomes.

2.1. Uniform Advertising (UA)

Under the UA format, first, solving the platform's problem on the advertising intensity gives $d = \frac{2v + (q_1 + q_2)\phi}{4\beta}$. Second, substituting d into π_{C_i} and solving the content creators' problems, we have

$$q_1 = \frac{vm\phi[8k\beta(1-\gamma) - m\phi^2\alpha]\alpha}{32k\beta^2(1-\gamma)^2(1+\gamma) - 2m\phi^2\beta(1+k)(1-\gamma)(3+\gamma)\alpha + m^2\phi^4\alpha^2}, \qquad q_2 =$$

$$\frac{vm\phi[8\beta(1-\gamma) - m\phi^2\alpha]\alpha}{32k\beta^2(1-\gamma)^2(1+\gamma) - 2m\phi^2\beta(1+k)(1-\gamma)(3+\gamma)\alpha + m^2\phi^4\alpha^2}, \qquad \text{and} \qquad d =$$

$$\frac{16kv\beta(1-\gamma)^2(1+\gamma) - vm\phi^2(1+k)(1-\gamma^2)\alpha}{32k\beta^2(1-\gamma)^2(1+\gamma) - 2\beta m\phi^2(1+k)(1-\gamma)(3+\gamma)\alpha + m^2\phi^4\alpha^2}.$$ The content creator's profits can be given by

$$\pi_{C_1} = \frac{v^2m\{256k^2\beta^3(1+\gamma)^4(1+\gamma) + 32k\beta^2m\phi^2(1-\gamma)^2[k(\gamma^2+2\gamma-1)-(3-\gamma)(1+\gamma)]\alpha - \beta m^2\phi^4(1-\gamma)[k^2(1+\gamma)(3+\gamma)-2k(9-\gamma^2)-(5-\gamma)(1+\gamma)]\alpha^2 - m^3\phi^6\alpha^3\}\alpha}{[32k\beta^2(1-\gamma)^2(1+\gamma) - 2\beta m\phi^2(1+k)(1-\gamma)(3+\gamma)\alpha + m^2\phi^4\alpha^2]^2},$$

and

$$\pi_{C_2} = \frac{v^2m\{256k^2\beta^3(1+\gamma)^4(1+\gamma) - 32k\beta^2m\phi^2(1-\gamma)^2[1+k(3-\gamma)(1+\gamma)-\gamma(2+\gamma)]\alpha + \beta m^2\phi^4(1-\gamma)[k^2(5-\gamma)(1+\gamma)-(1+\gamma)(3+\gamma)-2k(9-\gamma^2)]\alpha^2 - km^3\phi^6\alpha^3\}\alpha}{[32k\beta^2(1-\gamma)^2(1+\gamma) - 2\beta m\phi^2(1+k)(1-\gamma)(3+\gamma)\alpha + m^2\phi^4\alpha^2]^2}.$$

Plugging in, the platform's problem on the ad revenue-sharing rate becomes

$$\max_{\alpha} \pi_P(\alpha) = \frac{2v^2m\beta(1-\gamma)^2(1+\gamma)(1-\alpha)[16k\beta(1-\gamma) - m\phi^2(1+k)\alpha]^2}{[32k\beta^2(1-\gamma)^2(1+\gamma) - 2\beta m\phi^2(1+k)(1-\gamma)(3+\gamma)\alpha + m^2\phi^4\alpha^2]^2}.$$

Note that the platform should determine the optimal ad revenue-sharing rate to maximize its profit and also ensure that each content creator will obtain positive profit (i.e., $\pi_{C_i} > 0$, $i \in \{1, 2\}$).

2.2. Differentiated Advertising (DA)

Under the DA format, first, solving the platform's problem on the advertising intensity obtains $d_i = \frac{v+\phi q_i}{2\beta}$. Next, substituting d_i into π_{C_i} and solving the content creators' problems on content qualities

gives $\quad q_1 = \frac{vm\phi(2-\gamma)[8k\beta(1-\gamma^2)-m\phi^2\alpha(2+\gamma)]\alpha}{64k\beta^2(1-\gamma^2)^2-16\beta m\phi^2(1+k)(1-\gamma^2)\alpha+m^2\phi^4(4-\gamma^2)\alpha^2}$ $\quad$ and $\quad q_2 =$

$\frac{vm\phi(2-\gamma)[8\beta(1-\gamma^2)-m\phi^2\alpha(2+\gamma)]\alpha}{64k\beta^2(1-\gamma^2)^2-16\beta m\phi^2(1+k)(1-\gamma^2)\alpha+m^2\phi^4(4-\gamma^2)\alpha^2}$. Then, the content creators' profits can be given by

$$\pi_{C_1} = \frac{v^2m\{1024k^2\beta^3(1-\gamma)^4(1+\gamma)^3+64k\beta^2 m\phi^2(1-\gamma^2)^2[k(\gamma^2+4\gamma-4)+2\gamma(2+\gamma)-8]\alpha+16\alpha^2\beta m^2\phi^4(1-\gamma^2)[4+8k-4k\gamma-(k^2+2k+2)\gamma^2]-m^3\phi^6\alpha^3(4-\gamma^2)^2\}\alpha}{[64k\beta^2(1-\gamma^2)^2-16\beta m\phi^2(1+k)(1-\gamma^2)\alpha+m^2\phi^4(4-\gamma^2)\alpha^2]^2},$$

and

$$\pi_{C_2} = \frac{v^2m\{1024k^2\beta^3(1-\gamma)^4(1+\gamma)^3+64k\beta^2 m\phi^2(1-\gamma^2)^2[\gamma^2+4\gamma-4+2k(\gamma^2+2\gamma-4)]\alpha+16\alpha^2\beta m^2\phi^4(1-\gamma^2)[4k(2+k)-4k\gamma-(2k^2+2k+1)\gamma^2]-km^3\phi^6\alpha^3(4-\gamma^2)^2\}\alpha}{[64k\beta^2(1-\gamma^2)^2-16\beta m\phi^2(1+k)(1-\gamma^2)\alpha+m^2\phi^4(4-\gamma^2)\alpha^2]^2}.$$

Plugging in, the platform's problem on the ad revenue-sharing rate can be written as

$$\max_{\alpha} \pi_P(\alpha) = \frac{16v^2m\beta(1-\gamma^2)\{m^2\phi^4[4(1+k^2)-3(1+k^2)\gamma^2-2k\gamma^3]\alpha^2-16k\beta m\phi^2(1+k)(1-\gamma)^2(1+\gamma)(2+\gamma)\alpha+128k^2\beta^2(1-\gamma)^3(1+\gamma)^2\}(1-\alpha)}{[64k\beta^2(1-\gamma^2)^2-16\beta m\phi^2(1+k)(1-\gamma^2)\alpha+m^2\phi^4(4-\gamma^2)\alpha^2]^2}.$$

The platform should set the optimal ad revenue-sharing rate to maximize its profit and ensure that each

content creator will obtain positive profit (i.e., $\pi_{C_i} > 0$, $i \in \{1, 2\}$).

2.3. Creators-Set Advertising (CA)

Under the CA format, first, solving the content creators' problems on the advertising intensity gives

$d_i = \frac{v(2-\gamma-\gamma^2)+(2-\gamma^2)\phi q_i-\gamma\phi q_{3-i}}{\beta(4-\gamma^2)}$. Second, substituting d_i into π_{C_i} and solving the content creators'

problems $\quad$ on $\quad$ content $\quad$ qualities, $\quad$ we $\quad$ have $\quad$ $q_1 =$

$\frac{vm\phi(2-\gamma^2)[k\beta(2-\gamma)(1-\gamma)(2+\gamma)^2-m\phi^2\alpha(2-\gamma^2)]\alpha}{k\beta^2(4-\gamma^2)^3(1-\gamma^2)-\beta m\phi^2(1+k)(4-\gamma^2)(2-\gamma^2)^2\alpha+m^2\phi^4(2-\gamma^2)^2\alpha^2}$ $\quad$ and $\quad$ $q_2 =$

$\frac{vm\phi(2-\gamma^2)[\beta(2-\gamma)(1-\gamma)(2+\gamma)^2-m\phi^2\alpha(2-\gamma^2)]\alpha}{k\beta^2(4-\gamma^2)^3(1-\gamma^2)-\beta m\phi^2(1+k)(4-\gamma^2)(2-\gamma^2)^2\alpha+m^2\phi^4(2-\gamma^2)^2\alpha^2}$. Then, the content creators' profits can be

given by

$$\pi_{C_1} = \frac{m[kv\beta(2-\gamma)(1-\gamma)(2+\gamma)^2-vm\phi^2\alpha(2-\gamma^2)]^2[\beta(4-\gamma^2)^2(1-\gamma^2)-m\phi^2\alpha(2-\gamma^2)^2]\alpha}{[k\beta^2(4-\gamma^2)^3(1-\gamma^2)-\beta m\phi^2(1+k)(4-\gamma^2)(2-\gamma^2)^2\alpha+m^2\phi^4(2-\gamma^2)^2\alpha^2]^2},$$

and

$$\pi_{C_2} = \frac{km[\nu\beta(2-\gamma)(1-\gamma)(2+\gamma)^2 - \nu m\phi^2\alpha(2-\gamma^2)]^2[k\beta(4-\gamma^2)^2(1-\gamma^2) - m\phi^2\alpha(2-\gamma^2)^2]\alpha}{[k\beta^2(4-\gamma^2)^3(1-\gamma^2) - \beta m\phi^2(1+k)(4-\gamma^2)(2-\gamma^2)^2\alpha + m^2\phi^4(2-\gamma^2)^2\alpha^2]^2}.$$

Plugging in, the platform's problem on the ad revenue-sharing rate is

$$\max_{\alpha} \pi_P(\alpha) = \frac{\nu^2 m\beta(4-\gamma^2)^2(1-\gamma^2)[m^2\phi^4(1+k^2)(2-\gamma^2)^2\alpha^2 - 2k\beta m\phi^2(1+k)(2-\gamma)(1-\gamma)(2+\gamma)^2(2-\gamma^2)\alpha + 2k^2\beta^2(2+\gamma)^4(2-3\gamma+\gamma^2)^2](1-\alpha)}{[k\beta^2(4-\gamma^2)^3(1-\gamma^2) - \beta m\phi^2(1+k)(4-\gamma^2)(2-\gamma^2)^2\alpha + m^2\phi^4\alpha^2(2-\gamma^2)^2]^2}.$$

The platform will determine the ad revenue-sharing rate to maximize its profit and also ensure that each content creator will obtain positive profit (i.e., $\pi_{C_i} > 0$, $i \in \{1, 2\}$).

Due to the technical complexity, we cannot analytically show the equilibrium results. Next, we rely on numerical studies to check the robustness of our findings. As in the main paper, we focus on the nontrivial case in which the content creators obtain positive profits. As illustrated in Table B1~B2, the numerical study shows that our main results regarding the market participants' preferences over different ad formats remain qualitatively the same as long as the asymmetric level is not extremely high. In detail, Table B1 presents the comparison results between the DA format and the UA format. The equilibrium ad revenue-sharing rate, content quality, and advertising intensity under the DA format are lower than those under the UA format. Meanwhile, the platform's profit and the consumer surplus are higher under the UA format, and the content creators prefer the UA format only when the substitutability between content creators is not high. Table B2 summarizes the comparison results between the CA and DA format. The equilibrium ad revenue-sharing rate, content quality, and advertising intensity under the CA format are lower than those under the DA format. Meanwhile, the DA format can be a win-win outcome for the platform and the content creators.

We also examine the outcomes when the asymmetric level in content production efficiency between the two content creators is relatively high. As illustrated in Table B3, the numerical study shows that the platform would prefer the DA format to the UA format when the asymmetric level is very high (i.e.,

when k_2 is small). The intuition lies in the fact that the DA format provides the more efficient content creator with stronger motivation to invest in content quality than the UA format does. Table B4 shows that the platform still prefers the DA format to the CA format as long as both creators exist in the market.

Table B1 Comparison Between DA and UA

($v = 1$, $m = 1$, $\phi = 1$, $\beta = 0.45$, $k_1 = 1$, $k_2 = 0.9$)

γ	$\alpha^{DA} - \alpha^{UA}$	$(q_1^{DA} - q_1^{UA},$ $q_2^{DA} - q_2^{UA})$	$(d_1^{DA} - d_1^{UA},$ $d_2^{DA} - d_2^{UA})$	$\pi_P^{DA} - \pi_P^{UA}$	$(\pi_{C1}^{DA} - \pi_{C1}^{UA},$ $\pi_{C2}^{DA} - \pi_{C2}^{UA})$	CS^{DA} $- CS^{UA}$
0.05	-0.0418	$(-0.0388, -0.0420)$	$(-0.0569, -0.0328)$	-0.0104	$(-0.0299, -0.0318)$	-0.0230
0.10	-0.0873	$(-0.0777, -0.0865)$	$(-0.0961, -0.0814)$	-0.0194	$(-0.0577, -0.0616)$	-0.0444
0.15	-0.1340	$(-0.1184, -0.1332)$	$(-0.1481, -0.1313)$	-0.0285	$(-0.0820, -0.0886)$	-0.0652
0.20	-0.1809	$(-0.1636, -0.1848)$	$(-0.2010, -0.1861)$	-0.0387	$(-0.1031, -0.1134)$	-0.0874
0.25	-0.2275	$(-0.2163, -0.2456)$	$(-0.2637, -0.2495)$	-0.0520	$(-0.1195, -0.1361)$	-0.1134
0.30	-0.2730	$(-0.2815, -0.3214)$	$(-0.3421, -0.3277)$	-0.0703	$(-0.1278, -0.1552)$	-0.1468
0.35	-0.3165	$(-0.3671, -0.4224)$	$(-0.4465, -0.4305)$	-0.0970	$(-0.1196, -0.1673)$	-0.1940
0.40	-0.3568	$(-0.4876, -0.5669)$	$(-0.5955, -0.5762)$	-0.1379	$(-0.0729, -0.1621)$	-0.2674
0.45	-0.3925	$(-0.6730, -0.7945)$	$(-0.8279, -0.8026)$	-0.2049	$(0.0763, -0.1101)$	-0.3975

Table B2 Comparison Between CA and DA

$(v = 1, \ m = 1, \ \phi = 1, \ \beta = 0.45, \ k_1 = 1, \ k_2 = 0.9)$

γ	$\alpha^{CA} - \alpha^{DA}$	$(q_1^{CA} - q_1^{DA},$ $q_2^{CA} - q_2^{DA})$	$(d_1^{CA} - d_1^{DA},$ $d_2^{CA} - d_2^{DA})$	$\pi_P^{CA} - \pi_P^{DA}$	$(\pi_{C1}^{CA} - \pi_{C1}^{DA},$ $\pi_{C2}^{CA} - \pi_{C2}^{DA})$	$CS^{CA} - CS^{DA}$
0.05	-0.0022	$(-0.0019, -0.0022)$	$(-0.0357, -0.0355)$	-0.0012	$(-0.0017, -0.0018)$	0.0158
0.10	-0.0096	$(-0.0073, -0.0084)$	$(-0.0801, -0.0753)$	-0.0044	$(-0.0064, -0.0067)$	0.0277
0.15	-0.0225	$(-0.0160, -0.0183)$	$(-0.1181, -0.1197)$	-0.0092	$(-0.0138, -0.0142)$	0.0367
0.20	-0.0421	$(-0.0280, -0.0319)$	$(-0.1652, -0.1686)$	-0.0156	$(-0.0235, -0.0242)$	0.0435
0.25	-0.0692	$(-0.0438, -0.0499)$	$(-0.2172, -0.2231)$	-0.0235	$(-0.0356, -0.0366)$	0.0484
0.30	-0.1048	$(-0.0641, -0.0729)$	$(-0.2753, -0.2843)$	-0.0335	$(-0.0503, -0.0517)$	0.0514
0.35	-0.1500	$(-0.0901, -0.1023)$	$(-0.3409, -0.3540)$	-0.0457	$(-0.0676, -0.0696)$	0.0524
0.40	-0.2064	$(-0.1235, -0.1405)$	$(-0.4160, -0.4348)$	-0.0608	$(-0.0877, -0.0907)$	0.0507

Table B3 Comparison Between DA and UA

$$(v = 1, \ m = 1, \ \phi = 1, \ \beta = 0.45, \ k_1 = 1, \ \gamma = 0.03)$$

k_2	$\alpha^{DA} - \alpha^{UA}$	$(q_1^{DA} - q_1^{UA},$ $q_2^{DA} - q_2^{UA})$	$(d_1^{DA} - d_1^{UA},$ $d_2^{DA} - d_2^{UA})$	$\pi_P^{DA} - \pi_P^{UA}$	$(\pi_{C1}^{DA} - \pi_{C1}^{UA},$ $\pi_{C2}^{DA} - \pi_{C2}^{UA})$
0.95	-0.0263	$(-0.0221, \ -0.0229)$	$(-0.0296, \ -0.0203)$	-0.0051	$(-0.0185, \ -0.0190)$
0.90	-0.0240	$(-0.0232, \ -0.0241)$	$(-0.0394, \ -0.0132)$	-0.0064	$(-0.0178, \ -0.0189)$
0.85	-0.0191	$(-0.0234, \ -0.0223)$	$(-0.0531, 0.0025)$	-0.0077	$(-0.0149, \ -0.0170)$
0.80	-0.0095	$(-0.0208, \ -0.0117)$	$(-0.0716, 0.0356)$	-0.0081	$(-0.0070, \ -0.0099)$
0.75	0.0093	$(-0.0115, 0.0244)$	$(-0.0952, 0.1097)$	-0.0053	$(0.0123, 0.0118)$
0.70	0.0466	$(0.0157, 0.1463)$	$(-0.1205, 0.3007)$	0.0100	$(0.0591, 0.0820)$
0.65	0.1203	$(0.0913, 0.6539)$	$(-0.1327, 0.9608)$	0.0810	$(0.1746, 0.3685)$
0.60	0.2065	$(0.1697, 3.5791)$	$(-0.2301, 4.3954)$	0.6220	$(0.3327, 1.9703)$

Table B4 Comparison Between CA and DA

$$(v = 1, \ m = 1, \ \phi = 1, \ \beta = 0.45, \ k_1 = 1, \ \gamma = 0.03)$$

k_2	$\alpha^{CA} - \alpha^{DA}$	$(q_1^{CA} - q_1^{DA},$ $q_2^{CA} - q_2^{DA})$	$(d_1^{CA} - d_1^{DA},$ $d_2^{CA} - d_2^{DA})$	$\pi_P^{CA} - \pi_P^{DA}$	$(\pi_{C1}^{CA} - \pi_{C1}^{DA},$ $\pi_{C2}^{CA} - \pi_{C2}^{DA})$
0.95	-0.0008	$(-0.0006, -0.0007)$	$(-0.0201, -0.0201)$	-0.0004	$(-0.0006, -0.0006)$
0.90	-0.0008	$(-0.0007, -0.0009)$	$(-0.0210, -0.0208)$	-0.0004	$(-0.0007, -0.0007)$
0.85	-0.0008	$(-0.0008, -0.0010)$	$(-0.0223, -0.0218)$	-0.0005	$(-0.0007, -0.0008)$
0.80	-0.0008	$(-0.0009, -0.0013)$	$(-0.0242, -0.0230)$	-0.0006	$(-0.0007, -0.0009)$
0.75	-0.0008	$(-0.0010, -0.0018)$	$(-0.0272, -0.0250)$	-0.0007	$(-0.0009, -0.0012)$
0.70	-0.0009	$(-0.0014, -0.0031)$	$(-0.0326, -0.0285)$	-0.0010	$(-0.0011, -0.0020)$
0.65	-0.0010	$(-0.0020, -0.0082)$	$(-0.0467, -0.0375)$	-0.0021	$(-0.0012, -0.0049)$
0.60	-0.0007	$(-0.0018, -0.0398)$	$(-0.1032, -0.0778)$	-0.0095	$(0.0031, -0.0228)$

Part C: *N*-Creator Model

We have presented a two-creator model in the main paper. Here we consider a model with $n > 2$ content creators on the platform. Similar to the main model, the representative consumer's net utility is given by

$$U(x_i, q_i, d_i) = \sum_{i=1}^{n}(x_i(v + \phi q_i - \beta d_i) - \frac{1}{2}x_i^2) - \gamma \sum_{i \neq i'}^{n} x_i x_{i'}. \tag{C1}$$

where $\gamma \in (0,1)$ denotes creator substitutability and $\gamma < 1$ is required by the second-order condition to obtain a maximum. The representative consumer determines the optimal amount of content consumption to maximize the net utility. The consumer's demand for content creator i's content is as follows

$$x_i = \frac{1}{(1-\gamma)(1+(n-1)\gamma)}\{v(1-\gamma) + [1+(n-2)\gamma](\phi q_i - \beta d_i) - \gamma \sum_{i' \neq i}^{n}(\phi q_{i'} - \beta d_{i'}\}. \tag{C2}$$

Other aspects of the model are the same as those in the main model. Next, we present the equilibrium outcomes.

3.1. Uniform Advertising (UA)

Under the UA format, first, solving the platform's problem on the advertising intensity gives $d = \frac{nv + \phi \sum_{i=1}^{n} q_i}{2n\beta}$. Second, substituting d into π_{C_i} and solving the content creators' problems, we have

$$q_i = \frac{vm\phi\alpha(1+(n-2)\gamma)}{4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2\alpha(1+(n-2)\gamma)} \quad \text{and} \quad \pi_{C_i} = \frac{kv^2\alpha m[4k\beta(1-\gamma)^2(1+(n-1)\gamma)-m\phi^2\alpha(1+(n-2)\gamma)^2]}{[m\phi^2\alpha(1+(n-2)\gamma)-4k\beta(1-\gamma)(1+(n-1)\gamma)]^2}.$$

The platform's problem on the ad revenue-sharing rate can be rewritten as

$$\max_{\alpha} \pi_P(\alpha) = \frac{4nk^2v^2m\beta(1-\alpha)(1-\gamma)^2(1+(n-1)\gamma)}{[m\phi^2\alpha(1+(n-2)\gamma)-4k\beta(1-\gamma)(1+(n-1)\gamma)]^2},$$

$$s.t. \begin{cases} \alpha \geq 0, \\ \alpha \leq 1, \\ \pi_{C_i} \geq 0. \end{cases}$$

We follow the analysis in Part A to derive the equilibrium results, the detailed analysis is omitted here. Under UA, the equilibrium ad revenue-sharing rate is

$$\alpha^{UA} = \begin{cases} \dfrac{4k\beta(1-\gamma)^2(1+(n-1)\gamma)}{m\phi^2(1+(n-2)\gamma)^2} & k \leq \dfrac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]}, \\[3mm] 2 - \dfrac{4k\beta(1-\gamma)[1+(n-1)\gamma]}{m\phi^2[1+(n-2)\gamma]} & \dfrac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]} < k < \dfrac{m\phi^2[1+(n-2)\gamma]}{2\beta(1-\gamma)[1+(n-1)\gamma]}, \\[3mm] 0 & k \geq \dfrac{m\phi^2[1+(n-2)\gamma]}{2\beta(1-\gamma)[1+(n-1)\gamma]}. \end{cases}$$

The equilibrium content qualities and ad numbers are

$$q_1^{UA} = q_2^{UA} = q^{UA} = \frac{m\phi v\alpha^{UA}[1+(n-2)\gamma]}{4k\beta(1-\gamma)[1+(n-1)\gamma]-m\phi^2\alpha^{UA}[1+(n-2)\gamma]},$$

and

$$d^{UA} = \frac{2kv(1-\gamma)[1+(n-1)\gamma]}{4k\beta(1-\gamma)[1+(n-1)\gamma]-m\phi^2\alpha^{UA}[1+(n-2)\gamma]}.$$

As in the main paper, we will focus on the case of $\dfrac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]} < k <$

$\dfrac{m\phi^2[1+(n-2)\gamma]}{2\beta(1-\gamma)[1+(n-1)\gamma]}$, under which both content creators will get positive profits under UA. Within this

parameter region, the equilibrium content qualities and ad numbers can be given by

$$q^{UA} = \frac{v[m\phi^2(1+(n-2)\gamma)-2k\beta(1-\gamma)(1+(n-1)\gamma)]}{\phi[4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)]},$$

and

$$d^{UA} = \frac{kv(1-\gamma)(1+(n-1)\gamma)}{4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)}.$$

Plugging in α^{UA}, q^{UA}, and d^{UA}, the platform's and the content creators' payoffs are

$$\pi_P^{UA} = \frac{nk^2v^2\beta(1-\gamma)^2(1+(n-1)\gamma)}{\phi^2[1+n-2)\gamma[4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)]},$$

and

$$\pi_{C_1}^{UA} = \pi_{C_2}^{UA} = \pi_C^{UA} =$$

$$\frac{kv^2[2k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)][m\phi^2(1+(n-2)\gamma)^2-2k\beta(1-\gamma)(2+(n-3)\gamma)(1+(n-1)\gamma)]}{\phi^2[1+(n-2)\gamma][4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)]^2}.$$

The consumer surplus and social welfare are

$$CS^{UA} = \frac{k^2v^2\beta^2n(1-\gamma)^2[1+(n-1)\gamma]}{2\{4k\beta(1-\gamma)[1-(1-n)\gamma]-m\phi^2[1-(2-n)\gamma]\}^2},$$

and

$$SW^{UA} = \frac{kv^2n\{k\beta\phi^2(\gamma-1)[1+(n-1)\gamma][\beta(\gamma-1)-2m(5-9\gamma+4n\gamma)]-8k^2\beta^2(1-\gamma)^2[1+(n-1)\gamma]^2-2m^2\phi^4[1+(n-2)\gamma]^2\}}{2\phi^2\{4k\beta(1-\gamma)[1+(n-1)\gamma]-m\phi^2[1+(n-2)\gamma]\}^2}.$$

Given the creators' positive payoffs, Proposition C1 characterizes the impacts of creator

substitutability on the equilibrium results under the UA format.

PROPOSITION C1. *Under the UA format, as creator substitutability (γ) increases,*

   (a) the platform's optimal ad revenue-sharing rate increases; mathematically, $\frac{\partial \alpha^{UA}}{\partial \gamma} > 0$;

   (b) each content creator's optimal content quality increases; mathematically, $\frac{\partial q^{UA}}{\partial \gamma} > 0$;

   (c) the platform's optimal ad intensity increases; mathematically, $\frac{\partial d^{UA}}{\partial \gamma} > 0$;

   (d) the platform's profit can first decrease and then increase; mathematically, there exists γ_1^{ne} such

   that $\frac{\partial \pi_P^{UA}}{\partial \gamma} < 0$ if $\gamma < \gamma_1^{ne}$ and $\frac{\partial \pi_P^{UA}}{\partial \gamma} > 0$ if $\gamma > \gamma_1^{ne}$;

   (e) each content creator's profit can increase or decrease; mathematically, there exists γ_2^{ne} and

   γ_3^{ne} such that $\frac{\partial \pi_C^{UA}}{\partial \gamma} > 0$ when $\gamma_2^{ne} < \gamma < \gamma_3^{ne}$ and $\frac{\partial \pi_C^{UA}}{\partial \gamma} < 0$ when $\gamma < \gamma_2^{ne}$ or $\gamma > \gamma_3^{ne}$;

   (f) the consumer surplus first decreases and then increases; mathematically, there exists γ_4^{ne} such

   that $\frac{\partial CS^{UA}}{\partial \gamma} < 0$ if $\gamma < \gamma_4^{ne}$ and $\frac{\partial CS^{UA}}{\partial \gamma} > 0$ if $\gamma > \gamma_4^{ne}$.

PROOF OF PROPOSITION C1. (a) We first analyze how α^{UA} changes with γ. Differentiating α^{UA} gives

$\frac{\partial \alpha^{UA}}{\partial \gamma} = \frac{4k\beta\gamma(n-1)[2+(n-2)\gamma]}{m\phi^2[1+(n-2)\gamma]^2} > 0$. Conditional on $\frac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]} < k < \frac{m\phi^2[1+(n-2)\gamma]}{2\beta(1-\gamma)[1+(n-1)\gamma]}$,

we have $\frac{\partial \alpha^{UA}}{\partial \gamma} > 0$. Hence, we get that α^{UA} increases in γ.

   (b) Next, we investigate the impact of γ on q^{UA}. Taking derivative gives $\frac{\partial q^{UA}}{\partial \gamma} =$

$\frac{2kv\beta m\phi\gamma(n-1)(2+(n-2)\gamma)}{[4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)]^2} > 0$. That is, q^{UA} increases in γ.

   (c) We then investigate the impact of γ on d^{UA}. Taking derivative gives $\frac{\partial d^{UA}}{\partial \gamma} =$

$\frac{kvm\phi^2\gamma(n-1)(2+(n-2)\gamma)}{[4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)]^2} > 0$. Hence, we get that d^{UA} increases in γ.

   (d) Next, we examine the impact of γ on π_P^{UA}. Taking derivative gives $\frac{\partial \pi_P^{UA}}{\partial \gamma} =$

$\frac{(n-1)nk^2v^2\beta(1-\gamma)}{\phi^2[1+(n-2)\gamma]^2[4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)]^2} f_1^{ne}(\gamma)$, where $f_1^{ne}(\gamma) = m\phi^2(1 + (n-2)\gamma)[1 +$

$\gamma(1 + n + (n-2)\gamma)] - 4k\beta(1-\gamma)(1 + (n-1)\gamma)^2$. We depict the analysis into two cases. When n

is small, follow the proof of Proposition 1 (d) in the main paper, one can show that $f_1^{ne}(\gamma)$ increases or first decreases and then increases in γ. Conditional on $\frac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]} < k < \frac{m\phi^2[1+(n-2)\gamma]}{2\beta(1-\gamma)[1+(n-1)\gamma]}$, one can show that $f_1^{ne}(\gamma)|_{\gamma=0} = m\phi^2 - 4k\beta < 0$ and $f_1^{ne}(\gamma)|_{\gamma=1} = m\phi^2(n-1)[1+\gamma(2n-1)] > 0$. Hence, there exists a threshold value $\gamma_1^{ne} > 0$ such that $f_1^{ne}(\gamma) < 0$ (i.e., $\frac{\partial\pi_P^{UA}}{\partial\gamma} < 0$) when $\gamma < \gamma_1^{ne}$ and $f_1^{ne}(\gamma) > 0$ (i.e., $\frac{\partial\pi_P^{UA}}{\partial\gamma} > 0$) when $\gamma > \gamma_1^{ne}$. When n is large, we have $f_1^{ne}(\gamma)$ decreases in k. Conditional on $\frac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]} < k < \frac{m\phi^2[1+(n-2)\gamma]}{2\beta(1-\gamma)[1+(n-1)\gamma]}$, one can obtain that $f_1^{ne}(\gamma) < f_1^{ne}(\gamma)|_{k=\frac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]}} = -\frac{m\phi^2\gamma(1-\gamma)[1+(n-2)\gamma][n-5+(n-3)(n-2)\gamma]}{2+(n-3)\gamma} < 0$. That is, $f_1^{ne}(\gamma) < 0$ (i.e., $\frac{\partial\pi_P^{UA}}{\partial\gamma} < 0$). In summary, we get that π_P^{UA} can first decrease and then increase in γ.

(e) We then examine how π_C^{UA} changes with γ. Differentiating π_C^{UA} gives $\frac{\partial\pi_C^{UA}}{\partial\gamma} = \frac{2(n-1)k^2v^2\beta}{\phi^2(1+(n-2)\gamma)^2[4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)]^3}f_2^{ne}(\gamma)$, where $f_2^{ne}(\gamma) = 8k^2\beta^2(1-\gamma)^3(1+(n-1)\gamma)^3 - 2k\beta m\phi^2(1-\gamma)(1+(n-2)\gamma)(1+(n-1)\gamma)[3-(10-3n)\gamma-3(3n-5)\gamma^2 - 2(n-2)^2\gamma^3] + m^2\phi^4[1-(4-n)\gamma-(6n-9)\gamma^2-(n-2)(2n-3)\gamma^3](1+(n-2)\gamma)^2$. Follow the proof of Proposition 1 (e) in the main paper, one can show that there exist γ_2^{ne} and γ_3^{ne} such that $\frac{\partial\pi_C^{UA}}{\partial\gamma} > 0$ if $\gamma_2^{ne} < \gamma < \gamma_3^{ne}$ and $\frac{\partial\pi_C^{UA}}{\partial\gamma} < 0$ if $\gamma < \gamma_2^{ne}$ or $\gamma > \gamma_3^{ne}$. Because the detailed deriving process is quite tedious, we omit the proof steps here.

(f) Finally, we examine the impact of γ on CS^{UA}. Differentiating CS^{UA} gives $\frac{\partial CS^{UA}}{\partial\gamma} = \frac{(n-1)nk^2v^2\beta^2(1-\gamma)}{2[4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)]^3}f_3^{ne}(\gamma)$, where $f_3^{ne}(\gamma) = m\phi^2[1+(1+n)\gamma+(n-2)\gamma^2] - 4k\beta(1-\gamma)^2(1+(n-1)\gamma)$. Follow the proof of Proposition 1(f) in the main paper, one can show that $f_3^{ne}(\gamma)$ increases in γ or first decreases and then increases in γ. Further, conditional on $\frac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]} < k < \frac{m\phi^2[1+(n-2)\gamma]}{2\beta(1-\gamma)[1+(n-1)\gamma]}$, one can get that $f_3^{ne}(\gamma)|_{\gamma=0} = m\phi^2 - 4k\beta < 0$ and $f_3^{ne}(\gamma)|_{\gamma=1} = 2nm\phi^2 > 0$. Hence, there exists a threshold value γ_4^{ne} such that $\frac{\partial CS^{UA}}{\partial\gamma} < 0$ if

$\gamma < \gamma_4^{ne}$ and $\frac{\partial CS^{UA}}{\partial \gamma} > 0$ if $\gamma > \gamma_4^{ne}$. Thus, we get that CS^{UA} first decreases and then increases in γ.

This completes the proof of Proposition C1. □

3.2. Differentiated Advertising (DA)

Under the DA format, first, solving the platform's problem on the advertising intensity obtains $d_i = \frac{v+\phi q_i}{2\beta}$. Second, substituting d_i into π_{C_i} and solving the content creators' problems on content qualities, we have $q_i = \frac{vm\phi\alpha(2+(n-3)\gamma)}{8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2\alpha(2+(n-3)\gamma)}$ and $\pi_{C_i} = \frac{kv^2\alpha m[16k\beta(1-\gamma)^2(1+(n-1)\gamma)-m\phi^2\alpha(2+(n-3)\gamma)^2]}{[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2\alpha(2+(n-3)\gamma)]^2}$. The platform's problem on the ad revenue-sharing rate can be rewritten as

$$\max_{\alpha} \pi_P(\alpha) = \frac{16nk^2v^2m\beta(1-\alpha)(1-\gamma)^2(1+(n-1)\gamma)}{[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2\alpha(2+(n-3)\gamma)]^2},$$

$$s.t. \begin{cases} \alpha \geq 0, \\ \alpha \leq 1, \\ \pi_{C_i} \geq 0. \end{cases}$$

We follow the analysis in Part A to derive the equilibrium results, the detailed analysis is omitted here. Under DA, the equilibrium ad revenue-sharing rate is

$$\alpha^{DA} = \begin{cases} \frac{16k\beta(1-\gamma)^2[1+(n-1)\gamma]}{m\phi^2[2+(n-3)\gamma]^2} & k \leq \frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]}, \\ 2 - \frac{8k\beta(1-\gamma)[1+(n-1)\gamma]}{m\phi^2[2+(n-3)\gamma]} & \frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]} < k < \frac{m\phi^2[2+(n-3)\gamma]}{4\beta(1-\gamma)[1+(n-1)\gamma]}, \\ 0 & k \geq \frac{m\phi^2[2+(n-3)\gamma]}{4\beta(1-\gamma)[1+(n-1)\gamma]}. \end{cases}$$

The equilibrium content qualities and ad numbers are

$$q_1^{DA} = q_2^{DA} = q^{DA} = \frac{m\phi v\alpha^{DA}[2+(n-3)\gamma]}{8k\beta(1-\gamma)[1+(n-1)\gamma]-m\phi^2\alpha^{DA}[2+(n-3)\gamma]},$$

and

$$d_1^{DA} = d_2^{DA} = d^{DA} = \frac{4kv(1-\gamma)[1+(n-1)\gamma]}{8k\beta(1-\gamma)1+(n-1)\gamma-m\phi^2\alpha^{DA}[2+(n-3)\gamma]}.$$

As in the main paper, we will focus on the case of $\frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]} < k < \frac{m\phi^2[2+(n-3)\gamma]}{4\beta(1-\gamma)[1+(n-1)\gamma]}$, under which both content creators will get positive profits under DA. Within this

parameter region, the equilibrium content qualities and ad numbers under DA can be given by

$$q^{DA} = \frac{v[m\phi^2(2+(n-3)\gamma)-4k\beta(1-\gamma)(1+(n-1)\gamma)]}{\phi[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)]},$$

and

$$d^{DA} = \frac{2kv(1-\gamma)(1+(n-1)\gamma)}{8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)}.$$

Plugging in α^{DA}, q^{DA}, and d^{DA}, the platform's and the content creators' payoffs are

$$\pi_P^{DA} = \frac{4nk^2v^2\beta(1-\gamma)^2(1+(n-1)\gamma)}{\phi^2(2+(n-3)\gamma)[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)]},$$

and

$$\pi_{C_1}^{DA} = \pi_{C_2}^{DA} = \pi_C^{DA} =$$

$$\frac{kv^2[4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)][m\phi^2(2+(n-3)\gamma)^2-4k\beta(1-\gamma)(4+(n-5)\gamma)(1+(n-1)\gamma)]}{(2+(n-3)\gamma)[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)]^2}.$$

The consumer surplus and social welfare are

$$CS^{DA} = \frac{2k^2v^2\beta^2n(1-\gamma)^2[1+(n-1)\gamma]}{\{8k\beta(\gamma-1)[1+(n-1)\gamma]+m\phi^2[2+(n-3)\gamma]\}^2},$$

and

$$SW^{DA} = \frac{kv^2n\{2k\beta\phi^2(1-\gamma)[1+(n-1)\gamma][\beta(1-\gamma)+2m(5-7\gamma+2n\gamma)]-16k^2\beta^2(1-\gamma)^2[1+(n-1)\gamma]^2+m^2\phi^4[2+(n-3)\gamma]^2\}}{\phi^2\{8k\beta(\gamma-1)[1+(n-1)\gamma]+m\phi^2[2+(n-3)\gamma]\}^2}.$$

Given the creators' positive payoffs, Proposition C2 characterizes the impacts of creator substitutability on the equilibrium results under DA.

PROPOSITION C2. *Under the DA format, as creator substitutability (γ) increases,*

(a) *the platform's optimal ad revenue-sharing rate first decreases and then increases;*

(b) *each content creator's optimal content quality first decreases and then increases;*

(c) *the platform's optimal ad intensity first decreases and then increases;*

(d) *the platform's profit can first decrease and then increase; mathematically, there exists $\gamma_5^{ne} > 0$*

such that $\frac{\partial \pi_P^{DA}}{\partial \gamma} < 0$ if $\gamma < \gamma_5^{ne}$ and $\frac{\partial \pi_P^{DA}}{\partial \gamma} > 0$ if $\gamma > \gamma_5^{ne}$;

(e) *each content creator's profit can decrease or increase; mathematically, when* $k < \frac{m\phi^2}{4\beta}$, *there*

exists γ_6^{ne} *such that* $\frac{\partial \pi_C^{DA}}{\partial \gamma} > 0$ *if* $\gamma < \gamma_6^{ne}$ *and* $\frac{\partial \pi_C^{DA}}{\partial \gamma} < 0$ *if* $\gamma > \gamma_6^{ne}$; *when* $k > \frac{m\phi^2}{4\beta}$, *there*

exists γ_7^{ne} *and* γ_8^{ne} *such that* $\frac{\partial \pi_C^{DA}}{\partial \gamma} > 0$ *if* $\gamma_7^{ne} < \gamma < \gamma_8^{ne}$ *and* $\frac{\partial \pi_C^{DA}}{\partial \gamma} < 0$ *if* $\gamma < \gamma_7^{ne}$ *or*

$\gamma > \gamma_8^{ne}$;

(f) *the consumer surplus can first decrease and then increase; mathematically, there exists* $\gamma_9^{ne} >$

0 *such that* $\frac{\partial CS^{DA}}{\partial \gamma} < 0$ *if* $\gamma < \gamma_9^{ne}$ *and* $\frac{\partial CS^{DA}}{\partial \gamma} > 0$ *if* $\gamma > \gamma_9^{ne}$.

PROOF OF PROPOSITION C2. (a) We first examine the impact of γ on α^{DA}. Taking derivative gives

$\frac{\partial \alpha^{DA}}{\partial \gamma} = \frac{8k\beta(n-1)[(n-3)\gamma^2+4\gamma-1]}{m\phi^2(2+(n-3)\gamma)^2}$. When $n = 3$, $\frac{\partial \alpha^{DA}}{\partial \gamma} < 0$ if $\gamma < 0.25$ and $\frac{\partial \alpha^{DA}}{\partial \gamma} > 0$ if $\gamma > 0.25$.

When $n > 3$, one can verify that $\frac{\partial \alpha^{DA}}{\partial \gamma} < 0$ when $\gamma < \frac{\sqrt{n+1}-2}{n-3}$ and $\frac{\partial \alpha^{DA}}{\partial \gamma} > 0$ when $\gamma > \frac{\sqrt{n+1}-2}{n-3}$.

Therefore, we get that α^{DA} first decreases and then increases in γ.

(b) Next, we examine the impact of γ on q^{DA}. Taking derivative gives $\frac{\partial q^{DA}}{\partial \gamma} =$

$\frac{4kv\beta m\phi(n-1)[(n-3)\gamma^2+4\gamma-1]}{[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)]^2}$. Follow the analysis in Proposition C2 (a), we get that when $n =$

3, $\frac{\partial q^{DA}}{\partial \gamma} < 0$ if $\gamma < 0.25$ and $\frac{\partial q^{DA}}{\partial \gamma} > 0$ if $\gamma > 0.25$. When $n > 3$, $\frac{\partial q^{DA}}{\partial \gamma} < 0$ when $\gamma < \frac{\sqrt{n+1}-2}{n-3}$

and $\frac{\partial q^{DA}}{\partial \gamma} > 0$ when $\gamma > \frac{\sqrt{n+1}-2}{n-3}$. Therefore, we get that q^{DA} first decreases and then increases in γ.

(c) We then examine the impact of γ on d^{DA}. Taking derivative gives $\frac{\partial d^{DA}}{\partial \gamma} =$

$\frac{2kvm\phi^2(n-1)[(n-3)\gamma^2+4\gamma-1]}{[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)]^2}$. Follow the analysis in Proposition C2 (b), we can get that d^{DA}

first decreases and then increases in γ.

(d) Next, we analyze how π_P^{DA} changes with γ. Taking derivative gives $\frac{\partial \pi_P^{DA}}{\partial \gamma} =$

$\frac{4k^2v^2\beta n(n-1)(1-\gamma)}{\phi^2(2+(n-3)\gamma)^2(8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma))^2} f_4^{ne}(\gamma)$, where $f_4^{ne}(\gamma) = m\phi^2\gamma(2 + (n -$

$3)\gamma)(3 + n + (n - 3)\gamma) - 8k\beta(1 - \gamma)(1 + (n - 1)\gamma)^2$. We depict the analysis into two cases. When

n is small, follow the proof of Proposition 2 (d) in the main paper, one can show that $f_4^{ne}(\gamma)$ increases

or first decreases and then increases in γ. One can show that $f_4^{ne}(\gamma)|_{\gamma=0} = -8k\beta < 0$ and

$f_4^{ne}(\gamma)|_{\gamma=1} = 2nm\phi^2(n-1) > 0$. Hence, there exists a threshold value γ_5^{ne} such that $f_4^{ne}(\gamma) < 0$ when $\gamma < \gamma_5^{ne}$ and $f_4^{ne}(\gamma) > 0$ when $\gamma > \gamma_5^{ne}$. When n is large, conditional on $\frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]} < k < \frac{m\phi^2[2+(n-3)\gamma]}{4\beta(1-\gamma)[1+(n-1)\gamma]}$, one can show that $f_4^{ne}(\gamma) < 0$. That is, π_P^{DA} decreases in γ. In summary, we get that π_P^{DA} can first decrease and then increase in γ.

(e) We then examine how π_C^{DA} changes with γ. Differentiating π_C^{DA} gives $\frac{\partial \pi_C^{DA}}{\partial \gamma} = \frac{8k^2v^2\beta(n-1)}{\phi^2(2+(n-3)\gamma)^2[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)]^3} f_5^{ne}(\gamma)$, where $f_5^{ne}(\gamma) = 32k^2\beta^2(1-\gamma)^3(1+(n-1)\gamma)^3 - 4(1-\gamma)(2+(n-3)\gamma)(1+(n-1)\gamma)[5-(17-4n)\gamma - 3(3n-7)\gamma^2 - (n-3)^2\gamma^3]m\phi^2k\beta + (2+(n-3)\gamma)^2[2-(8-2n)\gamma - 6(n-2)\gamma^2 - (n-3)(n-2)\gamma^3]m^2\phi^4$. Follow the proof of Proposition 2(e) in the main paper, we can depict the analysis into two cases. When $k < \frac{m\phi^2}{4\beta}$, one can get that $f_5^{ne}(\gamma)|_{\gamma=0} = 8(k\beta - m\phi^2)(4k\beta - m\phi^2) > 0$ and $f_5^{ne}(\gamma)|_{\gamma=1} = -m^2\phi^4 n(n-1)^3 < 0$. Hence, there exists a threshold value γ_6^{ne} such that $f_5^{ne}(\gamma) > 0$ (i.e., $\frac{\partial \pi_C^{DA}}{\partial \gamma} > 0$) if $\gamma < \gamma_6^{ne}$ and $f_5^{ne}(\gamma) < 0$ (i.e., $\frac{\partial \pi_C^{DA}}{\partial \gamma} < 0$) if $\gamma > \gamma_6^{ne}$. When $k > \frac{m\phi^2}{4\beta}$, conditional on $\frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]} < k < \frac{m\phi^2[2+(n-3)\gamma]}{4\beta(1-\gamma)[1+(n-1)\gamma]}$, we can get that $f_5^{ne}(\gamma)|_{\gamma=0} < 0$ and $f_5^{ne}(\gamma)|_{\gamma=1} < 0$, and there can happen $f_5^{ne}(\gamma) > 0$. Hence, there exist thresholds γ_7^{ne} and γ_8^{ne} such that $f_5^{ne}(\gamma) > 0$ (i.e., $\frac{\partial \pi_C^{DA}}{\partial \gamma} > 0$) when $\gamma_7^{ne} < \gamma < \gamma_8^{ne}$ and $f_5^{ne}(\gamma) < 0$ (i.e., $\frac{\partial \pi_C^{DA}}{\partial \gamma} < 0$) when $\gamma < \gamma_7^{ne}$ or $\gamma > \gamma_8^{ne}$. By summarizing the above results, we get that π_C^{DA} can decrease or increase in γ.

(f) Finally, we examine the impact of γ on CS^{DA}. Taking derivative gives $\frac{\partial CS^{DA}}{\partial \gamma} = \frac{2k^2v^2\beta^2(n-1)n(1-\gamma)}{[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)]^3} f_6^{ne}(\gamma)$, where $f_6^{ne}(\gamma) = m\phi^2\gamma(3+n+(n-3)\gamma) - 8k\beta(1-\gamma)^2(1+(n-1)\gamma)$. Follow the proof of Proposition 2(f) in the main paper, one can verify that $f_6^{ne}(\gamma)$ increases or first decreases and then increases in γ. Further, note that $f_6^{ne}(\gamma)|_{\gamma=0} = -8k\beta < 0$ and $f_6^{ne}(\gamma)|_{\gamma=1} = 2nm\phi^2 > 0$. Hence, there exists a threshold value γ_9^{ne} such that

$f_6^{ne}(\gamma) < 0$ (i.e., $\frac{\partial CS^{DA}}{\partial \gamma} < 0$) when $\gamma < \gamma_9^{ne}$ and $f_6^{ne}(\gamma) > 0$ (i.e., $\frac{\partial CS^{DA}}{\partial \gamma} > 0$) when $\gamma > \gamma_9^{ne}$.

Therefore, we get that CS^{DA} first decreases and then increases in γ. This ends the proof of Proposition C2. □

Next, we compare the equilibrium results under DA with those under UA. The findings are summarized in Proposition C3 and Proposition C4. As in the main paper, we will focus on the case of $\frac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]} < k < \frac{m\phi^2[2+(n-3)\gamma]}{4\beta(1-\gamma)[1+(n-1)\gamma]}$, under which the content creators will get positive profits under both UA and DA formats.

PROPOSITION C3. $\alpha^{DA} < \alpha^{UA}$, $q^{DA} < q^{UA}$, and $d^{DA} < d^{UA}$.

PROOF OF PROPOSITION C3. First, we compare α^{DA} with α^{UA}. We have $\alpha^{DA} - \alpha^{UA} = -\frac{4k\beta(n-1)(1-\gamma)\gamma(1+(n-1)\gamma)}{m\phi^2(2+(n-3)\gamma)(1+(n-2)\gamma)} < 0$. That is, α^{DA} is lower than α^{UA}.

Second, we compare q^{DA} with q^{UA}. Plugging in q^{DA} and q^{UA}, we have $q^{DA} - q^{UA} = -\frac{2(n-1)kv\beta m\phi\gamma(1-\gamma)(1+(n-1)\gamma)}{[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)][4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)]} < 0$. That is, q^{DA} is lower than q^{UA}.

Third, we compare d^{DA} with d^{UA}. Plugging in d^{DA} and d^{UA}, we obtain $d^{DA} - d^{UA} = -\frac{(n-1)kvm\phi^2\gamma(1-\gamma)(1+(n-1)\gamma)}{[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)][4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)]} < 0$. That is, d^{DA} is lower than d^{UA}. This completes the proof of Proposition C3. □

PROPOSITION C4.

(a) $\pi_P^{DA} < \pi_P^{UA}$.

(b) There exists $\hat{\gamma}_1^{ne}$ such that $\pi_C^{DA} < \pi_C^{UA}$ if $\gamma < \hat{\gamma}_1^{ne}$ and $\pi_C^{DA} > \pi_C^{UA}$ if $\gamma > \hat{\gamma}_1^{ne}$.

(c) $CS^{DA} < CS^{UA}$.

PROOF OF PROPOSITION C4: (a) We first compare π_P^{DA} with π_P^{UA}. One can verify that when $k <$

$\frac{m\phi^2[4+(3n-7)\gamma]}{8\beta(1-\gamma)[1+(n-1)\gamma]}$, $\pi_P^{DA} < \pi_P^{UA}$ (and when $k > \frac{m\phi^2[4+(3n-7)\gamma]}{8\beta(1-\gamma)[1+(n-1)\gamma]}$, $\pi_P^{DA} > \pi_P^{UA}$). Note that

$\frac{m\phi^2[4+(3n-7)\gamma]}{8\beta(1-\gamma)[1+(n-1)\gamma]} > \frac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]}$, conditional on $\frac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]} < k <$

$\frac{m\phi^2[2+(n-3)\gamma]}{4\beta(1-\gamma)[1+(n-1)\gamma]}$, there is, $\pi_P^{DA} < \pi_P^{UA}$. Therefore, we get that π_P^{DA} is lower than π_P^{UA}.

(b) We then compare π_C^{DA} with π_C^{UA}. Plugging in π_C^{DA} and π_C^{UA}, one can obtain that $\pi_C^{DA} < \pi_C^{UA}$

is equivalent to $f_7^{ne}(\gamma) < 0$ (and $\pi_C^{DA} > \pi_C^{UA}$ is equivalent to $f_7^{ne}(\gamma) > 0$), where $f_7^{ne}(\gamma) =$

$-128k^3\beta^3(1-\gamma)^4(1+(n-1)\gamma)^3 + 32k^2\beta^2(1-\gamma)^2(1+(n-1)\gamma)^2[2-4\gamma-(n^2-2n-$

$1)\gamma^2]m\phi^2 - 2k\beta m^2\phi^4(1-\gamma)(1+(n-1)\gamma)[4-12n\gamma-12(3+(2n^2-6n))\gamma^2+(41-87n+$

$51n^2-9n^3)\gamma^3] - m^3\phi^6(n-1)(2\gamma+(n-3)\gamma^2)(1+(n-2)\gamma)(3+(2n-5)\gamma)$. Follow the

proof of Proposition 4(b) in the main paper, one can verify that $\frac{\partial^3 f_7^{ne}(\gamma)}{\partial\gamma^3} < 0$. That is, $\frac{\partial^2 f_7^{ne}(\gamma)}{\partial\gamma^2}$

decreases in γ. Further, one can show that $\frac{\partial f_7^{ne}(\gamma)}{\partial\gamma}$ first increases and then decreases in γ. Moreover,

$f_7^{ne}(\gamma)$ first increases and then decreases in γ. Conditional on $\frac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]} < k <$

$\frac{m\phi^2[2+(n-3)\gamma]}{4\beta(1-\gamma)[1+(n-1)\gamma]}$, one can obtain that $f_7^{ne}(\gamma)|_{\gamma=0} = -8k\beta(m\phi^2-4k\beta)^2 < 0$, and there can happen

$f_7^{ne}(\gamma)|_{\gamma=\frac{\sqrt{2}}{\sqrt{2}+n-1}} > 0$.[1] Hence, there exists a threshold value $\hat{\gamma}_1^{ne}$ such that $\pi_C^{DA} < \pi_C^{UA}$ (i.e.,

$f_7^{ne}(\gamma) < 0$) when $\gamma < \hat{\gamma}_1^{ne}$ and $\pi_C^{DA} > \pi_C^{UA}$ (i.e., $f_7^{ne}(\gamma) > 0$) when $\gamma > \hat{\gamma}_1^{ne}$. Therefore, we

obtain that π_C^{DA} is lower (higher) than π_C^{UA} when γ is low (high).

(c) Finally, we compare CS^{DA} with CS^{UA}. Plugging in, one can verify that when $k >$

$\frac{m\phi^2[4+(3n-7)\gamma]}{16\beta(1-\gamma)[1+(n-1)\gamma]}$, $CS^{DA} - CS^{UA} < 0$ (and when $k < \frac{m\phi^2[4+(3n-7)\gamma]}{16\beta(1-\gamma)[1+(n-1)\gamma]}$, $CS^{DA} - CS^{UA} > 0$).

Note that $\frac{m\phi^2[4+(3n-7)\gamma]}{16\beta(1-\gamma)[1+(n-1)\gamma]} < \frac{m\phi^2[2+(n-3)\gamma]}{4\beta(1-\gamma)[1+(n-1)\gamma]}$, conditional on $\frac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]} < k <$

$\frac{m\phi^2[2+(n-3)\gamma]}{4\beta(1-\gamma)[1+(n-1)\gamma]}$, there is, $CS^{DA} < CS^{UA}$. Therefore, CS^{DA} is lower than CS^{UA}. This completes the

proof of Proposition C4. □

---

[1] When we show the comparative statics, we have focused on the case of $\frac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]} < k < \frac{m\phi^2[2+(n-3)\gamma]}{4\beta(1-\gamma)[1+(n-1)\gamma]}$,

which can hold only if $0 < \gamma < \frac{\sqrt{2}}{\sqrt{2}+n-1}$. We use $\gamma = 0$ and $\gamma = \frac{\sqrt{2}}{\sqrt{2}+n-1}$ as the two boundary points in the proof.

3.3. Creators-Set Advertising (CA)

Under the CA format, first, solving the content creators' problems on the advertising intensity gives

$$d_i = \frac{v[2+\gamma(1+2(n-3)-(3+2(n-3))\gamma)]+[2+\gamma(3(n-2)+((n-2)(n-3)-1)\gamma)]\phi q_i - \gamma(1+(n-2)\gamma)\phi \sum_{i'\neq i} q_{i'}}{\beta(2+(n-3)\gamma)[2+(3+2(n-3))\gamma]}$$. Second,

solving the content creators' problems on content qualities gives $q_i =$

$$\frac{vm\phi\alpha(1+(n-2)\gamma)[2+\gamma(3(n-2)+((n-2)(n-3)-1)\gamma)]}{k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)-m\phi^2\alpha(1+(n-2)\gamma)[2+\gamma(3(n-2)+((n-2)(n-3)-1)\gamma)]}$$. Third, substituting

d_i and q_i into π_{C_i} , we obtain $\pi_{C_i} =$

$$\frac{kv^2m\alpha(1+(n-2)\gamma)\{k\beta(1-\gamma)(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)^2-m\phi^2\alpha(1+(n-2)\gamma)[2+\gamma(3(n-2)+((n-2)(n-3)-1)\gamma)]^2\}}{\{k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)-m\phi^2\alpha(1+(n-2)\gamma)[2+\gamma(3(n-2)+((n-2)(n-3)-1)\gamma)]\}^2}$$

. The platform's problem on the ad revenue-sharing rate can be rewritten as

$$\max_\alpha \pi_P(\alpha) = \frac{nk^2v^2m\beta(1-\alpha)(1-\gamma)(2+(n-3)\gamma)^2(1+(n-2)\gamma)(1+(n-1)\gamma)(2+(3+2(n-3))\gamma)^2}{\{k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)-m\phi^2\alpha(1+(n-2)\gamma)[2+\gamma(3(n-2)+((n-2)(n-3)-1)\gamma)]\}^2},$$

$$s.t. \begin{cases} \alpha \geq 0, \\ \alpha \leq 1, \\ \pi_{C_i} \geq 0. \end{cases}$$

We follow the analysis in Part A to derive the equilibrium results, the detailed analysis is omitted

here. Under CA, the equilibrium ad revenue-sharing rate is

$$\alpha^{CA} =$$

$$\begin{cases} \frac{k\beta(1-\gamma)[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(3+2(n-3))\gamma]^2}{m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]^2} & k \leq \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]^2}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma][4+(5n-11)\gamma+(8+(n-7)n)\gamma^2]}, \\ 2 - \frac{k\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}{m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]} & \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]^2}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma][4+(5n-11)\gamma+(8+(n-7)n)\gamma^2]} < k < \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}, \\ 0 & k \geq \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}. \end{cases}$$

The equilibrium content qualities and ad numbers are

$$q_1^{CA} = q_2^{CA} = q^{CA} =$$

$$\frac{v\{2m\phi^2(1+(n-2)\gamma)[2+\gamma(3(n-2)+((n-2)(n-3)-1)\gamma)]-k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)\}}{2\phi\{(k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma))-(1+(n-2)\gamma)[2+\gamma(3(n-2)+((n-2)(n-3)-1)\gamma)]m\phi^2\}},$$

and

$$d_1^{CA} = d_2^{CA} = d^{CA} =$$

$$\frac{kv(1-\gamma)(2+\gamma(n-3))(1+(n-1)\gamma)[2+\gamma(3+2(n-3))]}{2\{(k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma))-(1+(n-2)\gamma)[2+\gamma(3(n-2)+((n-2)(n-3)-1)\gamma)]m\phi^2\}}.$$

As in the main paper, we will focus on the case of

$$\frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]^2}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma][4+(5n-11)\gamma+(8+(n-7)n)\gamma^2]} < k <$$

$$\frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}, \text{ under which both content creators will get positive profits}$$

under CA. Within this parameter region, the equilibrium content qualities and ad numbers can be given

by

$$q^{CA} = \frac{2m\phi^2[1+(n-2)\gamma]\{2+\gamma[3(n-2)+((n-2)(n-3)-1)\gamma]\}-kv\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}{2\phi\{k\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]-m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]\}},$$

and

$$d^{CA} = \frac{kv(1-\gamma)[1+(n-1)\gamma][2+(3+2(n-3))\gamma][2+(n-3)\gamma]}{2k\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]-2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}.$$

Plugging in α^{CA}, q^{CA}, and d^{CA}, the platform's and the content creators' payoffs are

$$\pi_P^{CA} =$$

$$\frac{nk^2v^2\beta(1-\gamma)(1+(n-1)\gamma)[2+(n-3)\gamma]^2[2+(2n-3)\gamma]^2}{4\phi^2[2+\gamma(n(3+(n-5)\gamma)+5\gamma-6)][k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)-m\phi^2(1+(n-2)\gamma)(2+\gamma(n(3+(n-5)\gamma)+5\gamma-6))]},$$

and

$$\pi_{C_1}^{CA} = \pi_{C_2}^{CA} = \pi_C^{CA} =$$

$$\frac{kmv^2(1+(n-2)\gamma)\{k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)[6+\gamma(8n-17+(13+2n(n-6))\gamma)]-2m\phi^2(1+(n-2)\gamma)[2+\gamma(5\gamma-6+n(3+(n-5)\gamma))]^2\}}{2\{k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)-m\phi^2(1+(n-2)\gamma)[2+\gamma(5\gamma-6+n(3+(n-5)\gamma))]\}^2}$$

$$-\frac{k^3v^2\beta^2(2+(n-3)\gamma)^4(1+(n-1)\gamma)^2(2+(2n-3)\gamma)^2[4+\gamma(5n-11+(8+n(n-7))\gamma)]}{4\phi^2[2+\gamma(5\gamma-6+n(3+(-5+n)\gamma))]\{k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)-m\phi^2(1+(n-2)\gamma)[2+\gamma(5\gamma-6+n(3+(n-5)\gamma))]\}^2}.$$

The consumer surplus is

$$CS^{CA} = \frac{k^2v^2\beta^2n[2+(n-3)\gamma]^2[1+(n-2)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]^2}{8\{k\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]-m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]\}^2},$$

and the social welfare is $SW^{CA} = CS^{CA} + \pi_{C_1}^{CA} + \pi_{C_2}^{CA} + \pi_P^{CA}$.

Given the creators' positive payoffs, Proposition C5 examines the impact of creator substitutability on market outcomes under CA.

PROPOSITION C5. *Under the CA format, as creator substitutability (γ) increases,*

(a) the platform's optimal ad revenue-sharing rate decreases; mathematically, $\frac{\partial \alpha^{CA}}{\partial \gamma} < 0$;

(b) each content creator's optimal content quality decreases; mathematically, $\frac{\partial q^{CA}}{\partial \gamma} < 0$;

(c) the optimal ad intensity decreases; mathematically, $\frac{\partial d^{CA}}{\partial \gamma} < 0$;

(d) the platform's profit decreases; mathematically, $\frac{\partial \pi_p^{CA}}{\partial \gamma} < 0$;

(e) each content creator's profit can decrease or increases; mathematically, when $k < \frac{m\phi^2}{4\beta}$, there exists γ_{10}^{ne} such that $\frac{\partial \pi_C^{CA}}{\partial \gamma} > 0$ if $\gamma < \gamma_{10}^{ne}$ and $\frac{\partial \pi_C^{CA}}{\partial \gamma} < 0$ if $\gamma > \gamma_{10}^{ne}$; when $k > \frac{m\phi^2}{4\beta}$, $\frac{\partial \pi_C^{CA}}{\partial \gamma} < 0$;

(f) the consumer surplus decreases; mathematically, $\frac{\partial CS^{CA}}{\partial \gamma} < 0$.

PROOF OF PROPOSITION C5. (a) We first examine the impact of γ on α^{CA}. Taking derivative gives

$$\frac{\partial \alpha^{CA}}{\partial \gamma} = \frac{k\beta(n-1)}{m\phi^2(1+(n-2)\gamma)^2[2+\gamma(5\gamma-6+3n+n(n-5)\gamma)]^2} f_8^{ne}(\gamma) \quad , \quad \text{where} \quad f_8^{ne}(\gamma) = -8 + (88 - 40n)\gamma -$$

$2(199 + n(41n - 182))\gamma^2 + 2(478 + 11n^2(27 - 4n) - 659n)\gamma^3 + (2381n + (477 - 52n)n^3 -$

$1615n^2 - 1287)\gamma^4 - 2(n - 3)^2(2n - 3)(17 + n(4n - 17))\gamma^5 - (n - 3)^2(n - 2)(2n - 3)(5 +$

$(n - 5)n)\gamma^6$. One can verify that $f_8^{ne}(\gamma) < 0$ (i.e., $\frac{\partial \alpha^{CA}}{\partial \gamma} < 0$). That is, α^{CA} decreases in γ.

(b) Next, we examine the impact of γ on q^{CA}. Taking derivative gives $\frac{\partial q^{CA}}{\partial \gamma} =$

$-\frac{kv\beta m\phi(n-1)(2+(n-3)\gamma)}{2[k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3+\gamma)\gamma)-m\phi^2(1+(n-2)\gamma)(2-\gamma(6-5\gamma-n(3+(n-5)\gamma)))]^2} g_0^{ne}$, where $g_0^{ne} =$

$4 + \gamma(18n - 38) + 2(71 + 4n(4n - 17))\gamma^2 + [n(384 + n(28n - 181)) - 265]\gamma^3 + 2(2n -$

$3)[n(53 + n(3n - 22)) - 41]\gamma^4 + (n - 3)(n - 2)(2n - 3)(5 + (n - 5)n)\gamma^5$. One can verify that

$g_0^{ne} > 0$. That is, $\frac{\partial q^{CA}}{\partial \gamma} < 0$. Therefore, we get that q^{CA} decreases in γ.

(c) Next, we examine the impact of γ on d^{CA}. Taking derivative gives $\frac{\partial d^{CA}}{\partial \gamma} =$

$\frac{kv(n-1)}{2[k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3+\gamma)\gamma)-m\phi^2(1+(n-2)\gamma)(2-\gamma(6-5\gamma-n(3+(n-5)\gamma)))]^2} g_1^{ne}(k) \quad , \quad \text{where}$

$g_1^{ne}(k) = m\phi^2\gamma[12 + 45(n - 2)\gamma + (272 - 272n + 66n^2)\gamma^2 + (n - 2)(205 + n(47n -$

$205))\gamma^3 + 2(n - 3)(2n - 3)(17 + n(4n - 17))\gamma^4 + (n - 3)(n - 2)(2n - 3)(5 + n(n -$

$5))\gamma^5] - k\beta(2 + (n-3)\gamma)^2(1 + (n-1)\gamma)^2(2 + (2n-3)\gamma)^2$. Note that $g_1^{ne}(k)$ decreases in k.

Conditional on $\dfrac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]^2}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma][4+(5n-11)\gamma+(8+(n-7)n)\gamma^2]} < k <$ $\dfrac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}$, one can verify that $g_1^{ne}(k) <$

$g_1^{ne}(k)\big|_{k=\frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]^2}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma][4+(5n-11)\gamma+(8+(n-7)n)\gamma^2]}} < 0$. That is, $\dfrac{\partial d^{CA}}{\partial \gamma} < 0$. Therefore, we get that

d^{CA} decreases in γ.

(d) We then examine the impact of γ on π_p^{CA}. Taking derivative gives $\dfrac{\partial \pi_P^{CA}}{\partial \gamma} =$

$\dfrac{(n-1)nk^2v^2\beta(2+(n-3)\gamma)(2+(2n-3)\gamma)}{4\phi^2[2-6\gamma+5\gamma^2+n\gamma(3+(n-5)\gamma)]^2[k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)-m\phi^2(1+(n-2)\gamma)(2-6\gamma+5\gamma^2+n\gamma(3+(n-5)\gamma))]^2} g_2^{ne}(k)$,

where $g_2^{ne}(k) = m\phi^2\gamma[2 - 6\gamma + 5\gamma^2 + n\gamma(3 + (n-5)\gamma)][8 + 34(n-2)\gamma + 4(57 + n(14n -$

$57))\gamma^2 + 2(n-2)(93 + n(22n - 93))\gamma^3 + (294 - 588n + 431n^2 + n^3(16n - 137))\gamma^4 + (n -$

$3)(n-2)(2n-3)(5 + n(n-5))\gamma^5] - k\beta(2 + (n-3)\gamma)^3(1 + (n-1)\gamma)^2(2 + (2n-3)\gamma)[2 -$

$8\gamma + 7\gamma^2 + n\gamma(4 + (2n-7)\gamma)]$. When $n \geq 3$, one can verify that $(2 + (n-3)\gamma)^3(1 + (n -$

$1)\gamma)^2(2 + (2n-3)\gamma)(2 - 8\gamma + 7\gamma^2 + n\gamma(4 + (2n-7)\gamma)) > 0$. That is, $g_2^{ne}(k)$ decreases in k.

Conditional on $\dfrac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]^2}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma][4+(5n-11)\gamma+(8+(n-7)n)\gamma^2]} < k <$ $\dfrac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}$, one can verify that $g_2^{ne}(k) <$

$g_2^{ne}(k)\big|_{k=\frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]^2}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma][4+(5n-11)\gamma+(8+(n-7)n)\gamma^2]}} < 0$. Therefore, there is $\dfrac{\partial \pi_P^{CA}}{\partial \gamma} < 0$, i.e.,

π_P^{CA} decreases in γ.

(e) We then examine the impact of γ on π_C^{CA}. Taking derivative gives $\dfrac{\partial \pi_C^{CA}}{\partial \gamma} =$

$\dfrac{(n-1)k^2v^2\beta(2+(n-3)\gamma)}{4[k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)-m\phi^2(1+(n-2)\gamma)(2-8\gamma+7\gamma^2+n\gamma(4+(2n-7)\gamma))]^3} f_9^{ne}(\gamma)$. Because of the

tedious expression, we do not give the explicit format of $f_9^{ne}(\gamma)$ here. Follow the proof of Proposition

5(e) in the main paper, we can depict the analysis into two cases. When $k < \dfrac{m\phi^2}{4\beta}$, one can verify that

$f_9^{ne}(\gamma)$ first decreases and then increases in γ. Further, one can show that $f_9^{ne}(\gamma)\big|_{\gamma=0} =$

$\frac{32(k\beta - m\phi^2)(4k\beta - m\phi^2)}{\phi^2} > 0$ and $f_9^{ne}(\gamma)|_{\gamma = \tilde{\gamma}^{ne}} < 0.$[2] Hence, there exists a threshold value γ_{10}^{ne} such

that $f_9^{ne}(\gamma) > 0$ (i.e., $\frac{\partial \pi_C^{CA}}{\partial \gamma} > 0$) when $\gamma < \gamma_{10}^{ne}$ and $f_9^{ne}(\gamma) < 0$ (i.e., $\frac{\partial \pi_C^{CA}}{\partial \gamma} < 0$) when $\gamma > \gamma_{10}^{ne}$.

When $k > \frac{m\phi^2}{4\beta}$, one can verify that $f_9^{ne}(\gamma) < 0$ (i.e., $\frac{\partial \pi_C^{CA}}{\partial \gamma} < 0$) in the feasible parameter region. By

summarizing the above results, we get that π_C^{CA} can decrease or increase in γ.

(f) Finally, we examine the impact of γ on CS^{CA}. Taking derivative gives $\frac{\partial CS^{CA}}{\partial \gamma} =$

$\frac{(n-1)nk^2 v^2 \beta^2 (2+(n-3)\gamma)(1+(n-2)\gamma)(2+(2n-3)\gamma)}{8[k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma) - m\phi^2(1+(n-2)\gamma)(2-6\gamma+5\gamma^2+n\gamma(3+(n-5)\gamma))]^3} f_{10}^{ne}(\gamma)$, where

$f_{10}^{ne}(\gamma) = k\beta\gamma(2+(n-3)\gamma)^2(5-n-(n-3)(n-2)\gamma)(1+(n-1)\gamma)(2+(2n-3)\gamma)^2 -$

$m\phi^2(1+(n-2)\gamma)^2[8+(24n-40)\gamma+90\gamma^2+2n(13n-48)\gamma^2+3(n-2)(17+4n^2-$

$17n)\gamma^3+(n-3)(2n-3)(5+(n-5)n)\gamma^4]$. Note that $f_{10}^{ne}(\gamma)$ is a linear function of k. When

$n \leq 4$, $f_{10}^{ne}(\gamma)$ can increases in k . Conditional on

$\frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]^2}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma][4+(5n-11)\gamma+(8+(n-7)n)\gamma^2]} < k <$

$\frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}$, one can verify that $f_{10}^{ne}(\gamma) <$

$f_{10}^{ne}(\gamma)|_{\gamma = \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}} < 0$. That is, CS^{CA} decreases in γ. When $n > 4$,

$f_{10}^{ne}(\gamma)$ decreases in k, and $f_{10}^{ne}(\gamma) < f_{10}^{ne}(\gamma)|_{\gamma = \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]^2}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma][4+(5n-11)\gamma+(8+(n-7)n)\gamma^2]}} <$

0. By summarizing the above results, we get that CS^{CA} decreases in γ. This ends the proof of

Proposition C5. $\square$

Next, we compare the equilibrium outcomes under CA with those under DA. The results are

summarized in Proposition C6 and Proposition C7. As in the main paper, we focus on the case of

$\frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]} < k < \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}$, under which the

content creators will get positive profits under both CA and DA formats.

---

[2] Note that $\frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]^2}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma][4+(5n-11)\gamma+(8+(n-7)n)\gamma^2]} < k <$ $\min(\frac{m\phi^2}{4\beta}, \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]})$ holds only when $0 < \gamma < \tilde{\gamma}^{ne}$. $\tilde{\gamma}^{ne}$ solves $\frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]^2}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma][4+(5n-11)\gamma+(8+(n-7)n)\gamma^2]} = \frac{m\phi^2}{4\beta}$.

PROPOSITION C6. $\alpha^{CA} < \alpha^{DA}$, $q^{CA} < q^{DA}$, and $d^{CA} < d^{DA}$.

PROOF OF PROPOSITION C6. We first compare α^{CA} with α^{DA}. Plugging in α^{CA} and α^{DA}, we have

$$\alpha^{CA} - \alpha^{DA} = -\frac{(n-1)k\beta\gamma^2(1+(n-1)\gamma)[4n+2n(3n-7)\gamma-(1-n(n-2)(2n-7))\gamma^2]}{m\phi^2(2+(n-3)\gamma)(1+(n-2)\gamma)[2-6\gamma+5\gamma^2+n\gamma(3+(n-5)\gamma)]}$$. Conditional on

$\frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]} < k < \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}$, one can verify that

$\alpha^{CA} - \alpha^{DA} < 0$. That is, α^{CA} is lower than α^{DA}.

Second, we compare q^{CA} with q^{DA}. Plugging in q^{CA} and q^{DA}, one can show that $q^{CA} - q^{DA} =$

$$-\frac{(n-1)kv\beta m\phi\gamma^2(1+(n-1)\gamma)[4n+2n(3n-7)\gamma+(n(n-2)(2n-7)-1)\gamma^2]}{2[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)][k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)-m\phi^2(1+(n-2)\gamma)(2-6\gamma+5\gamma^2+3n\gamma+n(n-5)\gamma^2)]}$$.

Conditional on $\frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]} < k < \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}$, one

can show that $q^{CA} - q^{DA} < 0$. That is, q^{CA} is lower than q^{DA}.

Finally, we compare d^{CA} with d^{DA}. Plugging in d^{CA} and d^{DA} , one can show that when $k >$

$\frac{m\phi^2[4-14\gamma+13\gamma^2+6n\gamma+n(2n-11)\gamma^2]}{4\beta(2+(n-3)\gamma)(1+(n-1)\gamma)(2+(2n-3)\gamma)}$, $d^{CA} - d^{DA} < 0$ (and when $k <$

$\frac{m\phi^2[4-14\gamma+13\gamma^2+6n\gamma+n(2n-11)\gamma^2]}{4\beta(2+(n-3)\gamma)(1+(n-1)\gamma)(2+(2n-3)\gamma)}$, $d^{CA} - d^{DA} > 0$) . Note that $\frac{m\phi^2[4-14\gamma+13\gamma^2+6n\gamma+n(2n-11)\gamma^2]}{4\beta(2+(n-3)\gamma)(1+(n-1)\gamma)(2+(2n-3)\gamma)} -$

$\frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]} < 0$, conditional on $\frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]} < k <$

$\frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}$, there is $d^{CA} < d^{DA}$. That is, d^{CA} is lower than d^{DA}.

This completes the proof of Proposition C6.   □

We then examine all participants' preferences between CA and DA. The results are summarized in

the following proposition.

PROPOSITION C7.

(a) $\pi_P^{CA} < \pi_P^{DA}$.

(b) There exists $\hat{\gamma}_2^{ne}$ such that $\pi_C^{CA} < \pi_C^{DA}$ if $\gamma < \hat{\gamma}_2^{ne}$ and $\pi_C^{CA} > \pi_C^{DA}$ if $\gamma > \hat{\gamma}_2^{ne}$.

(c) There exists $\hat{\gamma}_3^{ne}(< \hat{\gamma}_2^{ne})$ such that $CS^{CA} > CS^{DA}$ if $\gamma < \hat{\gamma}_3^{ne}$ and $CS^{CA} < CS^{DA}$ if $\gamma >$

$\hat{\gamma}_3^{ne}$.

PROOF OF PROPOSITION C7: (a) We first compare π_P^{CA} with π_P^{DA}. One can verify that when $k <$

$$\frac{m\phi^2 H^{ne}(\gamma)}{8\beta(1-\gamma)[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}, \qquad \pi_P^{CA} < \pi_P^{DA} \qquad \text{(and} \qquad \text{when} \qquad k >$$

$\frac{m\phi^2 H^{ne}(\gamma)}{8\beta(1-\gamma)[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}$, $\pi_P^{CA} > \pi_P^{DA}$), where $H^{ne}(\gamma) = 16(1+n) - 16(6+4n-$

$3n^2)\gamma + 4(53 + 21n - 51n^2 + 13n^3)\gamma^2 - 4(51 + 11n - 77n^2 + 41n^3 - 6n^4)\gamma^3 + [71 + 15n -$

$n^2(9-2n)(19-11n+2n^2)]\gamma^4$. Conditional on $\frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]} < k <$

$\frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}$, one can verify that

$\frac{m\phi^2 H^{ne}(\gamma)}{8\beta(1-\gamma)[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]} > \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}$. Hence, we have

$\pi_P^{CA} < \pi_P^{DA}$. Therefore, we get that π_P^{CA} is lower than π_P^{DA}.

(b) We then compare π_C^{CA} with π_C^{DA}. Plugging in π_C^{CA} and π_C^{DA}, one can verify that $\pi_C^{CA} < \pi_C^{DA}$

is equivalent to $f_{11}^{ne}(\gamma) < 0$ (and $\pi_C^{CA} > \pi_C^{DA}$ is equivalent to $f_{11}^{ne}(\gamma) > 0$), $\pi_C^{CA} < \pi_C^{DA}$, where

$f_{11}^{ne}(\gamma) = 4(2 + 3n\gamma - 6\gamma + 5\gamma^2 + n(n-5)\gamma^2)[m\phi^2(2 + (n-3)\gamma) - 4k\beta(1-\gamma)(1 + (n-$

$1)\gamma)][m\phi^2(2 + (n-3)\gamma)^2 - 4k\beta(1-\gamma)(4 + (n-5)\gamma)(1 + (n-1)\gamma)][k\beta(2 + (n-3)\gamma)^2(1 +$

$(n-1)\gamma)(2 + (2n-3)\gamma) - m\phi^2(1 + (n-2)\gamma)(2 + 3n\gamma - 6\gamma + 5\gamma^2 + n(n-5)\gamma^2)]^2 + (2 +$

$(n-3)\gamma)[-8k\beta(1-\gamma)(1 + (n-1)\gamma) + m\phi^2(2 + (n-3)\gamma)]^2\{2m\phi^2 k\beta(2 + (n-3)\gamma)^2(1 +$

$(n-2)\gamma)(1 + (n-1)\gamma)(2 + (2n-3)\gamma)(6 - 17\gamma + 8n\gamma + (13 - 12n + 2n^2)\gamma^2)(2 + 3n\gamma -$

$6\gamma + 5\gamma^2 + n(n-5)\gamma^2) - k^2\beta^2(2 + (n-3)\gamma)^4(1 + (n-1)\gamma)^2(2 + (2n-3)\gamma)^2(4 - 11\gamma +$

$5n\gamma + (8 - 7n + n^2)\gamma^2) - 4m^2\phi^4[1 + (n-2)\gamma]^2[2 + 3n\gamma - 6\gamma + 5\gamma^2 + n(n-5)\gamma^2]^3\}$. By

repeating the proof of Proposition 4(b) in the main paper, one can derive that $f_{11}^{ne}(\gamma)$ first increases

and then decreases in γ. Meanwhile, one can show that $f_{11}^{ne}(\gamma)|_{\gamma=0} < 0$ and $f_{11}^{ne}(\gamma)|_{\gamma=\hat{\gamma}^{ne}} > 0$.

Hence, there exists a threshold value $\hat{\gamma}_2^{ne}$ such that $\pi_C^{CA} < \pi_C^{DA}$ when $\gamma < \hat{\gamma}_2^{ne}$ and $\pi_C^{CA} > \pi_C^{DA}$

when $\gamma > \hat{\gamma}_2^{ne}$. To reduce clutter, we omit the tedious detailed deriving process here.

(c) We then compare CS^{CA} with CS^{DA}. Plugging in, one can verify that $CS^{CA} - CS^{DA} < 0$ is

equivalent to $f_{12}^{ne}(\gamma) < 0$ (and $CS^{CA} - CS^{DA} > 0$ is equivalent to $f_{12}^{ne}(\gamma) > 0$), where $f_{12}^{ne}(\gamma) = 4k\beta(1-\gamma)[2+(n-3)\gamma][1+(n-1)\gamma][2+(2n-3)\gamma] - m\phi^2[1+(n-2)\gamma][4-10\gamma+7\gamma^2 + 6n\gamma + (2n^2-9n)\gamma^2]$. Note that $\frac{\partial^4 f_{12}^{ne}(\gamma)}{\partial\gamma^4} = -96k\beta(n-3)(n-1)(2n-3) < 0$, i.e., $\frac{\partial^3 f_{12}^{ne}(\gamma)}{\partial\gamma^3}$ decreases in γ. Follow the similar steps, one can get that $\frac{\partial^2 f_{12}^{ne}(\gamma)}{\partial\gamma^2}$ decreases in γ, or first increases and then decreases in γ. Further, one can get that $\frac{\partial f_{12}^{ne}(\gamma)}{\partial\gamma}$ first increases and then decreases in γ. Moreover, we can show that $f_{12}^{ne}(\gamma)$ first increases and then decreases in γ. Conditional on

$$\frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]} < k < \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]},$$ one can show that

$f_{12}^{ne}(\gamma)|_{\gamma=0} = 16k\beta - 4m\phi^2 > 0$ and $f_{12}^{ne}(\gamma)|_{\gamma=\hat{\gamma}^{ne}} < 0$.[3] Hence, there exists a threshold value $\hat{\gamma}_3^{ne}$ such that $CS^{CA} > CS^{DA}$ (i.e., $f_{12}^{ne}(\gamma) > 0$) when $\gamma < \hat{\gamma}_3^{ne}$ and $CS^{CA} < CS^{DA}$ (i.e., $f_{12}^{ne}(\gamma) < 0$) when $\gamma > \hat{\gamma}_3^{ne}$. Therefore, we obtain that CS^{CA} is higher (lower) than CS^{DA} when γ is low (high). This ends the proof of Proposition C7. □

In summary, when N content creators compete in the platform, we show that the impacts of ad format on the content creators' incentives to invest in content creation remain the same as those in the main model; thus, most of our main results are qualitatively the same as those in the main model. For example, the equilibrium ad revenue-sharing rate, content quality, and advertising intensity will be lower under DA than those under UA. The platform's payoff will be higher under UA than that under DA. Meanwhile, the platform prefers DA to CA while the content creators prefer DA to CA when creator substitutability is relatively low.

---

[3] When we show the comparative statics, we focus on the case of $\frac{m\phi^2[2+(n-3)\gamma]^2}{4\beta(1-\gamma)[1+(n-1)\gamma][4+(n-5)\gamma]} < k < \frac{2m\phi^2[1+(n-2)\gamma][2+3(n-2)\gamma+((n-2)(n-3)-1)\gamma^2]}{\beta[2+(n-3)\gamma]^2[1+(n-1)\gamma][2+(2n-3)\gamma]}$, which can hold only if $0 < \gamma < \hat{\gamma}^{ne}$, where $\hat{\gamma}^{ne}$ is the unique solution within zero and one of the equation $(157 - 194n + 22n^2 + 48n^3 - 19n^4 + 2n^5)\gamma^5 - (590 - 680n + 164n^2 + 32n^3 - 10n^4)\gamma^4 + (864 - 824n + 184n^2)\gamma^3 - 8(n-2)(7n-39)\gamma^2 - (80n-224)\gamma - 32 = 0$. We use $\gamma = 0$ and $\gamma = \hat{\gamma}^{ne}$ as the two boundary points in the proof of the comparison between CA and DA.

3.4. Heterogenous Entry Cost

We have analyzed a model in which the number of creators on the platform is exogenously given. We now study a model in which the content creators are heterogenous in their entry costs into the platform. More specifically, we assume that there are $\bar{N}$ creators in the content market.[4] Creator's entry cost is denoted by c, which is assumed to be uniformly distributed over $[0, \bar{C}]$. Then, a creator's net profit under ad format f ($f \in \{UA, DA, CA\}$) is $\pi_C^f(n) - c$, where $\pi_C^f(n)$ is a creator's revenue which we have obtained in Subsection 3.1~3.3 of the Supplementary Materials file, and n is the number of creators on the platform. We assume that a creator joins the platform only if his/her net profit is nonnegative. Thus, the creators with $c \leq \pi_C^f$ will join the platform and the number of creators that join the platform can be given by $\frac{\pi_C^f(n)}{\bar{C}} \bar{N}$. Thus, the number of content creators that join the platform under the UA format can be yielded by solving

$$\frac{\pi_C^{UA}(n)}{\bar{C}} \bar{N} = n,$$

where $\pi_C^{UA}(n) = \frac{kv^2[2k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)][m\phi^2(1+(n-2)\gamma)^2-2k\beta(1-\gamma)(2+(n-3)\gamma)(1+(n-1)\gamma)]}{\phi^2[1+(n-2)\gamma][4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(1+(n-2)\gamma)]^2}$.[5]

The number of content creators that join the platform under the DA format can be yielded by solving

$$\frac{\pi_C^{DA}(n)}{\bar{C}} \bar{N} = n,$$

---

[4] We assume that there is a sufficient number of content creators in the market. That is, $\bar{N}$ is sufficiently high in our analysis.

[5] Note that equation $\frac{\pi_C^{UA}(n)}{\bar{C}} \bar{N} = n$ is equivalent to equation $\Delta(n) = -\bar{C}\phi\gamma^3(4k\beta(1-\gamma)-m\phi^2)^2n^4 - \gamma^2[\bar{N}kv^2\gamma(2k\beta(1-\gamma)-m\phi^2)^2 + \bar{C}\phi^2(4k\beta(1-\gamma)-m\phi^2)(4k\beta(1-\gamma)(3-4\gamma)-3m\phi^2(1-2\gamma))]n^3 + \gamma[\bar{N}kv^2\gamma(m\phi^2-2k\beta(1-\gamma))(2k\beta(1-\gamma)(4-5\gamma)-3m\phi^2(1-2\gamma)) - \bar{C}\phi^2(16k^2\beta^2(1-\gamma)^3(3-5\gamma) - 8km\phi^2\beta(1-\gamma)(1-2\gamma)(3-4\gamma) + 3m^2\phi^4(1-2\gamma)^2)]n^2 - [\bar{C}\phi^2(1-2\gamma)(4k\beta(1-\gamma)^2-m\phi^2(1-2\gamma))^2 + \bar{N}kv^2\gamma(4k^2\beta^2(1-\gamma)^3(5-7\gamma) - 2km\phi^2\beta(1-\gamma)(8-\gamma(25-19\gamma)) + 3m^2\phi^4(1-2\gamma)^2)]n - \bar{N}kv^2[4k^2\beta^2(1-\gamma)^4(2-3\gamma) - 2km\phi^2\beta(1-\gamma)^2(1-2\gamma)(3-5\gamma) + m^2\phi^4(1-2\gamma)^3] = 0$. One can verify that $\frac{\partial^3\Delta(n)}{\partial n^3} = -6\bar{N}kv^2\gamma^3[2k\beta(1-\gamma)-m\phi^2]^2 - 6\bar{C}\gamma^2\phi^2[4k\beta(1-\gamma)-m\phi^2][4k\beta(1-\gamma)(3+4(n-1)\gamma)-m\phi^2(3-(6-4n)\gamma)] < 0$. That is, $\frac{\partial^2\Delta(n)}{\partial n^2}$ decreases in n. Further, conditional on $\frac{m\phi^2[1+(n-2)\gamma]^2}{2\beta(1-\gamma)[1+(n-1)\gamma][2+(n-3)\gamma]} < k < \frac{m\phi^2[1+(n-2)\gamma]}{2\beta(1-\gamma)[1+(n-1)\gamma]}$, we have $\frac{\partial^2\Delta(n)}{\partial n^2}|_{n=0}$ can be negative or positive, and $\frac{\partial^2\Delta(n)}{\partial n^2}|_{n=\bar{N}} < 0$. Thus, $\frac{\partial\Delta(n)}{\partial n}$ decreases in n, or first increases and then decreases in n. Following similar steps, we can verify that $\Delta(n)$ decreases in n, or first increases and then decreases in n. One can verify that $\Delta(n)|_{n=0} > 0$ and $\Delta(n)|_{n=\bar{N}} < 0$. Therefore, there can exist only one solution to $\Delta(n) = 0$. Similar steps can be applied to analyze the DA and CA formats.

where $\pi_C^{DA}(n) = \frac{kv^2[4k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)][m\phi^2(2+(n-3)\gamma)^2-4k\beta(1-\gamma)(4+(n-5)\gamma)(1+(n-1)\gamma)]}{(2+(n-3)\gamma)[8k\beta(1-\gamma)(1+(n-1)\gamma)-m\phi^2(2+(n-3)\gamma)]^2}$. The

number of content creators that join the platform under the CA format can be yielded by solving

$$\frac{\pi_C^{CA}(n)}{\bar{C}}\bar{N} = n,$$

where $\pi_C^{CA}(n) =$

$$\frac{kmv^2(1+(n-2)\gamma)\{k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)[6+\gamma(8n-17+(13+2n(n-6))\gamma)]-2m\phi^2(1+(n-2)\gamma)[2+\gamma(5\gamma-6+n(3+(n-5)\gamma))]^2\}}{2\{k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)-m\phi^2(1+(n-2)\gamma)[2+\gamma(5\gamma-6+n(3+(n-5)\gamma))]\}^2}$$

$$-\frac{k^3v^2\beta^2(2+(n-3)\gamma)^4(1+(n-1)\gamma)^2(2+(2n-3)\gamma)^2[4+\gamma(5n-11+(8+n(n-7))\gamma)]}{4\phi^2[2+\gamma(5\gamma-6+n(3+(-5+n)\gamma))]\{k\beta(2+(n-3)\gamma)^2(1+(n-1)\gamma)(2+(2n-3)\gamma)-m\phi^2(1+(n-2)\gamma)[2+\gamma(5\gamma-6+n(3+(n-5)\gamma))]\}^2}.$$

Given the above analysis, one can expect that the number of content creators on the platform can be

different under different ad formats, and thus the platform's realized profit under different ad formats

will also be different. Due to the technical complexity, we cannot analytically show the equilibrium

number of content creators. We will rely on numerical studies to present our findings. As illustrated in

Table C1, the numerical study shows that our main results regarding the platform's ad format preference

remain qualitatively the same as those in the main model. Moreover, we show that the number of content

creators on the platform under UA is higher than those under DA and CA when the creator

substitutability is relatively low. When the creator substitutability is high, the number of content creators

on the platform under DA is higher than those under UA and CA.

Table C1 Number of Content Creators and Platform's Profit

$(v = 1,\ m = 1,\ \phi = 1,\ \beta = 1,\ k = 0.4,\ \overline{C} = 1,\ \overline{N} = 100)$

γ	n^{UA}	n^{DA}	n^{CA}	π_P^{UA}	π_P^{DA}	π_P^{CA}
0.1	7.2084	4.2489	3.8268	1.2244	0.8123	0.7396
0.2	4.9043	3.3424	2.7413	0.8098	0.5748	0.4950
0.3	3.2111	3.1648	2.2904	0.6148	0.4855	0.3952
0.4	2.2310	3.3669	2.0408	0.5161	0.4421	0.3377
0.5	1.7011	3.4844	1.8788	0.4700	0.4144	0.2970

Part D: Complementarity Between Creators

We have presented a model with substitutability between the content creators in the main paper. Here

we consider a model with complementarity between the two content creators. Similar to the main model,

the representative consumer's net utility is given by

$$U(x_i, q_i, d_i) = \sum_{i=1}^{n}(x_i(v + \phi q_i - \beta d_i) - \frac{1}{2}x_i^2) + \gamma \sum_{i \neq i'}^{n} x_i x_{i'}. \tag{D1}$$

where $\gamma \in (0,1)$ captures the level of complementarity between the creators. The higher γ is, the

more complementary the creators are in the eyes of the consumer. The representative consumer

determines the optimal amount of content consumption to maximize the net utility. The consumer's

demand for content creator i's content is as follows

$$x_i = \frac{1}{1-\gamma^2}[v(1+\gamma) + (\phi q_i - \beta d_i) + \gamma(\phi q_{i'} - \beta d_{i'})], i = \{1,2\}, i \neq i'. \tag{D2}$$

Other aspects of the model are the same as those in the main model. Next, we present the equilibrium

outcomes

4.1. Uniform Advertising (UA)

We follow the analysis in Part A to derive the equilibrium results, the detailed analysis is omitted here.

As in the main paper, we will focus on the case of $\frac{m\phi^2}{4\beta(1-\gamma^2)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$, under which both content

creators will get positive profits under the UA format. Then, the equilibrium ad revenue-sharing rate,

content qualities, and ad number can be given by

$$\alpha^{UA} = 2 - \frac{4k\beta(1-\gamma^2)}{m\phi^2},$$

$$q_1^{UA} = q_2^{UA} = q^{UA} = \frac{v[m\phi^2 - 2k\beta(1-\gamma^2)]}{\phi[4k\beta(1-\gamma^2) - m\phi^2]},$$

$$d^{UA} = \frac{kv(1-\gamma^2)}{4k\beta(1-\gamma^2) - m\phi^2}.$$

Plugging in α^{UA}, q^{UA}, and d^{UA}, the platform's and the content creators' payoffs are

$$\pi_P^{UA} = \frac{2k^2v^2\beta(1+\gamma)^2(1-\gamma)}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]},$$

and

$$\pi_{C_1}^{UA} = \pi_{C_2}^{UA} = \pi_C^{UA} = \frac{kv^2[2k\beta(2+\gamma)(1-\gamma^2)-m\phi^2][m\phi^2-2k\beta(1-\gamma^2)]}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2}.$$

The consumer surplus and social welfare are

$$CS^{UA} = \frac{k^2v^2\beta^2(1+\gamma)^2(1-\gamma)}{[4k\beta(1-\gamma^2)-m\phi^2]^2},$$

and

$$SW^{UA} = \frac{kv^2\{\phi^2(1-\gamma^2)[\beta(1+\gamma)+2m(5+\gamma)]k\beta-8(1-\gamma^2)^2k^2\beta^2-2m^2\phi^4\}}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2}.$$

Given the creators' positive payoffs, Proposition D1 characterizes the impacts of creator complementarity on the equilibrium results under the UA format.

PROPOSITION D1. *Under the UA format, as creator complementarity (γ) increases,*

(a) *the platform's optimal ad revenue-sharing rate increases; mathematically,* $\frac{\partial \alpha^{UA}}{\partial \gamma} > 0$;

(b) *each content creator's optimal content quality increases; mathematically,* $\frac{\partial q^{UA}}{\partial \gamma} > 0$;

(c) *the platform's optimal ad intensity increases; mathematically,* $\frac{\partial d^{UA}}{\partial \gamma} > 0$;

(d) *the platform's profit increases; mathematically,* $\frac{\partial \pi_P^{UA}}{\partial \gamma} > 0$;

(e) *each content creator's profit increases; mathematically,* $\frac{\partial \pi_C^{UA}}{\partial \gamma} > 0$;

(f) *the consumer surplus increases; mathematically,* $\frac{\partial CS^{UA}}{\partial \gamma} > 0$.

PROOF OF PROPOSITION D1. (a) We first analyze how α^{UA} changes with γ. Taking derivative gives $\frac{\partial \alpha^{UA}}{\partial \gamma} = \frac{8k\beta\gamma}{m\phi^2} > 0$. Thus, we get that α^{UA} increases in γ.

(b) Next, we investigate the impact of γ on q^{UA}. Taking derivative gives $\frac{\partial q^{UA}}{\partial \gamma} = \frac{4kv\beta m\phi\gamma}{[4k\beta(1-\gamma^2)-m\phi^2]^2} > 0$. Thus, we get that q^{UA} increases in γ.

(c) We then examine how d^{UA} changes with γ. Taking derivative gives $\frac{\partial d^{UA}}{\partial \gamma} =$

$\frac{2kv\gamma m\phi^2}{[4k\beta(1-\gamma^2)-m\phi^2]^2} > 0$. Thus, we get that d^{UA} increases in γ.

(d) We then examine how π_P^{UA} changes with γ. Taking derivative gives $\frac{\partial \pi_P^{UA}}{\partial \gamma} =$

$\frac{2k^2v^2\beta}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2} f_1^C(\gamma)$, where $f_1^C(\gamma) = 4k\beta(1-\gamma^2)^2 - m\phi^2(1+\gamma)(1-3\gamma)$. Note that

$f_1^C(\gamma)$ increases in k. Conditional on $\frac{m\phi^2}{4\beta(1-\gamma^2)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$, one can verify that $f_1^C(\gamma) > 0$. Thus,

we get that π_P^{UA} increases in γ.

(e) We then examine how π_C^{UA} changes with γ. Taking derivative gives $\frac{\partial \pi_C^{UA}}{\partial \gamma} =$

$\frac{2k^2v^2\beta(1-\gamma)}{\phi^2(4k\beta(1-\gamma^2)-m\phi^2)^3} f_2^C(\gamma)$, where $f_2^C(\gamma) = -8\beta^2(1-\gamma)^2(1+\gamma)^3k^2 + 2\beta(3+7\gamma+\gamma^2 -$

$3\gamma^3)m\phi^2k - m^2\phi^4(1+3\gamma)$. Conditional on $\frac{m\phi^2}{4\beta(1-\gamma^2)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$, one can verify that $f_2^C(\gamma) >$

0. Thus, we get that π_C^{UA} increases in γ.

(f) We then examine how CS^{UA} changes with γ. Taking derivative gives $\frac{\partial CS^{UA}}{\partial \gamma} =$

$\frac{k^2v^2\beta^2(1+\gamma)}{[4k\beta(1-\gamma^2)-m\phi^2]^3} f_3^C(\gamma)$, where $f_3^C(\gamma) = 4k\beta(1-\gamma)(1+\gamma)^2 - m\phi^2(1-3\gamma)$. Note that $f_3^C(\gamma)$

increases in k. Conditional on $\frac{m\phi^2}{4\beta(1-\gamma^2)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$, one can verify that $f_3^C(\gamma) > 0$. Thus, we get

that CS^{UA} increases in γ. This ends the proof of Proposition D1. □

4.2. Differentiated Advertising (DA)

We follow the analysis in Part A to derive the equilibrium results, the detailed analysis is omitted here.

Under the DA format, both content creators get positive profits under the DA format only when the

creators' content production efficiency k satisfies $\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)} < k < \frac{m\phi^2(2+\gamma)}{4\beta(1-\gamma^2)}$. Within this parameter

region, the equilibrium ad revenue-sharing rate, content qualities, and ad numbers under DA can be

given by

$$\alpha^{DA} = 2 - \frac{8k\beta(1-\gamma^2)}{m\phi^2(2+\gamma)},$$

$$q_1^{DA} = q_2^{DA} = q^{DA} = \frac{v[m\phi^2(2+\gamma)-4k\beta(1-\gamma^2)]}{\phi[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]},$$

$$d_1^{DA} = d_2^{DA} = d^{DA} = \frac{2kv(1-\gamma^2)}{8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)}.$$

Plugging in α^{DA}, q^{DA}, and d^{DA}, the platform's and the content creators' payoffs are

$$\pi_P^{DA} = \frac{8k^2v^2\beta(1+\gamma)^2(1-\gamma)}{\phi^2(2+\gamma)[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]},$$

and

$$\pi_{C_1}^{DA} = \pi_{C_2}^{DA} = \pi_C^{DA} = \frac{kv^2[m\phi^2(2+\gamma)-4k\beta(1-\gamma^2)][m\phi^2(2+\gamma)^2-4k\beta(1-\gamma^2)(4+3\gamma)]}{\phi^2(2+\gamma)[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]^2}.$$

The consumer surplus and social welfare are

$$CS^{DA} = \frac{4k^2v^2\beta^2(1+\gamma)^2(1-\gamma)}{[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]^2},$$

and

$$SW^{DA} = \frac{2kv^2\{2\phi^2(1-\gamma^2)[\beta(1+\gamma)+2m(5+3\gamma)]k\beta-16(1-\gamma^2)^2k^2\beta^2-m^2\phi^4(2+\gamma)^2\}}{\phi^2\left[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)\right]^2}.$$

Given the creators' positive payoffs, Proposition D2 characterizes the impacts of creator complementarity on the equilibrium results under DA.

PROPOSITION D2. *Under the DA format, as creator complementarity (γ) increases,*

(a) *the platform's optimal ad revenue-sharing rate increases; mathematically,* $\frac{\partial \alpha^{DA}}{\partial \gamma} > 0$;

(b) *each content creator's optimal content quality increases; mathematically,* $\frac{\partial q^{DA}}{\partial \gamma} > 0$;

(c) *the platform's optimal ad intensity increases; mathematically,* $\frac{\partial d^{DA}}{\partial \gamma} > 0$;

(d) *the platform's profit increases; mathematically,* $\frac{\partial \pi_P^{DA}}{\partial \gamma} > 0$;

(e) *each content creator's profit increases; mathematically,* $\frac{\partial \pi_C^{DA}}{\partial \gamma} > 0$;

(f) *the consumer surplus increases; mathematically,* $\frac{\partial CS^{DA}}{\partial \gamma} > 0$.

PROOF OF PROPOSITION D2. (a) We first analyze how α^{DA} changes with γ. Taking derivative gives $\frac{\partial \alpha^{DA}}{\partial \gamma} = \frac{8k\beta(1+4\gamma+\gamma^2)}{m\phi^2(2+\gamma)^2} > 0$. Thus, we get that α^{DA} increases in γ.

(b) Next, we examine how q^{DA} changes with γ. Taking derivative gives $\frac{\partial q^{DA}}{\partial \gamma} = \frac{4kv\beta m\phi(1+4\gamma+\gamma^2)}{[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]^2} > 0$. That is, q^{DA} increases in γ.

(c) We then examine how d^{DA} changes with γ. Taking derivative gives $\frac{\partial d^{DA}}{\partial \gamma} = \frac{2kvm\phi^2(1+4\gamma+\gamma^2)}{[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]^2} > 0$. Thus, we get that d^{DA} increases in γ.

(d) We then examine how π_P^{DA} changes with γ. Taking derivative gives $\frac{\partial \pi_P^{DA}}{\partial \gamma} = \frac{8k^2v^2\beta(1+\gamma)}{\phi^2(2+\gamma)^2[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]^2} f_4^C(\gamma)$, where $f_4^C(\gamma) = 8k\beta(1-\gamma)^2(1+\gamma) + m\phi^2\gamma(2+\gamma)(5+\gamma)$.

Note that $f_4^C(\gamma)$ increases in k. Conditional on $\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)} < k < \frac{m\phi^2(2+\gamma)}{4\beta(1-\gamma^2)}$, one can verify that $f_4^C(\gamma) > 0$. Thus, we get that π_P^{DA} increases in γ.

(e) We then examine how π_C^{DA} changes with γ. Taking derivative gives $\frac{\partial \pi_C^{DA}}{\partial \gamma} = \frac{16k^2v^2\beta}{\phi^2(2+\gamma)^2[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]^3} f_5^C(\gamma)$, where $f_5^C(\gamma) = -16k^2\beta^2(1-\gamma^2)^3 + 2k\beta m\phi^2(1-\gamma)(1+\gamma)(2+\gamma)(5+9\gamma+3\gamma^2+\gamma^3) - m^2\phi^4(2+\gamma)^2(1+2\gamma)$. Conditional on $\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)} < k < \frac{m\phi^2(2+\gamma)}{4\beta(1-\gamma^2)}$, one can verify that $f_5^C(\gamma) > 0$. Thus, we get that π_C^{DA} increases in γ.

(f) We then examine how CS^{DA} changes with γ. Taking derivative gives $\frac{\partial CS^{DA}}{\partial \gamma} = \frac{4k^2v^2\beta^2(1+\gamma)[8k\beta(1-\gamma)(1+\gamma)^2+m\phi^2\gamma(5+\gamma)]}{[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]^3} > 0$. Thus, we get that CS^{DA} increases in γ. This ends the proof of Proposition D2. □

Next, we compare the equilibrium results under DA with those under UA. The findings are summarized in Proposition D3 and Proposition D4. As in the main paper, we will focus on the case of $\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$, under which the content creators will get positive profits under both UA and DA formats.

PROPOSITION D3. $\alpha^{DA} > \alpha^{UA}$, $q^{DA} > q^{UA}$, and $d^{DA} > d^{UA}$.

PROOF OF PROPOSITION D3. First, we compare α^{DA} with α^{UA}. We have $\alpha^{DA} - \alpha^{UA} = \frac{4k\beta\gamma(1-\gamma^2)}{m\phi^2(2+\gamma)} > 0$. That is, α^{DA} is higher than α^{UA}.

Second, we compare q^{DA} with q^{UA}. Plugging in q^{DA} and q^{UA}, we have $q^{DA} - q^{UA} = \frac{2kv\beta m\phi\gamma(1-\gamma^2)}{[4k\beta(1-\gamma^2)-m\phi^2][8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]} > 0$. That is, q^{DA} is higher than q^{UA}.

Third, we compare d^{DA} with d^{UA}. Plugging in d^{DA} and d^{UA}, we obtain $d^{DA} - d^{UA} =$

$$\frac{kvm\phi^2\gamma(1-\gamma^2)}{[4k\beta(1-\gamma^2)-m\phi^2][8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]} > 0.$$ That is, d^{DA} is higher than d^{UA}. This completes the proof

of Proposition D3. □

PROPOSITION D4.

(a) $\pi_P^{DA} > \pi_P^{UA}$.

(b) $\pi_C^{DA} > \pi_C^{UA}$.

(c) $CS^{DA} > CS^{UA}$.

PROOF OF PROPOSITION D4: (a) We first compare π_P^{DA} with π_P^{UA}. We have $\pi_P^{DA} - \pi_P^{UA} =$

$$\frac{2k^2v^2\beta\gamma(1-\gamma)(1+\gamma)^2}{\phi^2(2+\gamma)[4k\beta(1-\gamma^2)-m\phi^2][8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]}f_6^C(\gamma),$$ where $f_6^C(\gamma) = m\phi^2(4+\gamma) - 8k\beta(1-\gamma^2)$.

Note that $f_6^C(\gamma)$ decreases in k. Conditional on $\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$, one can verify that

$f_6^C(\gamma) > f_6^C(\gamma)|_{k=\frac{m\phi^2}{2\beta(1-\gamma^2)}} > 0$. Therefore, we obtain that π_P^{DA} is higher than π_P^{UA}.

(b) We then compare π_C^{DA} with π_C^{UA}. Plugging in π_C^{DA} and π_C^{UA}, We have $\pi_C^{DA} - \pi_C^{UA} =$

$$\frac{2k^2v^2\beta\gamma(1-\gamma)}{\phi^2[4k\beta(1-\gamma^2)-m\phi^2]^2[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]^2}g_1^C(k),$$ where $g_1^C(k) = 128\beta^3(1-\gamma)^3(1+\gamma)^4k^3 -$

$32\beta^2m\phi^2(1-\gamma^2)^2(2+4\gamma+\gamma^2)k^2 + 2\beta m^2\phi^4(1-\gamma^2)(4+24\gamma+12\gamma^2+\gamma^3)k - m^3\phi^6\gamma(2+$

$\gamma)(3+\gamma)$. Conditional on $\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$, one can verify that $\frac{\partial g_1^C(k)}{\partial k} > 0$. That is, $g_1^C(k)$

increases in k. Thus, $g_1^C(k) > g_1^C(k)|_{k=\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)}} > 0$. Therefore, we get that π_C^{DA} is higher than π_C^{UA}.

(c) Finally, we compare CS^{DA} with CS^{UA}. Plugging in CS^{DA} and CS^{UA}, We have $CS^{DA} -$

$CS^{UA} = \frac{k^2v^2\beta^2m\phi^2\gamma(1-\gamma)(1+\gamma)^2}{[4k\beta(1-\gamma^2)-m\phi^2]^2[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)]^2}g_2^C(k),$ where $g_2^C(k) = 16k\beta(1-\gamma^2) - m\phi^2(4+$

$\gamma)$. Note that $g_2^C(k)$ increases in k. Conditional on $\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)} < k < \frac{m\phi^2}{2\beta(1-\gamma^2)}$, one can verify that

$g_2^C(k) > g_2^C(k)|_{k=\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)}} > 0$. Therefore, CS^{DA} is higher than CS^{UA}. This completes the proof of

Proposition D4. □

In summary, when the content creators' contents are complementary to each other, the results in our

main paper will change. First, regardless of the ad format (UA or DA), the equilibrium ad revenue-sharing rate, ad intensity, and all participants' payoffs will increase with creator complementarity. These results are intuitive because an increase in creator complementarity will motivate the consumer to consume more content on the platform. In this case, the platform will benefit from providing the consumer with higher-quality content. To do this, the platform find it profitable to share more ad revenue with the content creators to incentivize content production. The content creators respond to the increased ad revenue-sharing rate by increasing their content qualities. The increased content qualities on the platform in turn enable the platform to sell more ads. Meanwhile, as creator complementarity increases, the consumer's higher demand for content makes both the platform and the creators better off. Higher content quality combined with more content consumption will lead to higher consumer surplus. Second, the equilibrium ad revenue-sharing rate, content quality, and the number of ads shown for each content will be lower under UA than under DA. This result arises because the content creators have more incentive to produce high-quality content under DA than under UA since they do expect to obtain differentiated compensation from displaying ads under DA. As a result, the platform tends to share more ad revenue with the content creators to motivate content production under DA than under UA. The higher-quality content in turn enables the platform to show more ads for the content under DA than under UA. Third, all participants' payoffs are higher under DA than those under UA. The intuition lies in the fact that the content creators have a stronger incentive to invest in content quality under DA than under UA. The higher-quality content leads to more content consumption, as well as higher payoffs under DA than under UA.

4.3. Creators-Set Advertising (CA)

We now examine the CA format and compare it with the DA format. We follow the analysis in Part A to derive the equilibrium results, the detailed analysis is omitted here. Both content creators get positive profits under CA only when the creators' content production efficiency k satisfies $\frac{m\phi^2(2-\gamma^2)}{\beta(8-4\gamma-6\gamma^2+\gamma^3+\gamma^4)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(8-4\gamma-6\gamma^2+\gamma^3+\gamma^4)}$. Within this parameter region, the equilibrium ad revenue-sharing rate, content qualities, and ad numbers can be given by

$$\alpha^{CA} = 2 - \frac{k\beta(2-\gamma)^2(1-\gamma)(2-\gamma)}{m\phi^2(2-\gamma^2)},$$

$$q_1^{CA} = q_2^{CA} = q^{CA} = \frac{v[2m\phi^2(2-\gamma^2)-k\beta(2+\gamma)^2(1-\gamma)(2-\gamma)]}{2\phi[k\beta(2+\gamma)^2(1-\gamma)(2-\gamma)-m\phi^2(2-\gamma^2)]},$$

$$d_1^{CA} = d_2^{CA} = d^{CA} = \frac{kv(2+\gamma)(2-\gamma)(1+\gamma)(1-\gamma)}{2[k\beta(2+\gamma)^2(1-\gamma)(2-\gamma)-m\phi^2(2-\gamma^2)]}.$$

The platform's and the content creators' profits are

$$\pi_P^{CA} = \frac{k^2v^2\beta(2+\gamma)^2(2-\gamma)^2(1+\gamma)(1-\gamma)}{2\phi^2(2-\gamma^2)[k\beta(2+\gamma)^2(1-\gamma)(2-\gamma)-m\phi^2(2-\gamma^2)]},$$

and

$$\pi_{C_1}^{CA} = \pi_{C_2}^{CA} = \pi_C^{CA} = \frac{kv^2\left[k\beta(2+\gamma)^2(1-\gamma)(2-\gamma)-2m\phi^2(2-\gamma^2)\right]\left[2m\phi^2(2-\gamma^2)^2-k\beta(2-\gamma)^2(1-\gamma)(2-\gamma)(4+\gamma-2\gamma^2)\right]}{4\phi^2(2-\gamma^2)\left[k\beta(2+\gamma)^2(1-\gamma)(2-\gamma)-m\phi^2(2-\gamma^2)\right]^2}.$$

The consumer surplus is

$$CS^{CA} = \frac{k^2v^2\beta^2(1-\gamma)(2+\gamma)^2(2-\gamma)^2}{4[k\beta(2+\gamma)^2(1-\gamma)(2-\gamma)-m\phi^2(2-\gamma^2)]^2},$$

and the social welfare is $SW^{CA} = CS^{CA} + \pi_{C_1}^{CA} + \pi_{C_2}^{CA} + \pi_P^{CA}$.

Given the creators' positive payoffs, Proposition D5 examines the impact of creator complementarity on market outcomes under CA.

PROPOSITION D5. *Under the CA format, as creator complementarity (γ) increases,*

(a) the platform's optimal ad revenue-sharing rate increases; mathematically, $\frac{\partial \alpha^{CA}}{\partial \gamma} > 0$;

(b) each content creator's optimal content quality increases; mathematically, $\frac{\partial q^{CA}}{\partial \gamma} > 0$;

(c)   the optimal ad intensity increases; mathematically, $\frac{\partial d^{CA}}{\partial \gamma} > 0$;

(d)   the platform's profit increases; mathematically, $\frac{\partial \pi_p^{CA}}{\partial \gamma} > 0$;

(e)   each content creator's profit increases; mathematically, $\frac{\partial \pi_C^{CA}}{\partial \gamma} > 0$;

(f)   the consumer surplus increases; mathematically, $\frac{\partial CS^{CA}}{\partial \gamma} > 0$.

PROOF OF PROPOSITION D5. (a) We first analyze how α^{CA} changes with γ. Taking derivative gives $\frac{\partial \alpha^{CA}}{\partial \gamma} = \frac{k\beta[8+\gamma(2-\gamma^2)(4-\gamma-2\gamma^2)]}{m\phi^2(2-\gamma^2)^2} > 0$. Thus, we get that α^{CA} increases in γ.

(b)   Next, we examine the impact of γ on q^{CA}. Taking derivative gives $\frac{\partial q^{CA}}{\partial \gamma} =$

$\frac{kv\beta m\phi[8+\gamma(2-\gamma^2)(4-\gamma-2\gamma^2)]}{2[k\beta(2-\gamma)(1-\gamma)(2+\gamma)^2-m\phi^2(2-\gamma^2)]^2} > 0$. That is, q^{CA} increases in γ.

(c)   We then examine how d^{CA} changes with γ. Taking derivative gives $\frac{\partial d^{CA}}{\partial \gamma} =$

$\frac{kv[k\beta(2-\gamma)^2(1-\gamma)^2(2+\gamma)^2+2m\phi^2\gamma(6-4\gamma^2+\gamma^4)]}{2[k\beta(2-\gamma)(1-\gamma)(2+\gamma)^2-m\phi^2(2-\gamma^2)]^2} > 0$. Thus, we get that d^{CA} increases in γ.

(d)   We then examine how π_P^{CA} changes with γ. Taking derivative gives $\frac{\partial \pi_P^{CA}}{\partial \gamma} =$

$\frac{k^2v^2\beta(2-\gamma)(2+\gamma)[k\beta(2-\gamma)(1-\gamma)^2(2+\gamma)^3(2+\gamma^2)+2m\phi^2\gamma(8-8\gamma^2+4\gamma^4-\gamma^6)]}{2\phi^2(2-\gamma^2)^2[k\beta(2-\gamma)(1-\gamma)(2+\gamma)^2-m\phi^2(2-\gamma^2)]^2} > 0$. Thus, we get that π_P^{CA} increases in γ.

(e)   We then examine how π_C^{DA} changes with γ. Taking derivative gives $\frac{\partial \pi_C^{DA}}{\partial \gamma} =$

$\frac{k^2v^2\beta(1-\gamma)(2+\gamma)^2}{4\phi^2(2-\gamma^2)^2[k\beta(2-\gamma)(1-\gamma)(2+\gamma)^2-m\phi^2(2-\gamma^2)]^3} f_7^C(\gamma)$, where $f_7^C(\gamma) = -k^2\beta^2(2-\gamma)^3(1-\gamma)^2(2+\gamma)^4(2+\gamma^2) + k\beta m\phi^2(2-\gamma)(2+\gamma)(2-\gamma^2)(40-16\gamma-10\gamma^2-22\gamma^3+9\gamma^4+9\gamma^5-4\gamma^6) - 4m^2\phi^4(2-\gamma^2)^2(4-2\gamma^3+\gamma^4)$. Conditional on $\frac{m\phi^2(2-\gamma^2)}{\beta(8-4\gamma-6\gamma^2+\gamma^3+\gamma^4)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(8-4\gamma-6\gamma^2+\gamma^3+\gamma^4)}$, one can verify that $f_7^C(\gamma) > 0$. Thus, we get that π_C^{CA} increases in γ.

(f)   We then examine how CS^{CA} changes with γ. Taking derivative gives $\frac{\partial CS^{DA}}{\partial \gamma} =$

$\frac{k^2v^2\beta^2[3k\beta\gamma(1-\gamma)(4-\gamma^2)^3+m\phi^2(2-\gamma)(2+\gamma)(8-8\gamma+2\gamma^2+\gamma^4)]}{4[k\beta(2-\gamma)(1-\gamma)(2+\gamma)^2-m\phi^2(2-\gamma^2)]^3} > 0$. Thus, we get that CS^{CA} increases in γ.

This ends the proof of Proposition D5. □

Next, we compare the equilibrium outcomes under CA with those under DA. The results are

summarized in Proposition D6 and Proposition D7. As in the main paper, we focus on the case of

$\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(8-4\gamma-6\gamma^2+\gamma^3+\gamma^4)}$, under which the content creators will get positive profits under

both CA and DA formats.

PROPOSITION D6.

(a) $\alpha^{CA} < \alpha^{DA}$;

(b) $q^{CA} < q^{DA}$;

(c) There exists a threshold value $\hat{\gamma}_1^C$ such that $d^{CA} < d^{DA}$ when $\gamma > \hat{\gamma}_1^C$ and $d^{CA} > d^{DA}$ when

$\gamma < \hat{\gamma}_1^C$.

PROOF OF PROPOSITION D6. (a) We first compare α^{CA} with α^{DA}. Plugging in α^{CA} and α^{DA}, we have

$\alpha^{CA} - \alpha^{DA} = -\frac{k\beta\gamma^2(1-\gamma)(8+4\gamma-\gamma^2)}{m\phi^2(2+\gamma)(2-\gamma^2)} < 0$. Therefore, α^{CA} is lower than α^{DA}.

(b) We then compare q^{CA} with q^{DA}. Plugging in q^{CA} and q^{DA}, one can show that $q^{CA} - q^{DA} =$

$-\frac{kv\beta m\phi\gamma^2(1-\gamma)(8+4\gamma-\gamma^2)}{2[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)][k\beta(2-\gamma)(1-\gamma)(2+\gamma)^2-m\phi^2(2-\gamma^2)]} < 0$. Therefore, q^{CA} is lower than q^{DA}.

(c) We then compare d^{CA} with d^{DA}. Plugging in d^{CA} and d^{DA}, we have $d^{CA} - d^{DA} =$

$\frac{kv\gamma(1-\gamma^2)}{2[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)][k\beta(2-\gamma)(1-\gamma)(2+\gamma)^2-m\phi^2(2-\gamma^2)]} f_8^C(\gamma)$, where $f_8^C(\gamma) = 4k\beta(2-\gamma)(1-\gamma)(2+\gamma) -$

$m\phi^2(4+2\gamma-\gamma^2)$ and $\frac{\partial f_8^C(\gamma)}{\partial\gamma} = -[4k\beta(4+2\gamma-3\gamma^2)+2m\phi^2(1-\gamma)] < 0$. That is, $f_8^C(\gamma)$

decreases in γ. Conditional on $\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(8-4\gamma-6\gamma^2+\gamma^3+\gamma^4)}$, one can show that $f_8^C(\gamma)|_{\gamma=0} >$

0 and $f_8^C(\gamma)|_{\gamma=1} < 0$. Hence, there exists a threshold value $\hat{\gamma}_1^C$ such that $f_8^C(\gamma) > 0$ (i.e., $d^{CA} >$

d^{DA}) when $\gamma < \hat{\gamma}_1^C$ and $f_8^C(\gamma) < 0$ (i.e., $d^{CA} < d^{DA}$) when $\gamma > \hat{\gamma}_1^C$. Therefore, we obtain that d^{CA}

is higher (lower) than d^{DA} when γ is small (large). This completes the proof of Proposition D6. □

We then examine all participants' preferences between CA and DA. The results are summarized in

the following proposition.

PROPOSITION D7.

(a) $\pi_P^{CA} < \pi_P^{DA}$.

(b) $\pi_C^{CA} < \pi_C^{DA}$.

(c) $CS^{CA} < CS^{DA}$.

PROOF OF PROPOSITION D7: (a) We first compare π_P^{CA} with π_P^{DA}. Plugging in π_P^{CA} and π_P^{DA}, we have

$$\pi_P^{CA} - \pi_P^{DA} = \frac{k^2 v^2 \beta \phi^2 \gamma^2 (1-\gamma^2)}{2\phi^4 (2-\gamma^2)(2+\gamma)[8k\beta(1-\gamma^2)-m\phi^2(2+\gamma)][k\beta(2-\gamma)(1-\gamma)(2+\gamma)^2 - m\phi^2(2-\gamma^2)]} f_9^C(\gamma) \quad , \quad \text{where} \quad f_9^C(\gamma) =$$

$8k\beta(2-\gamma)(1-\gamma^2)(2+\gamma)^2 - m\phi^2(48 + 32\gamma - 20\gamma^2 - 12\gamma^3 + \gamma^4)$. Note that $f_9^C(\gamma)$ increases

in k. Conditional on $\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(8-4\gamma-6\gamma^2+\gamma^3+\gamma^4)}$, one can show that $f_9^C(\gamma) >$

$f_9^C(\gamma)|_{k=\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)}} > 0$. Therefore, we get that π_P^{CA} is lower than π_P^{DA}.

(b) We then compare π_C^{CA} with π_C^{DA}. Plugging in π_C^{CA} and π_C^{DA}, we have $\pi_C^{CA} < \pi_C^{DA}$ is

equivalent to $g_3^C(k) < 0$ (and $\pi_C^{CA} > \pi_C^{DA}$ is equivalent to $g_3^C(k) > 0$), where $g_3^C(k) =$

$-64\beta^3(2-\gamma)^2(1+\gamma)^3(2-\gamma-\gamma^2)^4 k^3 + 16\beta^2 m\phi^2 \gamma (1-\gamma)^3(2+\gamma)^2(64 + 104\gamma - 60\gamma^3 -$

$13\gamma^4 + 9\gamma^5 + 2\gamma^6)k^2 + \beta m^2 \phi^4 (1-\gamma)^2 (768 - 256\gamma - 3328\gamma^2 - 2368\gamma^3 + 1184\gamma^4 +$

$1536\gamma^5 + 168\gamma^6 - 198\gamma^7 - 53\gamma^8 - 2\gamma^9)k - 2m^3 \phi^6 (1-\gamma)(2+\gamma)(2-\gamma^2)[16 - \gamma(2+\gamma)(8 +$

$\gamma(2-\gamma)(7+\gamma))]$. Conditional on $\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(8-4\gamma-6\gamma^2+\gamma^3+\gamma^4)}$, one can verify that $g_3^C(k)$

increases in k. Note also $g_3^C(k) < g_3^C(k)|_{k=\frac{2m\phi^2(2-\gamma^2)}{\beta(8-4\gamma-6\gamma^2+\gamma^3+\gamma^4)}} < 0$. Therefore, we get that π_C^{CA} is

lower than π_C^{DA}.

(c) We then compare CS^{CA} with CS^{DA}. Plugging in, one can verify that $CS^{CA} - CS^{DA} < 0$ is

equivalent to $g_4^C(k) < 0$ (and $CS^{CA} - CS^{DA} > 0$ is equivalent to $g_4^C(k) > 0$), where $g_4^C(k) =$

$-16\beta^2(4+\gamma)(4-5\gamma^2+\gamma^4)^2 k^2 + 16\beta m\phi^2(2-\gamma)(1-\gamma)(1+\gamma)(2+\gamma)^2(4-\gamma-2\gamma^2)k -$

$m^2 \phi^4 (4 - 2\gamma - 3\gamma^2)(16 + 12\gamma - 6\gamma^2 - 5\gamma^3)$. Conditional on $\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)} < k < \frac{2m\phi^2(2-\gamma^2)}{\beta(8-4\gamma-6\gamma^2+\gamma^3+\gamma^4)}$,

one can verify that $g_4^C(k)$ decreases in k. Note also $g_4^C(k) < g_4^C(k)|_{k=\frac{m\phi^2(2+\gamma)}{8\beta(1-\gamma^2)}} < 0$. Therefore, we

get that CS^{CA} is lower than CS^{DA}. This ends the proof of Proposition D7. □

Our analysis reveals that the result regarding the platform's preference between CA and DA remains the same with that in the main model: the platform always prefers to set the ad numbers by itself. Note also that the content creators will always prefer DA when there exists complementarity between the creators. This is because the competition between the creators vanishes and the creators' benefits from holding the decision right for the advertising intensity will be negligible. In this case, the loss due to the lower ad revenue-sharing rate makes the content creators' profits under CA lower than those under DA. We also show that the consumer surplus will always be higher under DA than under CA. The reason is that the content creators will have much stronger incentive to invest in content production under DA than under CA. The benefit from high content quality will dominates and makes the consumer surplus higher under DA than under CA.

Part E: Alternative Game Sequence

In this part, we investigate the alternative game sequence in which the content creators determine content quality *after* the ad intensity for their (anticipated) content has been chosen and committed by the platform. Given any ad format, the game proceeds in three stages. First, the platform sets the ad revenue-sharing rate α. Second, the platform under UA and DA or the content creators under CA choose the number of ads d_i for the content. Third, the content creators simultaneously determine their respective content quality q_i. In the following analysis, we first examine the model where the creators are *symmetric* in their content production efficiency (i.e., $k_1 = k_2 = k$), and then examine the model where the creators are *asymmetric* in their content production efficiency (i.e., $k_1 \neq k_2$).

5.1. Symmetric Creators

We first investigate a symmetric model in which the content creators are symmetric in content production efficiency. Other aspects of the model are the same as those in the main model. Next, we present the equilibrium outcomes.

5.1.1. Uniform Advertising (UA) and Differentiated Advertising (DA)

We first solve the platform's problem on the advertising intensity and then substitute the optimal ad number into π_{C_i} to solve the content creators' problems. Due to the symmetric assumption, we have

$$q_i = \frac{kvm\phi(1-\gamma^2)\alpha}{2k(1-\gamma^2)[2k\beta(1-\gamma^2)-\alpha m\phi^2]}, \quad \pi_{C_i} = \frac{kv^2\alpha m[4k\beta(1-\gamma)^2(1+\gamma)-\alpha m\phi^2(3-2\gamma)]}{4[2k\beta(1-\gamma^2)-\alpha m\phi^2]^2} \text{ and } \pi_P = \frac{kmv^2(1-\alpha)(1-\gamma)}{2k\beta(1-\gamma^2)-\alpha m\phi^2}$$

under both UA and DA formats. To ensure positive equilibrium payoffs and decision variables, the platform's problem on the ad revenue-sharing rate can be rewritten as

$$\max_{\alpha} \pi_P(\alpha) = \frac{kmv^2(1-\alpha)(1-\gamma)}{2k\beta(1-\gamma^2)-\alpha m\phi^2},$$

$$s.t. \begin{cases} \alpha \geq 0, \\ \alpha \leq 1, \\ \pi_{C_i} \geq 0. \end{cases}$$

Following the derivation in Part A, we get the equilibrium ad revenue-sharing rate as follows:

$$\alpha^{UA} = \alpha^{DA} = \alpha^{PA} = \begin{cases} \dfrac{4k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2(3-2\gamma)} & k \leq \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \\ 0 & k > \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \end{cases}$$

where superscript PA indicates variables in the case where the platform chooses the number of ads.

Then, the equilibrium content quality is

$$q^{UA} = q^{DA} = q^{PA} = \begin{cases} \dfrac{v(1-\gamma)}{\phi} & k \leq \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \\ 0 & k > \dfrac{m\phi^2}{2\beta(1-\gamma^2)}. \end{cases}$$

The equilibrium advertising intensity is

$$d^{UA} = d^{DA} = d^{PA} = \begin{cases} \dfrac{v(3-2\gamma)}{2\beta} & k \leq \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \\ \dfrac{v}{2\beta} & k > \dfrac{m\phi^2}{2\beta(1-\gamma^2)}. \end{cases}$$

The platform's profit is

$$\pi_P^{UA} = \pi_P^{DA} = \pi_P^{PA} = \begin{cases} \dfrac{v^2}{2}\left[\dfrac{m(3-2\gamma)}{\beta(1+\gamma)} - \dfrac{4k(1-\gamma)^2}{\phi^2}\right] & k \leq \dfrac{m\phi^2}{2\beta(1-\gamma^2)}, \\ \dfrac{mv^2}{2\beta(1+\gamma)} & k > \dfrac{m\phi^2}{2\beta(1-\gamma^2)}. \end{cases}$$

The content creators' profits can be given by $\pi_C^{UA} = \pi_C^{DA} = \pi_C^{PA} = 0$, the consumer surplus is $CS^{UA} = CS^{DA} = CS^{PA} = \dfrac{v^2}{4(1+\gamma)}$, and the social welfare can be obtained by adding up all participants' payoffs.

Note that the creators' equilibrium payoffs will be zero when the platform can choose and commit the ad intensity before the creators choose their content qualities. This result is intuitive because the platform acts as a Stackelberg leader in the game and can extract all the profits of the symmetric creators (whose outside option has zero profit).

5.1.2. Creators-Set Advertising (CA)

Under the CA format, first, solving the content creators' problems on content qualities gives $q_i = \dfrac{\alpha m\phi d_i}{2k(1-\gamma^2)}$. Second, solving the content creators' problems on ad intensities gives $d_i =$

$\frac{2kv(1-\gamma^2)}{2k\beta(2-\gamma)(1+\gamma)-\alpha m\phi^2}$. Third, substituting d_i and q_i into π_{C_i} , we obtain $\pi_{C_i} = \frac{kmv^2\alpha[4k\beta(1-\gamma^2)-\alpha m\phi^2]}{[2k\beta(2-\gamma)(1+\gamma)-\alpha m\phi^2]^2}$. When $\alpha > \frac{4k\beta(1-\gamma^2)}{m\phi^2}$, one can show that $\pi_{C_i} < 0$. In consequence, the

content creators will not join the platform. To ensure that the content creators will join the platform, the

platform's problem on the ad revenue-sharing rate can be rewritten as

$$\max_{\alpha} \pi_P(\alpha) = \frac{8k^2v^2m\beta(1-\alpha)(1-\gamma^2)}{[2k\beta(2-\gamma)(1+\gamma)-\alpha m\phi^2]^2},$$

$$s.t. \begin{cases} \alpha \geq 0, \\ \alpha \leq 1, \\ \pi_{C_i} \geq 0. \end{cases}$$

Following the derivation in Part A, we get the equilibrium ad revenue-sharing rate as follows:

$$\alpha^{CA} = \begin{cases} \frac{4k\beta(1-\gamma^2)}{m\phi^2} & k \leq \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)}, \\ 2 - \frac{2k\beta(2-\gamma)(1+\gamma)}{m\phi^2} & \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)} < k < \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}, \\ 0 & k \geq \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}. \end{cases}$$

The equilibrium content quality is

$$q^{CA} = \begin{cases} \frac{2v(1-\gamma)}{\gamma\phi} & k \leq \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)}, \\ \frac{v[m\phi^2-k\beta(1+\gamma)(2-\gamma)]}{\phi[2k\beta(2-\gamma)(1+\gamma)-m\phi^2]} & \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)} < k < \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}, \\ 0 & k \geq \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}. \end{cases}$$

The equilibrium advertising intensity is

$$d^{CA} = \begin{cases} \frac{v(1-\gamma)}{\beta\gamma} & k \leq \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)}, \\ \frac{kv(1-\gamma^2)}{2k\beta(2-\gamma)(1+\gamma)-m\phi^2} & \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)} < k < \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}, \\ \frac{v(1-\gamma)}{\beta(2-\gamma)} & k \geq \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}. \end{cases}$$

Plugging in α^{CA}, q^{CA}, and d^{CA}, the platform's and the content creators' profits are

$$\pi_P^{CA} = \begin{cases} \frac{2v^2(1-\gamma)[m\phi^2-4k\beta(1-\gamma^2)]}{\beta\phi^2\gamma^2(1+\gamma)} & k \leq \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)}, \\ \frac{2k^2v^2\beta(1-\gamma^2)}{\phi^2[2k\beta(2-\gamma)(1+\gamma)-m\phi^2]} & \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)} < k < \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}, \\ \frac{2mv^2(1-\gamma)}{\beta(2-\gamma)^2(1+\gamma)} & k \geq \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}, \end{cases}$$

and

$$\pi_C^{CA} = \begin{cases} 0 & k \le \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)}, \\ \frac{kv^2[k\beta(2-\gamma)(1+\gamma)-m\phi^2][m\phi^2-k\beta(1+\gamma)(4-3\gamma)]}{\phi^2[2k\beta(2-\gamma)(1+\gamma)-m\phi^2]^2} & \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)} < k < \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}, \\ 0 & k \ge \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}. \end{cases}$$

Moreover, the consumer surplus CS^{CA} is

$$CS^{CA} = \begin{cases} \frac{v^2}{\gamma^2(1+\gamma)} & k \le \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)}, \\ \frac{k^2v^2\beta^2(1+\gamma)}{[2k\beta(2-\gamma)(1+\gamma)-m\phi^2]^2} & \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)} < k < \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}, \\ \frac{v^2}{(2-\gamma)^2(1+\gamma)} & k \ge \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}, \end{cases}$$

and the social welfare SW^{CA} can be obtained by adding up all participants' payoffs.

Given the above equilibrium results, Proposition E1 summarizes the comparison results of the profits of the platform and the consumer surplus.

PROPOSITION E1.

(a) There exists $\tilde{\gamma}$ such that $\pi_P^{CA} < \pi_P^{PA}$ if $\gamma > \tilde{\gamma}$ and $\pi_P^{CA} > \pi_P^{PA}$ if $\gamma < \tilde{\gamma}$.

(b) $CS^{CA} > CS^{PA}$.

PROOF OF PROPOSITION E1: (a) We first compare π_P^{CA} with π_P^{PA}. We depict the following analysis into four cases. First, given $k \le \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)}$, we have $\pi_P^{CA} - \pi_P^{PA} = \frac{v^2(2-\gamma)}{2\beta\phi^2\gamma^2(1+\gamma)} f_1^G(\gamma)$, where $f_1^G(\gamma) = m\phi^2(2-\gamma-2\gamma^2) - 4k\beta(1-\gamma)^2(1+\gamma)(2+\gamma)$ and $\frac{\partial f_1^G(\gamma)}{\partial\gamma} = 4k\beta(1-\gamma)(1+7\gamma+4\gamma^2) - m\phi^2(1+4\gamma)$. Note that $f_1^G(\gamma)$ decreases in k. When $\gamma \le \frac{1}{2}$, one can verify that $f_1^G(\gamma) > f_1^G(\gamma)|_{k=\frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)}} > 0$. When $\gamma > \frac{1}{2}$, we can verify that $\frac{\partial f_1^G(\gamma)}{\partial\gamma} < 0$. That is, $f_1^G(\gamma)$ decreases in γ. Note also $f_1^G(\gamma)|_{\gamma=\frac{1}{2}} > 0$ and $f_1^G(\gamma)|_{\gamma=1} = -m\phi^2 < 0$. Thus, we get that there exists a threshold value $\tilde{\gamma}_1 > \frac{1}{2}$ such that $f_1^G(\gamma) < 0$ (i.e., $\pi_P^{CA} < \pi_P^{PA}$) if $\gamma > \tilde{\gamma}_1$ and $f_1^G(\gamma) > 0$ (i.e., $\pi_P^{CA} > \pi_P^{PA}$) if $\gamma < \tilde{\gamma}_1$. Second, given $\frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)} < k < \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}$, we have $\pi_P^{CA} - \pi_P^{PA} = \frac{v^2[m\phi^2-2k\beta(1-\gamma^2)]}{2\beta\phi^2[2k\beta(2-\gamma)(1+\gamma)-m\phi^2](1+\gamma)} f_2^G(\gamma)$, where $f_2^G(\gamma) = m\phi^2(3-2\gamma) - 2k\beta(1+\gamma)(5-6\gamma+2\gamma^2)$, $\frac{\partial f_2^G(\gamma)}{\partial\gamma} = 2[k\beta(1+8\gamma-6\gamma^2) - m\phi^2]$, and $\frac{\partial^2 f_2^G(\gamma)}{\partial\gamma^2} = 8k\beta(2-3\gamma)$. One can easily verify that

53

$\frac{\partial f_2^G(\gamma)}{\partial \gamma}$ first increases and then decreases in γ. Conditional on $\frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)} < k < \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}$, we get

that $\frac{\partial f_2^G(\gamma)}{\partial \gamma}|_{\gamma=0} < 0$ and $\frac{\partial f_2^G(\gamma)}{\partial \gamma}|_{\gamma=1} > 0$. That is, $f_2^G(\gamma)$ first decreases and then increases in γ.

Further, we have that $f_2^G(\gamma)|_{\gamma=0}$ can be negative or positive, and $f_2^G(\gamma)|_{\gamma=1} < 0$. Thus, we get that

there exists a threshold value $\tilde{\gamma}_2$ such that $f_2^G(\gamma) < 0$ (i.e., $\pi_P^{CA} < \pi_P^{PA}$) if $\gamma > \tilde{\gamma}_2$ and $f_2^G(\gamma) > 0$

(i.e., $\pi_P^{CA} > \pi_P^{PA}$) if $\gamma < \tilde{\gamma}_2$. Third, given $\frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)} \leq k \leq \frac{m\phi^2}{2\beta(1-\gamma^2)}$, we have $\pi_P^{CA} - \pi_P^{PA} = $

$\frac{v^2[4k\beta(1+\gamma)(2-3\gamma+\gamma^2)^2 - m\phi^2(8-\gamma(16-\gamma(11-2\gamma)))]}{2\phi^2\beta(2-\gamma)^2(1+\gamma)}$. Conditional on $\frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)} \leq k \leq \frac{m\phi^2}{2\beta(1-\gamma^2)}$, one can

verify that $\pi_P^{CA} < \pi_P^{PA}$. Fourth, given $k > \frac{m\phi^2}{2\beta(1-\gamma^2)}$, we have $\pi_P^{CA} - \pi_P^{PA} = -\frac{v^2\gamma^2 m}{2\beta(2-\gamma)^2(1+\gamma)} < 0$. By

summarizing the above results, we get that there exists a threshold value $\tilde{\gamma}$ such that $\pi_P^{CA} < \pi_P^{PA}$ if

$\gamma > \tilde{\gamma}$ and $\pi_P^{CA} > \pi_P^{PA}$ if $\gamma < \tilde{\gamma}$, where $\tilde{\gamma} = \begin{cases} \tilde{\gamma}_1 & k \leq \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)} \\ \tilde{\gamma}_2 & \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)} < k < \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)} \end{cases}$.

(b) We then compare CS^{CA} with CS^{PA}. We depict the following analysis into three cases. First,

given $k \leq \frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)}$, we have $CS^{CA} - CS^{PA} = \frac{v^2(4-\gamma^2)}{4\gamma^2(1+\gamma)} > 0$. Second, given $\frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)} < k < $

$\frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}$, we have $CS^{CA} - CS^{PA} = \frac{v^2[4k^2\beta^2(1+\gamma)^2 - (2k\beta(2-\gamma)(1+\gamma) - m\phi^2)^2]}{4(1+\gamma)[2k\beta(2-\gamma)(1+\gamma) - m\phi^2]^2}$. Conditional on

$\frac{m\phi^2}{\beta(1+\gamma)(4-3\gamma)} < k < \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}$, one can verify that $CS^{CA} > CS^{PA}$. Third, given $k \geq \frac{m\phi^2}{\beta(1+\gamma)(2-\gamma)}$, we

have $CS^{CA} - CS^{PA} = \frac{v^2\gamma(4-\gamma)\gamma}{4(2-\gamma)^2(1+\gamma)} > 0$. Therefore, we get that CS^{CA} is higher than CS^{PA}. This ends

the proof of Proposition E1. □

In summary, when two symmetric creators determine content qualities after the ad intensities are

chosen, the equilibrium results under the UA format are the same as those under the DA format. This

result arises due to the symmetric feature. As for all the participants' preferences over the three ad

formats, we show that the content creators always prefer to set ad number, the platform prefers to set

ad number only when the level of creator substitutability is high, and the consumer surplus is higher

under CA than those under UA and DA.

5.2. Asymmetric Creators

We now examine an asymmetric model in which one content creator is more efficient in content production than the other content creator. Without loss of generality, we assume $k_1 = 1$ and $k_2 = k < k_1$. Other aspects of the model are the same as those in the main model. Next, we present the equilibrium outcomes.

5.2.1. Uniform Advertising (UA)

Under the UA format, first, solving the creators' problems on the content quality gives $q_1 = \frac{\alpha m \phi d}{2(1-\gamma^2)}$ and $q_2 = \frac{\alpha m \phi d}{2k(1-\gamma^2)}$. Second, substituting q_i into π_P and solving the platform's problem, we have $d = \frac{2kv(1-\gamma^2)}{4k\beta(1-\gamma^2)-m\phi^2(1+k)\alpha}$. The content creator's profits can be given by

$$\pi_{C_1} = \frac{kv^2 m\alpha[4k\beta(1-\gamma)^2(1+\gamma)-\alpha m\phi^2(2+k(1-2\gamma))]}{[4k\beta(1-\gamma^2)-m\phi^2(1+k)\alpha]^2},$$

and

$$\pi_{C_2} = \frac{kv^2 m\alpha[4k\beta(1-\gamma)^2(1+\gamma)-\alpha m\phi^2(1+2k-2\gamma)]}{[4k\beta(1-\gamma^2)-m\phi^2(1+k)\alpha]^2}.$$

Plugging in, the platform's problem on the ad revenue-sharing rate becomes

$$\max_{\alpha} \pi_P(\alpha) = \frac{2kv^2 m(1-\alpha)(1-\gamma)}{4k\beta(1-\gamma^2)-m\phi^2(1+k)\alpha}.$$

Note that the platform should determine the optimal ad revenue-sharing rate to maximize its profit and also ensure that each content creator will obtain non-negative profit (i.e., $\pi_{C_i} \geq 0$, $i \in \{1, 2\}$).

Following the derivation in Part A, the equilibrium ad revenue-sharing rate can be given by

$$\alpha^{UA} = \begin{cases} \frac{4k\beta(1-\gamma)^2(1+\gamma)}{m\phi^2[2+k(1-2\gamma)]}, & 4k\beta(1-\gamma^2) \leq m\phi^2(1+k), \\ 0, & 4k\beta(1-\gamma^2) > m\phi^2(1+k). \end{cases}$$

The equilibrium content qualities are

$$q_1^{UA} = \begin{cases} \frac{kv(1-\gamma)}{(1+(1-k)\gamma)\phi}, & 4k\beta(1-\gamma^2) \leq m\phi^2(1+k), \\ 0, & 4k\beta(1-\gamma^2) > m\phi^2(1+k), \end{cases}$$

and

$$q_2^{UA} = \begin{cases} \dfrac{v(1-\gamma)}{\phi(1+\gamma-k\gamma)}, & 4k\beta(1-\gamma^2) \leq m\phi^2(1+k), \\ 0, & 4k\beta(1-\gamma^2) > m\phi^2(1+k). \end{cases}$$

The equilibrium advertising intensity is

$$d^{UA} = \begin{cases} \dfrac{v(2+k-2k\gamma)}{2\beta(1+\gamma-k\gamma)}, & 4k\beta(1-\gamma^2) \leq m\phi^2(1+k), \\ \dfrac{v}{2\beta}, & 4k\beta(1-\gamma^2) > m\phi^2(1+k). \end{cases}$$

Plugging in α^{UA}, q_i^{UA}, and d^{UA}, we have $\pi_{C_1}^{UA} = 0$. The platform's and the other content creator's

profits are

$$\pi_P^{UA} = \begin{cases} \dfrac{v^2[m\phi^2(2+k(1-2\gamma))-4k\beta(1-\gamma)^2(1+\gamma)]}{2\beta\phi^2(1+\gamma)(1+(1-k)\gamma)}, & 4k\beta(1-\gamma^2) \leq m\phi^2(1+k), \\ \dfrac{v^2 m}{2\beta(1+\gamma)}, & 4k\beta(1-\gamma^2) > m\phi^2(1+k), \end{cases}$$

and

$$\pi_{C_2}^{UA} = \begin{cases} \dfrac{kv^2(1-k)(1-\gamma)^2(1+2\gamma)}{\phi^2(1+\gamma-k\gamma)^2}, & 4k\beta(1-\gamma^2) \leq m\phi^2(1+k), \\ 0, & 4k\beta(1-\gamma^2) > m\phi^2(1+k). \end{cases}$$

The consumer surplus CS^{UA} is

$$CS^{UA} = \begin{cases} \dfrac{v^2[k^2+2(1+\gamma)-2k(1+\gamma)]}{4(1+\gamma)(1+\gamma-k\gamma)^2}, & 4k\beta(1-\gamma^2) \leq m\phi^2(1+k), \\ \dfrac{v^2}{4(1+\gamma)}, & 4k\beta(1-\gamma^2) > m\phi^2(1+k), \end{cases}$$

and the social welfare $SW^{UA} = CS^{UA} + \pi_{C_1}^{UA} + \pi_{C_2}^{UA} + \pi_P^{UA}$.

5.2.2. Differentiated Advertising (DA)

Under the DA format, solving the creators' problems on the content quality gives $q_1 = \dfrac{\alpha m\phi d_1}{2(1-\gamma^2)}$ and

$q_2 = \dfrac{\alpha m\phi d_2}{2k(1-\gamma^2)}$. Second, substituting q_i into π_P and solving the platform's problem, we have $d_1 =$

$\dfrac{2kv[4k\beta(1-\gamma^2)^3-\alpha m\phi^2(1-\gamma)^2(1+\gamma)(2+\gamma+k\gamma)]}{16k^2\beta^2(1-\gamma^2)^3-8k\beta m\phi^2(1+k)(1-\gamma^2)^2\alpha+m^2\phi^4(4k-(1+k)^2\gamma^2)\alpha^2}$ and $d_2 =$

$\dfrac{2kv[4k\beta(1-\gamma^2)^3-\alpha m\phi^2(1-\gamma)^2(1+\gamma)(\gamma+k(2+\gamma))]}{16k^2\beta^2(1-\gamma^2)^3-8k\beta m\phi^2(1+k)(1-\gamma^2)^2\alpha+m^2\phi^4(4k-(1+k)^2\gamma^2)\alpha^2}$. The content creator's profits can be given by

$\pi_{C_1} = \dfrac{k^2v^2m\alpha(1-\gamma)^2[4k\beta(1-\gamma)(1+\gamma)^2-\alpha m\phi^2(2+\gamma+k\gamma)][16k\beta^2(1-\gamma^2)^3-4\beta m\phi^2(1-\gamma)(1+\gamma)^2(2+3k(1-\gamma)+\gamma)\alpha+m^2\phi^4(6+\gamma(3-k-2(1+k)\gamma))\alpha^2]}{[16k^2\beta^2(1-\gamma^2)^3-8k\beta m\phi^2(1+k)(1-\gamma^2)^2\alpha+m^2\phi^4(4k-(1+k)^2\gamma^2)\alpha^2]^2}$,

and

$$\pi_{C_2} = \frac{kv^2 m\alpha(1-\gamma)^2[4k\beta(1-\gamma)(1+\gamma)^2-\alpha m\phi^2(\gamma+k(2+\gamma))][16k^2\beta^2(1-\gamma^2)^3-4k\beta m\phi^2(1-\gamma)(1+\gamma)^2(3+2k-(3+k)\gamma)\alpha+m^2\phi^4(6k-\gamma+3k\gamma-2(1+k)\gamma^2)\alpha^2]}{[16k^2\beta^2(1-\gamma^2)^3-8k\beta m\phi^2(1+k)(1-\gamma^2)^2\alpha+m^2\phi^4(4k-(1+k)^2\gamma^2)\alpha^2]^2}.$$

Plugging in, the platform's problem on the ad revenue-sharing rate becomes

$$\max_{\alpha} \pi_P(\alpha) = \frac{2mkv^2(1-\gamma)^2(1+\gamma)(1-\alpha)[4k\beta(1-\gamma^2)-m\phi^2(1+k)\alpha]}{16k^2\beta^2(1-\gamma^2)^3-8k\beta m\phi^2(1+k)(1-\gamma^2)^2\alpha+m^2\phi^4(4k-(1+k)^2\gamma^2)\alpha^2}.$$

Note that the platform should determine the optimal ad revenue-sharing rate to maximize its profit and

also ensure that each content creator will obtain non-negative profit (i.e., $\pi_{C_i} \geq 0, \ i \in \{1, 2\}$).

5.2.3. Creators-Set Advertising (CA)

Under the CA format, solving the creators' problems on the content quality gives $q_1 = \frac{\alpha m\phi d_1}{2(1-\gamma^2)}$ and

$q_2 = \frac{\alpha m\phi d_2}{2k(1-\gamma^2)}$. Second, substituting q_i into π_{C_i} and solving the platform's problem, we have $d_1 =$

$\frac{2v(1-\gamma^2)[2k\beta(2-\gamma-\gamma^2)-m\phi^2\alpha]}{4k\beta^2(4-5\gamma^2+\gamma^4)-2\beta m\phi^2(1+k)(2-\gamma^2)\alpha+m^2\phi^4\alpha^2}$ and $d_2 = \frac{2kv(1-\gamma^2)[2\beta(2-\gamma-\gamma^2)-m\phi^2\alpha]}{4k\beta^2(4-5\gamma^2+\gamma^4)-2\beta m\phi^2(1+k)(2-\gamma^2)\alpha+m^2\phi^4\alpha^2}$.

The content creator's profits can be given by

$$\pi_{C_1} = \frac{mv^2\alpha[4\beta(1-\gamma^2)-m\phi^2\alpha][2k\beta(2-\gamma-\gamma^2)-m\phi^2\alpha]^2}{[4k\beta^2(4-5\gamma^2+\gamma^4)-2\beta m\phi^2(1+k)(2-\gamma^2)\alpha+m^2\phi^4\alpha^2]^2},$$

and

$$\pi_{C_2} = \frac{kmv^2\alpha[4k\beta(1-\gamma^2)-m\phi^2\alpha][2\beta(2-\gamma-\gamma^2)-m\phi^2\alpha]^2}{[4k\beta^2(4-5\gamma^2+\gamma^4)-2\beta m\phi^2(1+k)(2-\gamma^2)\alpha+m^2\phi^4\alpha^2]^2}.$$

Plugging in, the platform's problem on the ad revenue-sharing rate becomes

$$\max_{\alpha} \pi_P(\alpha) = \frac{4v^2 m\beta(1-\gamma)(1+\gamma)(1-\alpha)[8k^2\beta^2(2-\gamma-\gamma^2)^2-4k\beta m\phi^2(1+k)(1-\gamma)(2+\gamma)\alpha+m^2\phi^4(1+k^2)\alpha^2]}{[4k\beta^2(4-5\gamma^2+\gamma^4)-2\beta m\phi^2(1+k)(2-\gamma^2)\alpha+m^2\phi^4\alpha^2]^2}.$$

Note that the platform should determine the optimal ad revenue-sharing rate to maximize its profit and

also ensure that each content creator will obtain non-negative profit (i.e., $\pi_{C_i} \geq 0, \ i \in \{1, 2\}$).

Due to the technical complexity, we cannot analytically show the equilibrium results under the DA

and CA formats. Next, we adopt the numerical approach for the equilibrium analysis. Note that the less

efficient creator will always get zero profit under UA. In the remaining analysis of this section, we will focus on the non-trivial case in which at least one content creator obtains positive profit under all ad formats. As illustrated in Table E1~E4, the numerical study shows that our main results regarding the platform's preference over different ad formats remain qualitatively the same only when the asymmetric level is not very high (i.e., k is relatively high) and creator substitutability is low (i.e., γ is not high). In detail, Table E1 presents the comparison results between the DA format and the UA format. The platform's profit is higher under the UA format only when the substitutability between content creators is not high. Table E2 summarizes the comparison results between the CA and DA format. The platform prefers the DA format. Meanwhile, the equilibrium ad revenue-sharing rate, content quality, and advertising intensity under the CA format are lower than those under the DA format only when the substitutability between content creators is relatively low.

We also examine the outcomes when the asymmetric level in content production efficiency between the two content creators is relatively high. As illustrated in Table E3, the numerical study shows that the platform would prefer the DA format to the UA format when the asymmetric level is relatively high (i.e., when k_2 is small). Table E4 shows that the platform prefers the DA format to the CA format as long as the asymmetric level is not very high.

Table E1 Comparison Between DA and UA

$$(v = 1, \ m = 1, \ \phi = 1, \ \beta = 0.45, \ k_1 = 1, \ k_2 = 0.9)$$

γ	$\alpha^{DA} - \alpha^{UA}$	$(q_1^{DA} - q_1^{UA},$ $q_2^{DA} - q_2^{UA})$	$(d_1^{DA} - d_1^{UA},$ $d_2^{DA} - d_2^{UA})$	$\pi_P^{DA} - \pi_P^{UA}$	$(\pi_{C1}^{DA} - \pi_{C1}^{UA},$ $\pi_{C2}^{DA} - \pi_{C2}^{UA})$	CS^{DA} $- CS^{UA}$
0.1	-0.0123	$(-0.1006, 0.0167)$	$(-0.3132, 0.1284)$	-0.0070	$(0.1329, -0.0858)$	-0.0025
0.2	-0.0059	$(-0.0604, 0.0300)$	$(-0.2059, 0.1410)$	-0.0003	$(0.0892, -0.0775)$	-0.0024
0.3	0.0001	$(-0.0286, 0.0398)$	$(-0.1198, 0.1481)$	0.0059	$(0.0556, -0.0665)$	-0.0022
0.4	0.0055	$(-0.0043, 0.0459)$	$(-0.0529, 0.1491)$	0.0122	$(0.0310, -0.0539)$	-0.0019
0.5	0.0095	$(0.0127, 0.0483)$	$(-0.0040, 0.1434)$	0.0183	$(0.0143, -0.0408)$	-0.0016
0.6	0.0118	$(0.0230, 0.0468)$	$(0.0280, 0.1305)$	0.0235	$(0.0043, -0.0282)$	-0.0012
0.7	0.0113	$(0.0253, 0.0396)$	$(0.0409, 0.1064)$	0.0250	$(0, -0.0166)$	-0.0009
0.8	0.0064	$(0.0166, 0.0232)$	$(0.0276, 0.0630)$	0.0177	$(0, -0.0065)$	-0.0006
0.9	0.0022	$(0.0082, 0.0103)$	$(0.0140, 0.0282)$	0.0094	$(0, -0.0014)$	-0.0003

Table E2 Comparison Between CA and DA

$$(v = 1,\ m = 1,\ \phi = 1,\ \beta = 0.45,\ k_1 = 1,\ k_2 = 0.9)$$

γ	$\alpha^{CA} - \alpha^{DA}$	$(q_1^{CA} - q_1^{DA},$ $q_2^{CA} - q_2^{DA})$	$(d_1^{CA} - d_1^{DA},$ $d_2^{CA} - d_2^{DA})$	$\pi_P^{CA} - \pi_P^{DA}$	$(\pi_{C1}^{CA} - \pi_{C1}^{DA},$ $\pi_{C2}^{CA} - \pi_{C2}^{DA})$	CS^{CA} $- CS^{DA}$
0.1	-0.2979	$(-0.5688, -0.7579)$	$(-1.4878,\ -1.9094)$	-0.2469	$(-0.0083, 0.1268)$	0.1010
0.2	-0.3236	$(-0.5557,\ -0.7133)$	$(-1.4859,\ -1.8192)$	-0.2546	$(-0.0104, 0.0799)$	0.1007
0.3	-0.3200	$(-0.5205,\ -0.6491)$	$(-1.4551,\ -1.7134)$	-0.2766	$(-0.0048, 0.0514)$	0.1109
0.4	-0.2883	$(-0.4673,\ -0.5695)$	$(-1.4046,\ -1.5991)$	-0.3070	$(0.0040, 0.0354)$	0.1298
0.5	-0.2299	$(-0.3985,\ -0.4765)$	$(-1.3415,\ -1.4819)$	-0.3410	$(0.0136, 0.0282)$	0.1576
0.6	0.6027	$(-0.3626, 1.3091)$	$(-1.9358, 0.3321)$	-0.3216	$(-0.0043, 0.6240)$	1.2330
0.7	0.4937	$(-0.2776, 0.8371)$	$(-1.7439, -0.1903)$	-0.0800	$(0, 0.3120)$	0.8736
0.8	0.3673	$(-0.1833, 0.4916)$	$(-1.5297,- 0.5651)$	-0.1025	$(0, 0.1245)$	0.6426
0.9	0.2087	$(-0.0908, 0.2202)$	$(-1.3188, -0.8639)$	-0.2808	$(0, 0.0283)$	0.4858

Table E3 Comparison Between DA and UA

$$(v = 1, \ m = 1, \ \phi = 1, \ \beta = 0.45, \ k_1 = 1, \ \gamma = 0.1)$$

k_2	$\alpha^{DA} - \alpha^{UA}$	$(q_1^{DA} - q_1^{UA},$ $q_2^{DA} - q_2^{UA})$	$(d_1^{DA} - d_1^{UA},$ $d_2^{DA} - d_2^{UA})$	$\pi_P^{DA} - \pi_P^{UA}$	$(\pi_{C1}^{DA} - \pi_{C1}^{UA},$ $\pi_{C2}^{DA} - \pi_{C2}^{UA})$
0.9	-0.0123	$(-0.1006, 0.0167)$	$(-0.3132, 0.1284)$	-0.0070	$(0.1329, \ -0.0858)$
0.8	-0.0233	$(-0.1566, 0.0313)$	$(-0.5250, 0.2525)$	-0.0056	$(0.1826, \ -0.1495)$
0.7	-0.0324	$(-0.1821, 0.0446)$	$(-0.6669, 0.3729)$	0.0020	$(0.1902, \ -0.1924)$
0.6	-0.0391	$(-0.1861, 0.0568)$	$(-0.7592, 0.4901)$	0.0145	$(0.1766, \ -0.2157)$
0.5	-0.0427	$(-0.1749, 0.0683)$	$(-0.8158, 0.6045)$	0.0307	$(0.1522, \ -0.2204)$
0.4	-0.0430	$(-0.1526, 0.0790)$	$(-0.8458, 0.7163)$	0.0500	$(0.1229, \ -0.2076)$
0.3	-0.0395	$(-0.1221, 0.0893)$	$(-0.8560, 0.8257)$	0.0721	$(0.0917, \ -0.1783)$
0.2	-0.0315	$(-0.0856, 0.0991)$	$(-0.8507, 0.9331)$	0.0965	$(0.0603, \ -0.1333)$
0.1	-0.0185	$(-0.0446, 0.1085)$	$(-0.8341, 1.0379)$	0.1230	$(0.0296, \ -0.0736)$

Table E4 Comparison Between CA and DA

$(v = 1, \ m = 1, \ \phi = 1, \ \beta = 0.45, \ k_1 = 1, \ \gamma = 0.1)$

k_2	$\alpha^{CA} - \alpha^{DA}$	$(q_1^{CA} - q_1^{DA},$ $q_2^{CA} - q_2^{DA})$	$(d_1^{CA} - d_1^{DA},$ $d_2^{CA} - d_2^{DA})$	$\pi_P^{CA} - \pi_P^{DA}$	$(\pi_{C1}^{CA} - \pi_{C1}^{DA},$ $\pi_{C2}^{CA} - \pi_{C2}^{DA})$
0.9	-0.2979	$(-0.5688, \ -0.7579)$	$(-1.4878, \ -1.9094)$	-0.2469	$(-0.0083, 0.1268)$
0.8	-0.1153	$(-0.3237, \ -0.6123)$	$(-1.0649, \ -1.7542)$	-0.2876	$(0.0276, 0.2255)$
0.7	0.1367	$(-0.0308, -0.2055)$	$(-0.6397, \ -1.3139)$	-0.2827	$(0.1730, 0.4619)$
0.6	0.5708	$(0.3802, 4.5991)$	$(-0.3547, 3.9926)$	0.4552	$(0.3005, 2.9741)$
0.5	0.5591	$(-0.2537, 17.9746)$	$(-1.7239, 18.8558)$	31.3219	$(-0.1522, 8.5050)$
0.4	0.4469	$(-0.1870, 17.9719)$	$(-1.5861, 18.8518)$	68.6625	$(-0.1229, 6.8040)$
0.3	0.3350	$(-0.1302, 17.9696)$	$(-1.4701, 18.8482)$	106.002	$(-0.0917, 5.1030)$
0.2	0.2232	$(-0.0811, 17.9676)$	$(-1.3713, 18.8449)$	143.339	$(-0.0603, 3.4020)$
0.1	0.1115	$(-0.0380, 17.9658)$	$(-1.2862, 18.8418)$	180.676	$(-0.0296, 1.7010)$

Part F: Cost Information Asymmetry

Now we consider a model in which the content creators have private information regarding their costs

of content creation. To capture the structure of the information asymmetry, we assume that the creators'

content production efficiency can either be high or low, denoted by $k - \epsilon > 0$ and $k + \epsilon$, respectively.

Each content creator knows his/her own content production efficiency, whereas the platform has an ex-

ante belief that the content production efficiency is low (i.e., $k + \epsilon$) with a probability of $\rho \in (0,1)$

and high (i.e., $k - \epsilon > 0$) with a probability of $1 - \rho$. The platform chooses the ad revenue-sharing

rate to maximize its *expected* profit in Stage 1 based on its belief about the content creators' costs of

content creation. All the profit functions are the same as those in the main model.

6.1. Uniform Advertising (UA)

Under the UA format, first, solving the platform's problem on the advertising intensity gives $d =$

$\frac{2v + (q_1 + q_2)\phi}{4\beta}$. Second, substituting d into the creators' profits and solving the content creators' problems,

we have $q_i = \frac{vm\phi\alpha}{4k\beta(1-\gamma^2) - m\phi^2\alpha}$ and $\pi_{C_i} = \frac{kv^2\alpha m[4k\beta(1-\gamma)^2(1+\gamma) - m\phi^2\alpha]}{[m\phi^2\alpha - 4k\beta(1-\gamma^2)]^2}$. Third, the platform chooses

the optimal ad revenue-sharing rate in Stage 1 to maximize its *expected* profit as below

$$\Pi_P^{UA}(\alpha) = \rho\{\frac{8mv^2\beta(k+\epsilon)^2(1-\gamma)^2(1+\gamma)(1-\alpha)}{[4\beta(k+\epsilon)\beta(1-\gamma^2) - \alpha m\phi^2]^2}\} + (1-\rho)\{\frac{8mv^2\beta(k-\epsilon)^2(1-\gamma)^2(1+\gamma)(1-\alpha)}{[4\beta(k-\epsilon)\beta(1-\gamma^2) - \alpha m\phi^2]^2}\}.$$

Note that the platform should determine the ad revenue-sharing rate to maximize its expected profit

and also ensure that each content creator will obtain positive profit.

6.2. Differentiated Advertising (DA)

Under the DA format, first, solving the platform's problem on the advertising intensity obtains $d_i =$

$\frac{v + \phi q_i}{2\beta}$. Second, substituting d_i into the content creators' profits and solving the content creators'

problems on content qualities, we have $q_i = \frac{vm\phi\alpha(2-\gamma)}{8k\beta(1-\gamma^2)-m\phi^2\alpha(2-\gamma)}$ and $\pi_{C_i} =$

$\frac{kv^2m\alpha[16k\beta(1-\gamma)^2(1+\gamma)-m\phi^2\alpha(2-\gamma)^2]}{[8k\beta(1-\gamma^2)-m\phi^2\alpha(2-\gamma)]^2}$. Third, the platform chooses the ad revenue-sharing rate in Stage 1

to maximize its *expected* profit as below

$$\Pi_P^{DA}(\alpha) = \rho\{\frac{32mv^2\beta(k+\epsilon)^2(1-\gamma)^2(1+\gamma)(1-\alpha)}{[8\beta(k+\epsilon)(1-\gamma^2)-\alpha m\phi^2(2-\gamma)]^2}\} + (1-\rho)\{\frac{32mv^2\beta(k-\epsilon)^2(1-\gamma)^2(1+\gamma)(1-\alpha)}{[8\beta(k-\epsilon)(1-\gamma^2)-\alpha m\phi^2(2-\gamma)]^2}\}.$$

The platform should choose the ad revenue-sharing rate to maximize its expected profit and ensure

that each content creator will obtain positive profit.

6.3. Creators-Set Advertising (CA)

Under the CA format, first, solving the content creators' problems on the advertising intensity gives

$d_i = \frac{v(2-\gamma-\gamma^2)+(2-\gamma^2)\phi q_i-\gamma\phi q_{3-i}}{\beta(4-\gamma^2)}$. Second, solving the content creators' problems on content qualities,

we have $q_i = \frac{vm\phi\alpha(2-\gamma^2)}{k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2\alpha(2-\gamma^2)}$ and $\pi_{C_i} = \frac{kv^2m\alpha[k\beta(4-\gamma^2)^2(1-\gamma^2)-m\phi^2\alpha(2-\gamma^2)^2]}{[k\beta(2-\gamma)^2(1+\gamma)(2+\gamma)-m\phi^2\alpha(2-\gamma^2)]^2}$. Third,

the platform chooses the optimal ad revenue-sharing rate in Stage 1 to maximize its *expected* profit as

below

$$\Pi_P^{CA}(\alpha) = \rho\{\frac{2mv^2\beta(k+\epsilon)^2(4-\gamma^2)^2(1-\gamma^2)(1-\alpha)}{[\beta(k+\epsilon)(2-\gamma)^2(1+\gamma)(2+\gamma)-\alpha m\phi^2(2-\gamma^2)]^2}\} + (1-\rho)\{\frac{2mv^2\beta(k-\epsilon)^2(4-\gamma^2)^2(1-\gamma^2)(1-\alpha)}{[\beta(k-\epsilon)(2-\gamma)^2(1+\gamma)(2+\gamma)-\alpha m\phi^2(2-\gamma^2)]^2}\}.$$

The platform should choose the ad revenue-sharing rate to maximize its expected profit and ensure

that each content creator will obtain positive profit.

As in the main paper, we will focus on the cases in which the content creators will get positive profits

under all ad formats. Though we cannot analytically obtain the final equilibrium results, we can still

shed lights on the platform's preference over different ad formats. The findings are summarized in

Proposition F1.

PROPOSITION F1. $\Pi_P^{DA}(\alpha) < \Pi_P^{UA}(\alpha)$ and $\Pi_P^{CA}(\alpha) < \Pi_P^{DA}(\alpha)$.

PROOF OF PROPOSITION F1. First, we compare the platform's expected profit under UA and DA. Given

any α, we have $\Pi_P^{DA}(\alpha) - \Pi_P^{UA}(\alpha) = \rho \left\{ \frac{8(k+\epsilon)^2 v^2 \beta m^2 \phi^2 \gamma (1-\gamma)^2 (1+\gamma)\alpha(1-\alpha)}{[4\beta(k+\epsilon)\beta(1-\gamma^2)-\alpha m\phi^2]^2 [8\beta(k+\epsilon)(1-\gamma^2)-\alpha m\phi^2(2-\gamma)]^2} \right\} G_1(\alpha) +$

$(1-\rho) \left\{ \frac{8(k-\epsilon)^2 v^2 \beta m^2 \phi^2 \gamma (1-\gamma)^2 (1+\gamma)\alpha(1-\alpha)}{[4\beta(k-\epsilon)\beta(1-\gamma^2)-\alpha m\phi^2]^2 [8\beta(k-\epsilon)(1-\gamma^2)-\alpha m\phi^2(2-\gamma)]^2} \right\} G_2(\alpha)$, where $G_1(\alpha) = \alpha m\phi^2(4-\gamma) -$

$16\beta(k+\epsilon)(1-\gamma^2)$ and $G_2(\alpha) = \alpha m\phi^2(4-\gamma) - 16\beta(k-\epsilon)(1-\gamma^2)$. Note that both $G_1(\alpha)$

and $G_2(\alpha)$ increase in α. One can verify that $G_1(\alpha)|_{\alpha = \frac{4\beta(1-\gamma)^2(1+\gamma)(k-\epsilon)}{m\phi^2}} <$

$G_1(\alpha)|_{\alpha = \frac{4\beta(1-\gamma)^2(1+\gamma)(k+\epsilon)}{m\phi^2}} < 0$ and $G_2(\alpha) < G_2(\alpha)|_{\alpha = \frac{4\beta(1-\gamma)^2(1+\gamma)(k-\epsilon)}{m\phi^2}} < 0$.[6] As a result, we have

$\Pi_P^{DA}(\alpha) - \Pi_P^{UA}(\alpha) < 0$ for any $\alpha < \frac{4\beta(1-\gamma)^2(1+\gamma)(k-\epsilon)}{m\phi^2}$.

Next, we compare the platform's expected profit under DA and CA. Given any α, we have

$\Pi_P^{CA}(\alpha) - \Pi_P^{DA}(\alpha) = \rho \left\{ \frac{2mv^2\beta(k+\epsilon)^2(\alpha-1)}{[8\beta(k+\epsilon)(1-\gamma^2)-\alpha m\phi^2(2-\gamma)]^2 [\beta(k+\epsilon)(2-\gamma)^2(1+\gamma)(2+\gamma)-\alpha m\phi^2(2-\gamma^2)]^2} \right\} G_3(\alpha) +$

$(1-\rho) \left\{ \frac{2mv^2\beta(k-\epsilon)^2(\alpha-1)}{[8\beta(k-\epsilon)(1-\gamma^2)-\alpha m\phi^2(2-\gamma)]^2 [\beta(k-\epsilon)(2-\gamma)^2(1+\gamma)(2+\gamma)-\alpha m\phi^2(2-\gamma^2)]^2} \right\} G_4(\alpha)$, where $G_3(\alpha) =$

$16\beta^2(k+\epsilon)^2 [(2-\gamma)^4(1-\gamma)^2(1+\gamma)^3(2+\gamma)^2 - 4(4-\gamma^2)^2(1-\gamma^2)^3] + 16\beta m\phi^2(k+\epsilon)(1-$

$\gamma^2)^2 [(2-\gamma)(4-\gamma^2)^2 - 2(2-\gamma)^2(2+\gamma)(2-\gamma^2)]\alpha + m^2\phi^4 [16(1-\gamma)^2(1+\gamma)(2-\gamma^2)^2 -$

$(2-\gamma)^2(4-\gamma^2)^2(1-\gamma^2)]\alpha^2$ and $G_4(\alpha) = 16\beta^2(k-\epsilon)^2 [(2-\gamma)^4(1-\gamma)^2(1+\gamma)^3(2+\gamma)^2 -$

$4(4-\gamma^2)^2(1-\gamma^2)^3] + 16\beta m\phi^2(k-\epsilon)(1-\gamma^2)^2 [(2-\gamma)(4-\gamma^2)^2 - 2(2-\gamma)^2(2+\gamma)(2-$

$\gamma^2)]\alpha + m^2\phi^4 [16(1-\gamma)^2(1+\gamma)(2-\gamma^2)^2 - (2-\gamma)^2(4-\gamma^2)^2(1-\gamma^2)]\alpha^2$. One can show that

$G_3(\alpha)$ and $G_4(\alpha)$ first increase and then decrease in α. We can verify that $G_3(\alpha)|_{\alpha=0} =$

$16\beta^2(k+\epsilon)^2 [(2-\gamma)^4(1-\gamma)^2(1+\gamma)^3(2+\gamma)^2 - 4(4-\gamma^2)^2(1-\gamma^2)^3] > 0$ and $G_4(\alpha)|_{\alpha=0} =$

$16\beta^2(k-\epsilon)^2 [(2-\gamma)^4(1-\gamma)^2(1+\gamma)^3(2+\gamma)^2 - 4(4-\gamma^2)^2(1-\gamma^2)^3] > 0$. Substituting $\alpha =$

$\frac{16\beta(1-\gamma)^2(1+\gamma)(k-\epsilon)}{m\phi^2(2-\gamma)^2}$ into $G_4(\alpha)$, we have $G_4(\alpha)|_{\alpha = \frac{16\beta(1-\gamma)^2(1+\gamma)(k-\epsilon)}{m\phi^2(2-\gamma)^2}} =$

$\frac{16\beta^2(1-\gamma)^2\gamma^3(1+\gamma)^3(512-960\gamma+128\gamma^2+752\gamma^3-480\gamma^4+32\gamma^5+24\gamma^6+\gamma^7)(k-\epsilon)^2}{(2-\gamma)^4} > 0$.[7] Further, we can verify

that $G_3(\alpha)|_{\alpha = \frac{16\beta(1-\gamma)^2(1+\gamma)(k+\epsilon)}{m\phi^2(2-\gamma)^2}} =$

---

[6] As in the main model, we focus on the case where both content creators obtain positive profits. We require $\alpha < \frac{4\beta(1-\gamma)^2(1+\gamma)(k-\epsilon)}{m\phi^2}$ to ensure that the content creators under UA and DA obtain positive profits.

[7] We require $\alpha < \frac{16\beta(1-\gamma)^2(1+\gamma)(k-\epsilon)}{m\phi^2(2-\gamma)^2}$ to ensure that the content creators under DA and CA obtain positive profits.

$\frac{16\beta^2(1-\gamma)^2\gamma^3(1+\gamma)^3(512-960\gamma+128\gamma^2+752\gamma^3-480\gamma^4+32\gamma^5+24\gamma^6+\gamma^7)(k+\epsilon)^2}{(2-\gamma)^4} > 0$. As a result,

$G_3(\alpha)\big|_{\alpha=\frac{16\beta(1-\gamma)^2(1+\gamma)(k-\epsilon)}{m\phi^2(2-\gamma)^2}} > 0$. Thus, both $G_3(\alpha)$ and $G_4(\alpha)$ are positive within the parameter region

where $\alpha < \frac{16\beta(1-\gamma)^2(1+\gamma)(k-\epsilon)}{m\phi^2(2-\gamma)^2}$. As a result, $\Pi_P^{CA}(\alpha) - \Pi_P^{DA}(\alpha) < 0$ for any $\alpha <$

$\frac{16\beta(1-\gamma)^2(1+\gamma)(k-\epsilon)}{m\phi^2(2-\gamma)^2}$. This completes the proof of Proposition F1. $\square$

Proposition F1 shows that, given any ad revenue-sharing rate α that ensures positive equilibrium

profits for the content creators, the platform's expected profit under the UA format will always be higher

than that under the DA format. Similarly, the platform's expected profit under the DA format is higher

than that under the CA format. In other words, our main results regarding the platform's ad format

preference remain qualitatively the same as those in the main model. This is because though the platform

is less informed about the cost information, the platform still knows the content quality.

Due to the complexity, we cannot fully solve the model analytically. Next, we rely on numerical

analyzes to present other findings. As in the main paper, we focus on the nontrivial case in which the

content creators obtain positive profits. As illustrated in Table F1~F2, the numerical study shows that

our main results regarding the market participants' preferences over different ad formats remain

qualitatively the same as those in the main model. In detail, Table F1 presents the comparison results

between the DA format and the UA format. The equilibrium ad revenue-sharing rate, content quality,

and advertising intensity under the DA format are lower than those under the UA format. Meanwhile,

the platform's profit and the consumer surplus are higher under the UA format, and the content creators

prefer the UA format only when the substitutability between content creators is not very high. Table F2

summarizes the comparison results between the CA and DA format. The equilibrium ad revenue-sharing

rate, content quality, and advertising intensity under the CA format are lower than those under the DA

format. Meanwhile, the DA format can be a win-win outcome for the platform and the content creators.

Table F1 Comparison Between DA and UA

$$(v = 1, \ m = 1, \ \phi = 1, \ \beta = 1, \ k = 0.45, \ \rho = 0.5, \ \epsilon = 0.01)$$

γ	$\alpha^{DA} - \alpha^{UA}$	$q^{DA} - q^{UA}$	$d^{DA} - d^{UA}$	$\Pi_P^{DA} - \Pi_P^{UA}$	$\pi_C^{DA} - \pi_C^{UA}$	$CS^{DA} - CS^{UA}$
0.10	−0.0940	−0.0687	−0.0343	−0.0049	−0.0255	−0.0345
0.15	−0.1429	−0.1044	−0.0523	−0.0071	−0.0366	−0.0503
0.20	−0.1922	−0.1438	−0.0720	−0.0100	−0.0470	−0.0669
0.25	−0.2414	−0.1894	−0.0948	−0.0137	−0.0563	−0.0860
0.30	−0.2895	−0.2453	−0.1226	−0.0193	−0.0642	−0.1096
0.35	−0.3355	−0.3174	−0.1587	−0.0277	−0.0691	−0.1418
0.40	−0.3787	−0.4167	−0.2084	−0.0406	−0.0674	−0.1891
0.45	−0.4177	−0.5647	−0.2823	−0.0613	−0.0484	−0.2667
0.50	−0.4513	−0.8097	−0.4049	−0.0973	0.0218	−0.4131

Table F2 Comparison Between CA and DA

$$(v = 1, \ m = 1, \ \phi = 1, \ \beta = 1, \ k = 0.45, \ \rho = 0.5, \ \epsilon = 0.01)$$

γ	$\alpha^{CA} - \alpha^{DA}$	$q^{CA} - q^{DA}$	$d^{CA} - d^{DA}$	$\Pi_P^{CA} - \Pi_P^{DA}$	$\pi_C^{CA} - \pi_C^{DA}$	$CS^{CA} - CS^{DA}$
0.10	−0.0099	−0.0064	−0.0312	−0.0016	−0.0026	0.0247
0.15	−0.0235	−0.0141	−0.0492	−0.0034	−0.0057	0.0333
0.20	−0.1922	−0.0248	−0.0690	−0.0057	−0.0097	0.0401
0.25	−0.2414	−0.0389	−0.0908	−0.0088	−0.0149	0.0455