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Abstract

The success of any User-Generated Content (UGC) website critically depends on the participation and effort of its content contributors. In this paper, we study the contributor motivation problem from a firm’s perspective. Drawing on the behavioral economics literature, we develop a unified framework of contributor behavior which captures diverse contributor motivations, including intrinsic fun, the need for self-expression, and monetary motivation. We focus on two decisions available to the firm which address different aspects of contributor motivations. First, we consider the website’s content promotion decision which addresses contributors’ need for self-expression by dictating the amount of viewer attention each content item receives. In equilibrium, the firm pursues either the “best take all” strategy where it directs all viewer attention to the highest quality content, or the “balanced allocation” strategy where all contributors, high skill or low skill, get a share of viewer attention. Second, we consider the firm’s monetary incentive decision. We find that under certain circumstances, paying the contributors may actually lower their efforts. In equilibrium, the optimal payment level changes discontinuously with the relative cost. The firm may either rely on socially motivated “community leaders” or on money-driven “entertainment workers” to generate the best content.

Keywords: User-Generated Content, Content Contributors, Motivation, Behavioral Economics, Game Theory, Signaling Games
1 Introduction

The past decade has witnessed an exponential growth of User-Generated Content (UGC) applications. Successful UGC websites like YouTube, Wikipedia, Yahoo Answers attract massive amounts of Internet traffic, often taking up the top positions in the world-wide page-view ranking.\(^1\) The quality and quantity of their contents stand in sharp contrast with the size of the companies: YouTube, for example, could serve over 100 million videos daily with merely 67 employees in 2006. With around 35 employees, Wikipedia is able to host 14 million articles with the help of approximately 1500 volunteers. A study by Nature magazine\(^2\) concluded that the quality and accuracy of Wikipedia articles are about the same as those of the prestigious Encyclopedia Britannica. The highly regarded contents have brought both financial and reputation gains for these websites.\(^3\)

It is precisely the idea of user contribution and crowd wisdom that underpins these achievements.

Although the idea of UGC represents large opportunities, it also poses novel challenges to firms. Content quality has been a critical factor underlying media firms’ success, and UGC websites are no exceptions. Unlike their traditional counterparts, UGC websites have almost no direct control over the quality of their contents. The content quality depends on the participation and effort of the content contributors. Therefore, contributor motivation has arisen as a decision of strategic importance for UGC websites. Firms are able to improve their content quality by designing more effective incentive schemes to motivate their contributors. In this paper, we take a firm’s perspective and study the contributor motivation problem. To address this issue, we build a game theoretic model that incorporates three key aspects of contributor motivation. This allows us to formally investigate the firm’s decision making in an equilibrium framework.

Contributors to the UGC websites usually have mixed motives. A number of survey-based studies have identified various sources of motivations, which could be classified in three broad

\(^1\)See Alexa.com.
\(^2\)http://www.nature.com/nature/journal/v438/n7070/full/438900a.html.
\(^3\)For example, the Google acquisition of YouTube amounted to $1.65 billion.
categories (Daugherty, Eastin, and Bright 2008):

- **Individual Motivation**: Despite the rapid commercialization of many UGC websites, *intrinsic fun* remains as one primary reason for people writing Wikipedia articles or posting videos on YouTube. In addition, contributors may experience “warm glows” (Andreoni 1990) from altruistic activities. We use individual motivation as a broad term for all contributor incentives that do not depend on the feedback from others.

- **Social Motivation**: Social motivations, such as self-expression and reputation, underly much of the contributing behavior in applications like social networks, video sharing websites, etc. Contributors may generate content to signal their skill levels or their pro-social attitudes. We use this term to refer to any contributor incentives that relate to the perception of oneself in the eyes of others.

- **Financial Motivation**: As many UGC websites have started to introduce monetary incentives in their systems, financial motivation has become another source of contributor incentives. YouTube, for example, has already implemented an advertising revenue sharing program that splits the ad revenue between the content contributors and the company.

The various sources of contributor incentives point to the richness of the contributor motivation problem. While firms usually have less control over contributors’ individual motivation, they have several instruments to address the social and monetary aspects of contributor incentives.\(^4\) We investigate two such instruments in turn.

First, in many UGC websites, firms frequently feature popular videos on their homepage or implement rating and ranking systems to help the best pieces of content stand out. We refer to these actions as *content promotion* decisions. Content promotion does not only help the *content viewers*...
locate the best content, but it may also impact the social motivation of the content contributors. For example, YouTube video makers are likely to derive greater satisfaction when their videos enjoy a large audience. By promoting some pieces of content while suppressing others, the firm directs the viewer attention from the low quality to the high quality content. When should the firm promote the best pieces of content as much as possible? When should it rather pursue a more balanced content promotion strategy, such that both the high-skill contributors and the low-skill contributors are able to get some viewer attention? This is the first contributor motivation decision we investigate.

Next, we study the website’s monetary incentive provision decisions. Many successful UGC websites have already implemented or are contemplating about some type of monetary incentive schemes. YouTube, for example, has implemented revenue sharing plans which split the ad revenue between the contributors and the website. Similarly, the casual gaming website Kongregate.com provides cash awards to the developers of the most popular games. Although this is still a relatively new practice, we believe that monetary incentives will become more prevalent as websites seek financially sustainable business models. When should the website provide monetary incentives to its contributors? What is the optimal level of monetary incentives? This is the second set of questions we seek to answer.

We model the three aspects of contributor motivation, and investigate the firm’s optimal content promotion and monetary incentive decisions. Our analysis reveals that the optimal incentive schemes depend critically on the relative magnitudes of the various aspects of contributor motivation. This suggests that there does not exist a one-size-fits-all approach to the contributor motivation problem. Instead, firms should choose qualitatively different incentive plans depending on the type of their UGC applications.

The first set of our results concern the firm’s content promotion decision. We find that firms may pursue two qualitatively different content promotion strategies, depending on the importance
of self-expression, contributor heterogeneity and the fixed cost of contribution. When the fixed
cost of content making is low, it is always optimal to direct all viewer attention to the content of
the highest quality. We call this strategy the best take all content promotion strategy. The inter-
esting case happens when the fixed cost of contribution is intermediate to large. In this case, the
firm also adopts the best take all strategy when social motivation is not important and contributor
heterogeneity is large. However, when social motivation is important or contributor heterogeneity
is small, the firm adopts a balanced allocation strategy. Under balanced allocation, high quality
content items get more attention, but pieces of low quality content also get a non-zero share of
viewer attention.

These results resonate well with anecdotal evidence from UGC markets. We observe differ-
ent content promotion strategies in different categories of UGC applications. In many knowledge-
based UGC websites where self-expression is less important, firms pursue the best take all strategy,
by directing all the viewer attention to the content of best quality. For example, Wikipedia only
displays a single version on each entry. In fact, each article undergoes a continuous improvement
process, in which contributions from less experienced contributors are usually discarded or re-
placed by writings from experienced contributors. In contrast, many video sharing websites tend
to adopt the balanced allocation strategy, where less experienced video makers also receive some
viewer attention. We try to explain these observed patterns by linking the content promotion strat-

The second set of our results address the optimal monetary incentive decision. Our re-
results show that the optimal monetary incentive decision depends on the correlation between the
contributors’ intrinsic motivation and monetary motivation. When contributors who derive greater
intrinsic fun are also more sensitive to money, paying the contributors always increases their equi-
librium efforts. However, when contributors who derive greater intrinsic fun also happen to be less
interested in money, paying the contributors has potentially large negative effects. Introducing pay-
ment attracts contributors who are interested in money but derive less intrinsic fun from the activity itself. This creates doubt about the true motives of the contributing action. As a consequence, the high type’s self expression motivation diminishes. The equilibrium effort level may become lower as the firm pays the contributors. In equilibrium, firms should either limit the amount of monetary incentives to guarantee the “purity” of the contributor community, or choose a very high level of monetary incentives to build a contributor community mainly based on financial motivation instead of intrinsic interest. Further, we find that when the firm does offer financial incentives, it is more effective to offer payments exclusively to top contributors instead of all participants of the website.

Among UGC practitioners, there has been considerable debate over the potential side effects of monetary incentives. In particular, it has been argued that introducing money is contrary to the spirit of altruism and voluntary contribution. Our model provides a formal theory for the above intuition, and confirms the caution against paying UGC contributors. Further, we provide boundaries for this problem and characterize the conditions under which paying contributors can indeed be beneficial.

Finally, we investigate the ‘interplay’ between the content promotion decision and the monetary incentives decision. Consider a money-free UGC website that is considering about introducing monetary incentives. How should it change its content promotion decision upon the introduction of financial payments? Our results show that with monetary payments, the firm has a greater incentive to pursue the ‘best take all’ strategy instead of the ‘balanced allocation’ strategy.

The rest of the paper is organized as follows. We review the related literature in section 2. In section 3, we outline our model setup. Results are presented in section 4. We end the paper with concluding remarks and a summary of future research opportunities. To ease exposition, all proofs are provided in the appendix.
2 Related Literature

Whilst the phenomenon labeled Web2.0 has gradually changed not only our lives, but also the advertising industry, marketing research on user-generated content websites is still sorely lacking. Social psychology has documented some of the fundamental attributes of consumer behavior in online communities (Jensen Schau and Gilly 2003, Mathwick, Wiertz, and De Ruyter 2007, Muñiz Jr and Jensen Schau 2005), but turning to the content that users generate, most research has either focused on the diffusion of such items within the community (Godes and Mayzlin 2004, Goldenberg, Han, Lehmann, and Hong 2009), or has in fact distinguished social relationships as the content area to be analyzed (Stephen and Toubia 2010, Trusov, Bucklin, and Pauwels 2009). Computing science has a deeper understanding of UGC websites (Cheng, Dale, and Liu 2008, Guo, Tan, Chen, Zhang, and Zhao 2009), however, their main focus is on the operational challenges related to running such websites. In this paper, we build a framework to better understand the impact of diverse incentives the website may provide to motivate its participants. Our work is closest in spirit to the marketing papers on the formation of online social networks. The biggest difference is that we look at content areas that are not related to social groups within the set of participants, and we assume that content is independently created by the contributors studied.

We build our model of contributor motivation on the economics and psychology literature on voluntary contributions and non-monetary motivations (Akerlof and Kranton 2000, Benabou and Tirole 2003, Bénabou and Tirole 2006, Glazer and Konrad 1996). A first approach (Andreoni 1990) to explain voluntary contributions assumes that contributors experience warm glows that spontaneously arise from contribution behavior. The warm glow is usually described as a ‘pure’ source of altruism that does not depend on the presence of others. A second approach explains voluntary contribution by arguing that contributors care about their images in the eyes of others. For example, Bénabou and Tirole (2006) build a general model of intrinsic motivations based on the assumption that people want to appear altruistic and non-greedy. Glazer and Konrad (1996) build
a signaling framework to explain donations, where the donors signal their wealth. These authors in general agree that people care about their images for both experiential reasons (e.g., affective self expression) or instrumental reasons (e.g., expecting reciprocity). We attempt to build a general framework that incorporates both the individual aspect (warm glow, intrinsic fun, practicing skill, etc) and the social aspect (signaling skill level, pro-social attitudes, expectation of reciprocity, etc) of contribution behavior. As in (Bénabou and Tirole 2006) and (Glazer and Konrad 1996), we adopt a signaling approach to model the social aspects of contributors’ motivations. Consistent with empirical findings (Frey and Jegen 2001), the Bénabou and Tirole (2006) model predicts that monetary incentives can actually hurt the intrinsic motivations of contributors. While our model shares largely similar insights, we focus on the implications of such crowding out phenomena on firm decisions.

In the specific context of UGC websites, a few studies have probed into the issue of contributor incentives. Almost all of these studies are confined to the website of Wikipedia. Rafaeli and Ariel (2008) provide a useful review. Most of the findings in this literature stream confirms that motivations underlying UGC contribution is largely similar to the motivations underlying general voluntary contribution behaviors. For example Snyder and Cantor (1998) find that contributing to Wikipedia serves four functions: value-expressive, social adjustive, utilitarian and knowledge. The value-expressive and social adjustive functions precisely correspond to our definition of social motivation, while the utilitarian and knowledge functions correspond to our definition of individual motivation.

Finally, we note that our model corresponds to a sequential move game where the firm first designs the incentive scheme, and contributors make their participation and effort decisions. Signaling games usually have multiple equilibria, because of the lack of restriction on off-equilibrium beliefs in the standard Perfect Bayesian Equilibrium. Since the second stage game does not have a unique equilibrium, the analysis of the first stage game becomes extremely difficult. To get around
this obstacle, just as in other applied work using the signaling model (Bagwell and Bernheim 1996, Bénabou and Tirole 2006), we refine our equilibrium concept by the widely used D1 criterion (Cho and Kreps 1987), which restricts the off-equilibrium beliefs and yields a unique equilibrium in the two-type signaling game.

3 Model

We assume that there is one firm (also referred to as website) operating a UGC website. This allows any contributor to register as a member of the community of participants and upload a piece of content in the format supported by the site.\(^5\)

3.1 Contributor Decisions

We assume that before uploading a piece of content, contributors have to exert a certain effort to create it. We assume that exerting such effort comes at a (convex) cost. The contributors may derive utility from participating in the website in three different ways. The first one corresponds to the individual motivation, such as the intrinsic fun of content making or experiential “warm glow” from helping others. We assume that the individual benefit, net of the effort cost, is

\[
\theta \cdot e - e^2.
\]

The term \(\theta \cdot e\) stands for the intrinsic benefit from content making. We assume two types of contributors, high \(\theta_h\) and low \(\theta_l\). The term \(\theta\) stands for the type of a contributor. It can represent the level of interest a contributor has in the activity, such that more interested contributors derive greater fun from participating. \(\theta\) can also stand for the pro-social attitudes of the contributor, such that the altruistic contributors experience greater “warm glow” from content making. Finally, \(\theta\) can

\(^5\)Depending on the profile of the website, this may be a video, a picture, or plain text. For simplicity, we focus on only one content area - in other words, the contributions of participants are only vertically differentiated.
stand for the skill level of a contributor, such that relative to a cost level, the high skill contributors derive greater intrinsic fun.

The type of each contributor is unobservable, and the contributors derive a social benefit from signaling. For example, when $\theta$ stands for the pro-social attitude of a contributor, the contributor derives greater social (reputational) benefit if he is perceived as more altruistic by the content viewers. Formally, we adopt a signaling formulation and assume that the social benefit is proportional to the perceived type of a contributor. The contributor utility function becomes

$$\theta \cdot e - e^2 + \alpha(e) \cdot \mu \cdot E(\theta | e).$$

The parameter $\mu$ measures the relative importance of social motivation versus intrinsic fun. The parameter $\alpha(e)$ measures the (quality-dependent) share of viewer attention this type of contributors receive (and so, independently from the actual participant decisions, we always have $\alpha(e(\theta_h)) + \alpha(e(\theta_l)) = 1$). Contributors’ social benefit increases as they get more viewer attention. $\alpha(e)$ depends on the content promotion choice of the firm, such that the higher effort contributors receive more viewer attention\(^6\). $E(\theta | e)$ is the expected type of a contributor, which is inferred by the content viewers upon observing an effort level $e$.

Finally, we assume that the contributors can be motivated by the website’s monetary payment. When the website offers an effort-contingent payment, the contributor utility becomes

$$\theta \cdot e - e^2 + \alpha(e) \cdot \mu \cdot E(\theta | e) + \beta \cdot m_{\theta} \cdot e.$$  

The parameter $m_{\theta}$ measures the strength of each type’s financial motivation. We allow for type heterogeneity with respect to the financial motivation ($m_{\theta_h} \neq m_{\theta_l}$) attributes. We assume that the contributor utility from monetary rewards is proportional to the financial motivation of the type.

\(^6\) In our simple two type model, there can be at most two effort levels, and $\alpha(e)$ can be sufficient described by a single parameter. See Section 3.2 for a detailed explanation.
\( m_\theta \), the effort level \( e \) chosen by the contributor, and a choice variable of the website \( \beta \) describing the strength of monetary incentives provided by the firm. The base case \( \beta = 0 \) corresponds to most UGC websites at which contributors do not receive monetary payments.

To summarize, for a contributor of type \( \theta \), the utility derived from participation at effort level \( e \) is

\[
U_\theta(e) = \begin{cases} 
\theta \cdot e + \mu \cdot E(\theta|e) + \beta \cdot m_\theta \cdot e - e^2 & \text{if only type } \theta \text{ contributors upload content} \\
\theta \cdot e + \mu \cdot \alpha \cdot E(\theta|e) + \beta \cdot m_\theta \cdot e - e^2 & \text{if type } \theta \text{ contributors upload the content of highest quality}, \\
\theta \cdot e + \mu \cdot (1 - \alpha) \cdot E(\theta|e) + \beta \cdot m_\theta \cdot e - e^2 & \text{if type } \theta \text{ contributors upload content of lower quality yet obtain monetary compensation, and} \\
\theta \cdot e + \mu \cdot (1 - \alpha) \cdot E(\theta|e) - e^2 & \text{otherwise}. 
\end{cases}
\]

As implicit above, we study two different regimes of financial incentives (discussed in more detail in section 3.2). Depending on the entry decision and the regime of monetary incentives, we have four possible expressions for contributors’ utility function. First, we look at the impact of paying every contributor (across-the-board payments) and analyze the effects of monetary compensation on contributors’ incentives. Next, we assume that the website only pays to the creators of the highest quality content on the site (top-only payments), and, taking the firm’s point of view, we compare this scheme to the across-the-board compensation.

We assume that each contributor has to incur a fixed cost \( F \) in order to participate in the website. This participation cost may differ for each class of UGC applications: it includes the cost of learning how to make content of the right format, learning how to upload the content onto the website, etc. When \( F \) is larger than the utility that a contributor could get from participation, then that contributor abstains from uploading content to the website.
3.2 Firm Objective and Decisions

The firm is interested in maximizing either the profit or the social impact of the website. Many UGC websites generate revenues by selling advertising. An advertising-based website can increase its advertising revenues by delivering higher (average) quality content to the visitors of the website (which results in more page views and/or better prices for the displayed advertising). Wikipedia is an interesting exception as it is run mainly based on donations - its stated objective is maximizing the social impact by delivering free knowledge. A non-profit website can increase its social impact by delivering more informative and reliable content to its audience. To study both types of websites in the same framework, we use the average quality as proxy for both types of objectives. Improving the quality of the presented content can be done via two incentivization mechanisms, content promotion and offering monetary rewards. We discuss these mechanisms in detail below.

We assume that the quality of any given piece of content is the same as the effort a contributor takes to make it. To assess the average quality of observed content, note that in our two-type formulation, there are never more than two quality levels in equilibrium. Let us denote the contributor type uploading the higher quality content as *winner* and the other type as *loser*. The objective function of the firm is then

\[
\Pi(\alpha, \beta) = \begin{cases} 
\alpha \cdot e_{\text{winner}}(\alpha, \beta) + (1 - \alpha) \cdot e_{\text{loser}}(\alpha, \beta) & \text{when both types enter and both types get paid}, \\
-c \cdot \beta \cdot (e_{\text{winner}}(\alpha, \beta) + e_{\text{loser}}(\alpha, \beta)) & \text{when both types enter and only the winner is paid}, \\
\alpha \cdot e_{\text{winner}}(\alpha, \beta) + (1 - \alpha) \cdot e_{\text{loser}}(\alpha, \beta) & \text{when one type enters}, \\
0 & \text{otherwise}.
\end{cases}
\]

The firm maximizes its objective by making two decisions:

**Content Promotion**
Through featuring and recommendation, the firm may direct the attention of viewers arriving to the website to pieces of content of specific quality. Since there may be at most two different quality levels, we assume that the firm chooses a variable $\alpha \in [0.5, 1]$, corresponding to the proportion of viewer attention received by the higher quality (“winner”) content. The lower quality (“loser”) content, therefore, gets the $1 - \alpha$ fraction of viewer attention. When only one type enters, there is only one quality level, and the content uploaded by the entering type receives all viewer attention.

**Monetary Incentives**

The other tool the website may use to motivate contributors is monetary compensation. The firm first decides whether to reward all contributors (a payment scheme we refer to as *across-the-board*), or only those contributors who upload the highest quality content (referred to as *top-only*). Then, the firm can choose the level of payment $\beta \in [0, \infty)$ which corresponds to a “conversion rate” between the quality of the piece of content in question and the offered monetary compensation (in the top-only regime, conditional upon that the uploaded piece ends to be that of highest quality). To be able to capture the impact of monetary incentives on contributor entry decisions, we allow for a scaling parameter, $c$ in the firm’s objective function which measures how financially costly rewarding contributors is. (To ease exposition, $c$ is kept uniform across types. Results for heterogeneous $c$ may be obtained from the authors.)

### 3.3 Information Structure and Timing of the Model

We assume that all players (the contributors and the firm) are all aware of all the values $\theta_h, m_{\theta_h}, \theta_l, m_{\theta_l}, c$ and $F$. The content generation process unfolds in discrete stages. In the first stage, the firm chooses $\alpha, \beta$ and the payment regime. In the second stage, the contributors observe the firm’s choices and decide whether or not to participate in the website. In the third stage, the contributors choose the level of their effort, respectively, keeping in mind that the viewers infer a contributor’s
type from his effort level. In this stage, we seek the Perfect Bayesian Equilibrium under the D1 Criterion (Cho and Kreps 1987).

4 Analysis

We organize our results into three parts. In section 4.1, we consider the firm’s optimal content promotion decision when monetary incentives are not used. In section 4.2, we consider the firm’s optimal monetary incentive decision, keeping its content promotion decision as given. In section 4.3, we investigate the interplay between the two decisions. The above sequence of analysis was chosen mainly for technical and exposition reasons. By treating the two decisions in isolation, we are able to shed lights on the fundamental driving forces behind each decision.

4.1 Content Promotion Decision

In this subsection, we turn our attention to the “classical” model of UGC websites and assume that the firm does not provide monetary incentives to contributors. We thus keep $\beta = 0$, and the contributor utility function simplifies to

$$U_\theta(e) = \begin{cases} 
\theta \cdot e + \mu \cdot E(\theta|e) - e^2 & \text{if only type } \theta \text{ contributors upload content} \\
\theta \cdot e + \mu \cdot \alpha \cdot E(\theta|e) - e^2 & \text{if type } \theta \text{ contributors upload the content of highest quality, and} \\
\theta \cdot e + \mu \cdot (1 - \alpha) \cdot E(\theta|e) - e^2 & \text{otherwise.}
\end{cases}$$

Promoting the high quality content corresponds to choosing a higher $\alpha$. This impacts both the content contributors and the content viewers. In a direct fashion, choosing a larger $\alpha$ helps the website’s visitors find higher quality content and improves their consumption experience. However, directing viewer attention from the low quality content to the high quality content also has
indirect incentive effects. We provide formal results in Lemma 1 and Lemma 2 in the Appendix. Overall, we identify three key effects of content promotion:

- **Increasing Viewer Benefit**: When the website promotes the high quality content, it improves viewer experience. Put differently, the average quality of observed content increases as the content pieces of high quality are directed greater attention to.

- **Enhancing Contributor Effort**: As more viewer attention is directed to the content pieces of highest quality, contributors have greater incentives to put effort into content generation. Under a large $\alpha$, making higher quality contents not only signals the contributor’s skill level or pro-social attitude, but also attracts a larger audience which makes social signaling more rewarding. In other words, when contributors care about self-expression, uneven allocation of viewer attention promotes a type of “social competition” between contributors.

- **Deterring Participation**: As the contributors of higher quality content get more viewer attention, their surplus subsequently increases. On the other hand, the contributors of lower quality content may get worse off since they get less viewer attention. This may deter the low type from participating in the website at all.

Before proceeding to the equilibrium analysis, we present some graphical illustrations of these effects. Assuming non-zero entry costs, Figure 1 illustrates the equilibrium effort level and equilibrium surplus as a function of $\alpha$.

Subplot (a) describes the equilibrium efforts. There are three ranges of $\alpha$ in which the contributors behave differently. When $\alpha \in [0, \alpha']$, both the low type and the high type choose the efficient effort level.\(^7\) Since the high type contributors derive greater intrinsic fun, they will put more effort into content making. The content viewers correctly infer the contributors’ types and

\(^7\)Throughout the paper, we use the term “efficient effort level” to denote the effort levels contributors would choose under full information. The efficient effort levels maximize the intrinsic fun minus the cost of effort.
Effort levels: $\theta_h = 3.5$, $\theta_l = 2$, $\mu = 0.4$, $F = 1.2$

 Contributor Surplus: $\theta_h = 3.5$, $\theta_l = 2$, $\mu = 0.4$, $F = 1.2$

Figure 1: Equilibrium Effort Levels and Contributor Surplus

perceive the high type as of higher skill or greater pro-social attitudes. In the range $\alpha \in [0, \alpha']$, the average effort is increasing in $\alpha$ although $e_h$ and $e_l$ are constant, reflecting the viewer benefit increasing effect of increasing $\alpha$.

When $\alpha \in (\alpha', \alpha'')$, the low type chooses its efficient effort level, but the high type incurs extra effort above the efficient level. This happens because the pressure of social competition becomes greater as $\alpha$ becomes higher. When the high types choose their efficient effort level, the low type contributors have incentives to keep up with the high types’ effort. If the low type can successfully mimic the high type, they both receive a greater amount of viewer attention and get to be perceived as of high skill. Such benefits related to self-expression motivate the low types to mimic their high type counterparts. In equilibrium, the high type contributors have to incur extra effort in order to separate themselves from the low type contributors. This makes both $e_h$ and the average equilibrium effort increase in $\alpha$.

On the surplus side (Subplot (b)), the high types become better off as more attention is allocated to content uploaded by them. Simultaneously, the low types become worse off. Despite that the firm always prefers higher average effort when both types participate, it should avoid “detering” the low type contributors from participating at all, which happens in $\alpha \in (\alpha'', 1]$. When
the low type does not participate at all, the high type can also lower their effort level because of
the absence of the social competition. In other words, although intensified “social competition” is
in general desirable because it raises the average effort when both types participate, it also risks
discouraging participation. In this case, directing more attention to the high quality content can
actually demotivate the high type contributors.

Next, we show how the above three effects jointly determine the firm’s optimal content
promotion strategy, leading to either a best take all strategy or a balanced allocation strategy. The
following proposition characterizes the equilibrium strategy choice:

**Proposition 1.** When the fixed cost of participation $F$ is sufficiently small, it is always optimal to
choose the ‘best take all’ content promotion strategy, in which all viewer attention is directed to the
content of the highest quality. When $F$ is sufficiently large, it is optimal to choose the best take all
strategy if self-expression is not important and type heterogeneity is large. Otherwise, it is optimal
to choose a balanced allocation strategy in which $\alpha^* = 1 - \frac{4F - \theta^2_l}{4\mu \cdot \theta_l}$.

Formally,

- When $\frac{\theta^2_l}{4} + \frac{\mu \cdot \theta_l}{2} < F$, the decision about $\alpha$ is irrelevant, i.e., either only the high type will
  participate or neither type will participate. In either case, the firm profit does not depend on
  $\alpha$.

- The firm chooses $\alpha^* = 1 - \frac{4F - \theta^2_l}{4\mu \cdot \theta_l}$ if
  
  \[
  \frac{\theta^2_l}{4} + \frac{\mu \cdot \theta_l}{2} > F > \frac{\theta^2_l}{4}
  \]

  and

  \[
  \left(1 - \frac{4F - \theta^2_l}{4\mu \theta_l}\right) \cdot \sqrt{\mu \cdot \left[\frac{\theta_h - 4F - \theta^2_l}{4\mu \theta_l} \cdot (\theta_h - \theta_l)\right]} > \frac{\theta_h - \theta_l}{2}.
  \]

- The firm chooses $\alpha^* = 1$ otherwise.
Figure 2: Equilibrium Content Promotion Strategies
Figure 2 illustrates Proposition 1. We find that firms may pursue two different content promotion strategies depending on the importance of self-expression, contributor heterogeneity and the fixed cost of contribution. When the fixed cost of contribution is very low, the individual motivation alone is sufficient to make all contributors participate. Therefore, the participation deterrence effect is not a concern. The effort enhancing effect and the viewer benefit improving effect both make the “best take all” allocation strategy optimal. When the fixed cost of contribution is intermediate to high, however, the entry deterrence effect takes place when most of viewer attention is directed to the highest quality content. Importantly, when low type contributors do not participate, the high type contributors no longer have to choose a high effort level in order to distinguish themselves: the mere fact of participation is enough to signal their skill level or pro-social attitudes. As a result, the equilibrium quality level may actually become lower when entry deterrence takes place. Therefore, it is optimal for the firm to pursue a “balanced allocation” strategy where the low type contributors are sufficiently motivated to participate. When social motivation is not important, both the entry deterrence effect and the effort enhancing effect are not important, and the firm pursues a “best take all” strategy in optimum.

The above findings resonate well with anecdotal evidence. In knowledge-based UGC websites such as Wikipedia and Yahoo Answers, the website usually adopts a “best take all” strategy. Arguably, in these applications, the social motivation is less important and the fixed cost of contribution is relatively low. For example, in Wikipedia, the user name of each contributor is rarely known, and self-expression is not a primary motivation for Wikipedia contributors (Glott, Schmidt, and Ghosh 2009). At the same time, since the content contributing involves mostly text editing, the fixed cost of contribution is presumably low. In accordance with our analysis, Wikipedia only displays a single version of content corresponding to each entry. In Yahoo Answers, although multiple answers to each question are available, the best answer receives almost all the viewer attention. In fact, the lower rated answers are hidden from the viewers by default. In contrast, in
video sharing websites such as YouTube, the need for self-expression is high, and the fixed cost of making videos is relatively high as well. Such websites tend to adopt a “balanced allocation” strategy: despite that clips made by proficient video makers are more often promoted, the contents uploaded by less experienced video makers also receive some viewer attention. For example, less popular videos on YouTube appear in the “Related Videos” list when a highly popular video is viewed. In fact, the availability of a large group of amateur videos made many advertisers hesitant to use YouTube as an advertising medium, being afraid that their products will be presented next to low quality videos. In the above analysis, we argue that although these amateur producers do seem to decrease expected video quality in a direct fashion, their presence encourages social competition between contributors and actually benefits the website.

4.2 Monetary Incentives Provision

In this section, we consider the firm’s decision about offering monetary payments to the contributors. We explore two cases sequentially. First, we consider a simple payment scheme where the firm pays all the contributors contingent on the quality of the content. In this formulation, all contributors get paid regardless of their relative rank in the community. Next, we consider a case where the firm only pays the top-ranked content makers according to the content quality. The two cases reveal largely similar insights as to when and how much should the firm pay its contributors. The comparison of the two cases sheds light on how the firm should design the structure of its incentive scheme. In this section, we assume a simple case where the fixed cost of participation is sufficiently low for both types to enter even in the absence of monetary incentives. Further, we assume that the firm does not change its content promotion strategy when it decides whether and how to introduce monetary incentives: throughout this section, we take $\alpha$ as exogenously determined before the monetary incentives provision decision. This loosely corresponds to the sequence of decision making of many firms: while content promotion has been relevant since the launch of
the corresponding websites, sharing advertising revenues or offering other monetary incentives is a recent phenomenon.

4.2.1 Across-the-Board Payment

In this section, we investigate a simple payment scheme where all contributors receive monetary payment, contingent upon their efforts. We refer to this payment scheme as “across-the-board” payment. Recall from section 3, that the firm has the following profit function:

\[
\Pi(\alpha, \beta) = \alpha \cdot e_{\text{winner}}(\alpha, \beta) + (1 - \alpha) \cdot e_{\text{loser}}(\alpha, \beta) - c \cdot \beta \cdot (e_{\text{winner}}(\alpha, \beta) + e_{\text{loser}}(\alpha, \beta)).
\]

The first two terms correspond to the average quality of content, while the last term stands for the cost of paying the contributors. Thus, the monetary decision involves a trade-off between motivating contributor efforts and cost. We first explain the intuition about how monetary payments change contributor incentives. Next, we proceed to analyze the firm’s optimal choice of \( \beta \).

We consider two cases, \( m_{\theta^h} > m_{\theta_l} \) and \( m_{\theta^h} < m_{\theta_l} \), separately. The \( m_{\theta^h} > m_{\theta_l} \) case represents a scenario where the high type - the type that obtains greater intrinsic fun from contributing content - also derives greater marginal utility from money. The \( m_{\theta^h} < m_{\theta_l} \) case means that the high type also tends to be disinterested in money, while the low type derives greater utility from monetary incentives. We analyze both cases in parallel, revealing how certain effects of monetary incentives differ for the two scenarios:

- **Enhancing Contributor Effort**: As payment is made contingent upon quality (e.g., effort), contributors respond to monetary incentives and may incur higher levels of effort. This is true for both the \( m_{\theta^h} > m_{\theta_l} \) case and the \( m_{\theta^h} < m_{\theta_l} \) case. In effect, increasing the magnitude of payments raises the efficient effort levels for both types.

- **Reinforcing Self-Expression**: In the case \( m_{\theta^h} > m_{\theta_l} \), paying the contributors has a greater marginal effect on the high type. As a result, with larger payments, the difference between
Effort levels: $\theta_h=5, \theta_l=2, m_{\theta_h}=5, m_{\theta_l}=2, \alpha=0.8, \mu=1$

- Inducing Crowding Out: When $m_{\theta_h} < m_{\theta_l}$, the monetary incentives have a greater impact on the low type. Although the low type derives less intrinsic fun from making content, they exert high effort for the monetary return. This interferes with the self-expression function of content making: upon observing a high effort level, the content viewers have doubt about the motives of the contributors. In the more severe situations, a high level of effort is perceived as indicative of a liking for money, and therefore, of lower intrinsic interest. This demotivates the high types from exerting high effort.

Specifically, crowding out takes place at $\hat{\beta} = \frac{m_{\theta_l} - m_{\theta_h}}{\theta_h - \theta_l}$. At this level of $\beta$, the efficient effort level of type $\theta_l$ exceeds the efficient effort level of type $\theta_h$.

Figure 3 illustrates the above results. In the left subplot, we observe that when $m_{\theta_h} > m_{\theta_l}$, the average effort is increasing in $\beta$. This reflects the effort enhancing effect of monetary payment when it reinforces self-expression. In the right subplot, we observe the equilibrium effort as a function of $\beta$ when $m_{\theta_h} < m_{\theta_l}$. In sharp contrast with the $m_{\theta_h} > m_{\theta_l}$ case, the equilibrium efforts
may decrease as the firm chooses higher levels of $\beta$. Specifically, there is a point of discontinuity at $\hat{\beta}$ where crowding-out takes place. As $\beta$ continues to increase, the monetary incentives become so strong that even in a crowding-out situation where high type incurs the lower effort, the average effort is very high because of the effort made by the money-driven low types.

Proposition 2 describes firm’s optimal monetary incentive decision.\(^8\)

**Proposition 2.** Let $\beta^*$ denote the optimal payment level set by the firm. When $m_{\theta_h} > m_{\theta_l}$, there exist two types of optimal incentive schemes:

- When $c$ is large, the optimal payment is $\beta^* = 0$.
- When $c$ is small, the optimal payment is $\beta^* > 0$ which is decreasing in $c$.

When $m_{\theta_h} < m_{\theta_l}$, define $\hat{\beta} = \frac{m_{\theta_h} - m_{\theta_l}}{\theta_h - \theta_l}$. There exist four types of optimal incentive schemes:

- When $c$ is very small, the optimal payment is $\beta^* > \hat{\beta}$, decreasing in $c$.
- When $c$ is small to intermediate, the optimal payment is $\beta^* = \hat{\beta}$.
- When $c$ is intermediate to large, the optimal payment is $0 < \beta^* < \hat{\beta}$, decreasing in $c$.
- When $c$ is very large, the optimal payment is $\beta^* = 0$.

Figure 4 illustrates the above proposition. We plot $\beta^*$, the rate of the firm’s optimal payments as a function of $c$, the relative cost of introducing such payments. The left subplot illustrates the case $m_{\theta_h} > m_{\theta_l}$ and the right subplot illustrates the $m_{\theta_h} < m_{\theta_l}$. Overall, three qualitatively different UGC communities may emerge:

\(^8\)Although we give detailed proofs of propositions in the appendix, a technical note is worth mentioning here. Bearing in mind the technical complexity of the model, to communicate the intuition behind our results, we have chosen to present a version of the proposition that qualitatively states the optimal payment behavior. There exists an elegant proof of the presented results based on the techniques of Monotone Comparative Statics. To generate the figures, however, we have developed a numeric procedure by identifying the exact expressions for $\beta$ and the exact conditions for each possible type of optimum.
Figure 4: Optimal Monetary Incentives Provision

- **Money-Free Community**: The firm maintains a community without offering monetary incentives. Contributors’ participation is purely driven by their intrinsic and social motivations. Individuals with high content creating skills or greater pro-social attitudes (‘high types’) make the highest quality content and emerge as “community leaders”.

- **Money-Complemented Community**: The firm introduces monetary incentives that complement the intrinsic and social motivations of the contributors. The high types emerge as community leaders, and all contributors receive monetary payments.

- **Money-Driven Community**: The firm introduces strong monetary incentives that eclipse the social and intrinsic motivations of the contributors. The low types put the highest effort into content making, but as this is interpreted in the community as a signal for the liking of money, whereby the low types become “entertainment workers”.

The above analysis indicates that the effect of monetary incentives is not always positive, and the firms should be cautious about introducing monetary payments. In fact, the condition $m_{\theta_h} < m_{\theta_l}$ may indeed turn out to be true for many UGC websites. Since many UGC websites have been running for years without monetary incentives, contributing content to the website resembles
a type of voluntary activity. Thus, the pool of contributors likely consists of individuals who enjoy participating even in the absence of monetary incentives, and who therefore tend to be the less money-driven. In 2006, industry observers debated about the desirability of introducing advertising revenue sharing schemes (Scrivens 2006). While some argued that the revenue sharing scheme is a weapon to dethrone YouTube, others cautioned against the over-justification effect it may bring. On the practitioner side, while sites like Metacafe started paying their contributors in 2006, YouTube refrained from such practices until recently. Despite the revenue sharing practices introduced only by its competitors, YouTube remained the video sharing website with the largest market share. Further, in a 2007 interview to the BBC, YouTube founder Chad Hurley told that “the fact that YouTube had not had a revenue sharing model was one of the reasons for its success, as that had allowed the website to focus on its key strength, making it easy to share videos with others.” (Weber 2007) These cautionary remarks by practitioners seem to be in accordance with our formal results.

4.2.2 Top-only Payment

In the above section, we examine the simple case where monetary payments are offered across-the-board, e.g., regardless of content quality. All the content contributors receive financial compensation directly proportional to the quality of their contributions. In practice, the firm usually has the option of designing alternative payment schemes. In this section, we examine one of such alternative schemes that we refer to as “top-only” payment. In this scenario, the firm only pays the contributors who generate the highest-quality content. As such, the payment scheme is conceptually similar to a contest where only the winners are awarded. We analyze contributor behavior under the above schema, and provide the formal results in the appendix. Compared to the across-the-board regime, top-only payment has the following characteristics:

- **Demotivating the “Losing” Type**: Given any positive payment level, as only the highest
quality content receives the payment, the contributors of the lower quality content are less motivated compared to the case of ‘across-the-board’ payment.

- **Motivating the “Winning” Type**: Given any positive payment level, the contributors of the lower quality content have greater incentives to mimic the “winner” type compared to the case of “across-the-board” payment. This is because mimicking the winners’ effort has both reputational benefit and monetary benefit. As a result, the winners may incur higher effort in order to induce separation.

- **Lowering or Increasing Cost**: Since the firm only pays a fraction of all the contributors, the cost of payment may be lower. However, as the winners now incur higher effort, the cost of payment may be higher.

The above effects imply that the top-only payment can lead to either higher or lower firm profit. The desirability of the top-only payment scheme depends on the relative strength of the various effects. The following proposition indicates that under realistic conditions, if the firm is interested in introducing monetary incentives, then top-only payments are always better than across-the-board payments.

**Proposition 3.** Assume that \( c \) is too high for the firm to allow the low type to win the “quality contest”. Assume further that for the proportion of viewer attention directed to the highest quality content, \( \alpha > 1 - c \cdot m_\theta_i / \theta_i \), and that the fix cost of participation is low enough so that both types participate. Then for any \( \beta > 0 \) for which \( \Pi_{atb}(\alpha, \beta) > 0 \),

\[
\Pi_{to}(\alpha, \beta) > \Pi_{atb}(\alpha, \beta).
\]

where \( \Pi_{atb} \) and \( \Pi_{to} \) denote the profits under the across-the-board and top-only scenarios, respectively. In other words, the firm prefers rewarding only the contributors of the best content items over paying all participants of the website.

26
The above proposition indicates the superiority of the top-only payment scheme. Unless paying the participants comes at a very low cost to the firm (e.g., when external funding supports such efforts), paying less participants is actually more effective. The limiting condition essentially states that inducing crowding out is not a desirable outcome. We believe this is a reasonable condition that most UGC applications satisfy, since non-monetary motivation and ‘voluntary participation’ are definitive features for websites that consider their content user-generated.

The superiority of the top-only payment scheme is also confirmed by anecdotal evidence. In the case of YouTube, the top-only pattern was amplified by the way in which the partner program was introduced. Since the launch of the program in May 2007, the possibility of monetary rewards has only been offered to participants whom YouTube approves. Further, by initially inviting professionals and individuals whose videos had regularly been viewed in the range of millions, YouTube ensured that among those contributors who are interested in revenue sharing, many have very high skills to make videos. In other words, YouTube designed its revenue sharing scheme so that it rewards contributors of highest skills. As a consequence, it is highly unlikely that the large group of “low type contributors” would find it feasible to invest a lot of money to the end of turning content generation into a full-time business.

4.3 Interplay Between Content Promotion Decision and Monetary Incentives Decision

In this section, we investigate the interplay between the firm’s content promotion decision and its monetary incentives decision. In the cases of most UGC websites, offering monetary incentives has been made possible only recently. We ask the following specific question: when the firm decides to offer its contributors monetary incentives, how should it change its content promotion decision? Following our findings presented in the previous section, we focus on the “top-only” payment regime and assume that the firm does not induce crowding out. Just as before, for
notational convenience, we assume $\mu = 1$ without loss of generality.

**Proposition 4.** Assume that the firm does not induce crowding out by a high level of monetary payment\(^9\). Then, when the firm introduces “top-only” monetary incentives, we can say the following about its content promotion strategy:

- When the fixed cost of participation, $F$ is either so low that both types participate or so high that only one type enters at $\beta = 0$, then upon introducing monetary incentives, the firm does not change its best take all content promotion strategy.

- For $\frac{\theta^2}{4} < F < \frac{\theta^2}{4} + \frac{\theta^2}{4}$, the firm may increase or decrease $\alpha$ upon introducing monetary incentives. For $\beta > 0$, the best take all strategy may only be optimal when the high type is much more sensitive to money than the low type. Otherwise, the firm chooses a balanced allocation after introducing financial rewards.

The above proposition describes a situation relevant to many websites. Historically, many UGC websites were running for years with low advertising revenues and no subscription fees at all. The uncertainty about advertising through user-generated media made many advertisers hesitant to embrace UGC as an advertising medium. Moreover, the uncertainty about the impact of paying their contributors made UGC websites themselves unwilling to introduce monetary incentives even after advertisers started engaging these websites.

At the same time, content promotion has always been a relevant decision. For many websites, at the time they introduced monetary incentives, they already had mature content promotion technologies up and running for years. The above results indicate that once the monetary incentive scheme is in place, the firm may have to adjust its content promotion system. In particular, we find that adjusting content promotion may be relevant in two scenarios, best described by the following examples. First, imagine a specialist community (with relatively high entry cost) where all viewer

---

\(^9\)e.g., $c$ is too high for the firm to allow the low type to win the “quality contest”
attention is allocated to the highest quality content. A possible way to further increase the average quality of contents and thus the number of page views may be to introduce a payment scheme that rewards the best contents while also displays some of the lower quality items posted on the website. Such a scheme may work if the lower-skill contributors have a high valuation of money and therefore have strong incentives to mimic the high-skill contributors. Then, encouraging their entry (by directing viewer attention to the contents they post) forces the higher-skill contributors to produce even higher quality contents, which results in a higher average quality of contents - so much that from the increased viewer interest allows the firm even to recover the money spent on rewards.

The other example, in which the firm increases $\alpha$ after introducing monetary payment, is a UGC website with a relatively higher entry cost that uses a balanced content promotion strategy. If this website discovers that the higher-skill contributors also have a (much) higher valuation for money than their lower-skill counterparts, it may choose to specialize in premium content by introducing monetary incentives and simultaneously switching to a best take all content promotion strategy, incidentally inducing the crowding-out of the low type.

The above two examples are realistic only under the assumption that the average content quality is perfectly correlated with the number of page views, and the advertising revenues of the website. In realistic settings, the two sides the market (content contributors and content consumers) are not perfectly disjoint. On the contrary, whereas there are likely much more content consumers than content contributors, many of the participants are also consumers of contents posted by other community members. Under such circumstances, the first scenario is somewhat more likely, but the second scenario may not happen at all (the firm could lose too much demand by losing the low-type contributors). Such limitations need to be taken into account when interpreting all of our results.
5 Discussion

In this paper we take a first step in analyzing the contributor motivation problem in User-Generated Content websites. We start with a general contributor utility function that encompasses the contributors’ individual, social and monetary motivations. We investigate the firm’s content promotion decision and monetary incentive decision. Our results reveal that the best practice is not unique. Instead, a diversity of qualitatively different business models can emerge depending on the type of UGC application. As to the content promotion decision, we find that when social motivation is not important, the firm may find it optimal to direct all viewer attention to the content items of highest quality. Meanwhile, when contributors care more about self-expression, a more balanced allocation may be optimal wherein both proficient and amateur contributors get their share of viewer attention. As to the monetary incentive decision, we find that the optimal payment critically depends on the correlation between contributors’ intrinsic motivation and financial motivation. When the more proficient contributors also tend to be less interested in money, paying contributors may “crowd out” their intrinsic interest and lead to lower content quality. As a result, the firm faces a choice of which type of contributors to rely on, depending on the relative cost of monetary payments. To the end of how to design the compensation scheme, we compare two simple payment regimes. We conclude that under realistic conditions, the firm always prefers to, contingent upon their effort, pay only the creators of the highest quality content as opposed to paying every participant who uploads content to the site.

User-Generated Content is an emerging phenomenon underpinned by a wide variety of technological and business model innovations. We study a UGC website and the contributor motivation problem in an abstract and general framework, and our model is unable to fully capture the richness and diversity of UGC applications. We propose a number of directions for future research. First, as the idea of UGC is being leveraged into more and more business and public policy contexts, websites tend to have diverse objectives. For example, the emerging open innova-
tion platforms\textsuperscript{10} bring inventors together and work on problems of business or social significance. Instead of the average content quality, the open innovation platforms may care about the best idea being contributed. Many other UGC websites may care about not only the quality of contents, but also the quantity of contents. This could happen when consumers have preference for variety or when the website wants to maximize social objectives by increasing its reach. Alternative objectives may change the firm’s optimal contributor motivation scheme.

Second, we assume a monopoly setting throughout our analysis. An interesting next step would be extending the model into a competitive setting. Competition may impact on firm behavior in several ways. First, as firms compete for viewer attention, they may have incentives to raise the content quality above the efficient monopoly level. This is similar to the classic price competition model, where competitive interaction drives the prices below the monopoly level. In the case of monetary incentives, the need for higher quality content may translate into higher levels of financial compensation. Second, as firms compete for contributor participation, their contributor motivation schemes serve to attract contributors from the competitor. For websites, this translates to incentivizing contributors as an instrument to compete for talent. As the UGC marketplace becomes increasingly competitive, these issues are gaining great managerial interest. We leave these issues for future research.

\textsuperscript{10}See www.innocentive.com for an example.
References


Appendix

Technical Lemmas

In this section, we provide lemmas that are key to our analysis. The first lemma characterizes the PBE in the post-entry contribution subgame.

**Lemma 1.** The equilibrium effort levels in the contribution subgame can be described as follows:

- In the contribution subgame where both types participate, the only PBE satisfying the D1 Criterion (Cho and Kreps 1987) is the most efficient separating equilibrium. The equilibrium levels of effort are

  \[
  \begin{cases}
  e_h = \frac{\theta_h}{2}, & e_l = \frac{\theta_l}{2} \\
  e_h = \frac{\theta_h}{2} + \sqrt{\mu \cdot (\alpha \cdot \theta_h - (1 - \alpha) \cdot \theta_l)}, & e_l = \frac{\theta_l}{2}
  \end{cases}
  \]

  if \( \mu \cdot (\alpha \cdot \theta_h - (1 - \alpha) \cdot \theta_l) < \left(\frac{\theta_h - \theta_l}{4}\right)^2 \), and otherwise.

- In the contribution subgame where only one type \( \theta \) enters, the equilibrium effort level is \( e_\theta = \frac{\theta}{2} \).

When both types enter, the equilibrium payoffs are

\[
\begin{align*}
  u_{\theta_h}(e_h) &= \theta_h \cdot e_h - e_h^2 + \mu \cdot \theta_h \quad \text{and} \\
  u_{\theta_l}(e_l) &= \theta_l \cdot e_l - e_l^2 + \mu \cdot (1 - \alpha) \cdot \theta_l.
\end{align*}
\]

The following lemma characterizes the equilibrium in the participation (entry) subgame.

**Lemma 2.** When \( F < \frac{\theta_h^2}{4} + \mu \cdot (1 - \alpha) \cdot \theta_l \), both types participate in the unique equilibrium. When \( F > \frac{\theta_h^2}{4} + \mu \cdot \theta_h \), neither type participates. Otherwise, only the high type will participate.

In any case, the high type contributors are better off than the low type contributors.

**Lemma 3.** Suppose \( F \) is small such that both types always enter. Under the “Across-the-Board” payment scheme, the impact of \( \beta \) on the average quality of contents can be described as follows:

- When \( m_{\theta_h} > m_{\theta_l} \), the average quality of contents is increasing in the strength of monetary incentives, \( \beta \). The surplus of both the high type and the low type are increasing in \( \beta \).
• When $m_{0h} < m_{0l}$, the average quality of contents may be either increasing or decreasing in the strength of monetary incentives, $\beta$. In particular, the high type’s effort is discontinuous at $\hat{\beta} = \frac{\theta_l - \theta_h}{m_{0h} - m_{0l}}$. The surplus of the low type is increasing in $\beta$, but the high type’s surplus may be decreasing in $\beta$.

More specifically, the equilibrium effort levels are:

• When $\alpha \cdot \theta_h - (1 - \alpha) \cdot \theta_l < \frac{(\delta_h - \delta_l)^2}{4}$ and $\delta_h > \delta_l$, then $e_h = \frac{\delta_h}{2}$ and $e_l = 0$.

• When $\alpha \cdot \theta_h - (1 - \alpha) \cdot \theta_l > \frac{(\delta_h - \delta_l)^2}{4}$ and $\delta_h > \delta_l$, then $e_h = \frac{\delta_h}{2} + \sqrt{\alpha \cdot \theta_h + (1 - \alpha) \cdot \theta_l}$ and $e_l = \frac{\delta_h}{2}$.

• When $(1 - \alpha) \cdot \theta_h > \alpha \cdot \theta_l$, $(1 - \alpha) \cdot \theta_h - \alpha \cdot \theta_l < \frac{(\delta_h - \delta_l)^2}{4}$ and $\delta_h < \delta_l$, then $e_h = \frac{\delta_h}{2}$ and $e_l = 0$.

• When $(1 - \alpha) \cdot \theta_h > \alpha \cdot \theta_l$, $(1 - \alpha) \cdot \theta_h - \alpha \cdot \theta_l > \frac{(\delta_h - \delta_l)^2}{4}$ and $\delta_h < \delta_l$, then $e_h = \frac{\delta_h}{2} - \sqrt{(1 - \alpha) \cdot \theta_h - \alpha \cdot \theta_l}$ and $e_l = \frac{\delta_h}{2}$.

• When $(1 - \alpha) \cdot \theta_h < \alpha \cdot \theta_l$, $-(1 - \alpha) \cdot \theta_h + \alpha \cdot \theta_l < \frac{(\delta_h - \delta_l)^2}{4}$ and $\delta_h < \delta_l$, then $e_h = \frac{\delta_h}{2}$ and $e_l = 0$.

• When $(1 - \alpha) \cdot \theta_h < \alpha \cdot \theta_l$, $-(1 - \alpha) \cdot \theta_h + \alpha \cdot \theta_l > \frac{(\delta_h - \delta_l)^2}{4}$ and $\delta_h < \delta_l$, then $e_h = \frac{\delta_h}{2} + \sqrt{-(1 - \alpha) \cdot \theta_h + \alpha \cdot \theta_l}$.

**Proofs of Lemmas and Propositions**

**Proof of Lemma 1:** The case when only one type enters, is trivial. Here, we focus on the case when both types enter. Rearranging the terms in the consumer utility function, we obtain

\[
\begin{align*}
U_\theta(e) &= \mu \cdot \alpha \cdot E(\theta | e) + \theta \cdot e - e^2 \text{ if } \theta \text{ makes the better content, and} \\
U_\theta(e) &= \mu \cdot (1 - \alpha) \cdot E(\theta | e) + \theta \cdot e - e^2 \text{ otherwise.}
\end{align*}
\]
Denoting $\theta \cdot e - e^2$ as $c_\theta(e)$, the content contribution game is mathematically equivalent to a two type signaling game with heterogeneous signaling cost $c_\theta(e)$.

We make use of an important result from Cho and Kreps (1987), which states that in any two type signaling game, the only Perfect Bayesian Equilibrium that satisfies the D1 criterion is the most efficient separating equilibrium, or the Riley outcome. The Riley outcome is a duple $(e_h, e_l)$ such that

$$U_{\theta_h}(e_h) \geq U_{\theta_l}(e_l), \text{ and } U_{\theta_l}(e_l) \geq U_{\theta_h}(e_h).$$

and $\forall (e_h', e_l')$ satisfying the above condition, $U_{\theta_h}(e_h) + U_{\theta_l}(e_l) > U_{\theta_h}(e_h') + U_{\theta_l}(e_l')$.

The result in Cho and Kreps (1987) essentially states that for a duple $(e_h, e_l)$ that consists a Riley outcome, there always exists a belief function $b$ that is consistent according to the Bayes rule and satisfies the D1 criterion. The triple $(e_h, e_l, b)$ is the unique PBE of the game satisfying the D1 Criterion.

Below, we determine the Riley outcome for two ranges of parameters separately.

- When $\mu \cdot (\alpha \cdot \theta_h - (1 - \alpha) \cdot \theta_l) < \frac{(\theta_h - \theta_l)^2}{4}$, then $\left(e_h = \frac{\theta_h}{2}, e_l = \frac{\theta_l}{2}\right)$ is the Riley outcome. From the condition, we have $U_{\theta_l}(e_l) > U_{\theta_h}(e_h)$ and $U_{\theta_h}(e_h) > U_{\theta_l}(e_l)$. Further, $\frac{\theta_h}{2}$ and $\frac{\theta_l}{2}$ maximize $U_{\theta_h}$ and $U_{\theta_l}$ respectively, therefore they are jointly efficient.

- When $\mu \cdot (\alpha \cdot \theta_h - (1 - \alpha) \cdot \theta_l) > \frac{(\theta_h - \theta_l)^2}{4}$, the efficient effort levels do not satisfy the SS constraint. For $\left(e_h = \frac{\theta_h}{2} + \sqrt{\mu \cdot (\alpha \cdot \theta_h - (1 - \alpha) \cdot \theta_l)}, e_l = \frac{\theta_l}{2}\right)$, we have $U_{\theta_l}(e_l) = U_{\theta_h}(e_h)$ and $U_{\theta_h}(e_h) > U_{\theta_l}(e_l)$. Further, for any $e_h'$ smaller than $e_h$, the SS constraint is not satisfied. For any $e_h'$ greater than $e_h$, the SS constraint is satisfied, but since $U_{\theta_h}(e)$ is a decreasing function for $e > e_h$, we have $U_{\theta_h}(e_h) > U_{\theta_h}(e_h')$. Since $e_l$ maximizes $U_{\theta_l}$, we conclude that for any $(e_h', e_l')$ satisfying the SS constraint, $U_{\theta_h}(e_h) + U_{\theta_l}(e_l) > U_{\theta_h}(e_h') + U_{\theta_l}(e_l')$. 


This concludes the proof of Lemma 1.

PROOF OF LEMMA 2: The participation subgame is a two-by-two matrix game. Each type chooses between Enter and Not Enter. The following attributes of the payoff matrix are sufficient to prove the lemma:

- Both types enter: \( U_{\theta_l}(e_l) = \frac{\theta_l^2}{4} + \mu \cdot (1 - \alpha) \cdot \theta_l - F, \) \( U_{\theta_h}(e_h) > U_{\theta_l}(e_l). \)

- Only the high type enters: \( U_{\theta_l}(e_l) = 0, \) \( U_{\theta_h}(e_h) = \frac{\theta_h^2}{4} + \mu \cdot \theta_h - F. \)

- Only the low type enters: \( U_{\theta_l}(e_l) = \frac{\theta_l^2}{4} + \mu \cdot \theta_l - F, \) \( U_{\theta_h}(e_h) = 0. \)

- Neither type enters: \( U_{\theta_l}(e_l) = 0, \) \( U_{\theta_h}(e_h) = 0. \)

Note that, in the case where both types enter, the high type’s utility is either

\[
U_{\theta_h}(e_h) = \frac{\theta_h^2}{4} + \mu \alpha \theta_h - F, \text{ or }
\]

\[
U_{\theta_h}(e_h) = \theta_h \cdot \left( \frac{\theta_l}{2} + \sqrt{\mu \left( \alpha \theta_h - (1 - \alpha) \theta_l \right)} \right) + \mu \alpha \theta_h - \left( \frac{\theta_l}{2} + \sqrt{\mu \left( \alpha \theta_h - (1 - \alpha) \theta_l \right)} \right)^2 - F.
\]

In either case, the utility the high type derives from participating is higher than that of the low type.

The results in Lemma 2 can be derived by comparing payoffs in the two-by-two matrix. For intermediate levels of \( F, \) there exist two equilibria where only one type enters. Without qualitatively restricting the results, we assume that in such cases, the high type enters.

\[
\square
\]

PROOF OF LEMMA 3: When \( F \) is low and monetary incentives are introduced across-the-board, the utility functions of the two types are as follows:

\[
U_{\theta_h}(e_h) = \left( \theta_h + \beta \cdot m_h \right) \cdot e_h + \alpha \cdot E(\theta|e_h) - e_h^2, \text{ and }
\]

\[
U_{\theta_l}(e_l) = \left( \theta_l + \beta \cdot m_l \right) \cdot e_l + (1 - \alpha) \cdot E(\theta|e_l) - e_l^2.
\]
As in Proposition 1, when both types enter, the subgame corresponds to a signaling game with two types. Define $\delta_h = \theta_h + \beta \cdot m_h$ and $\delta_l = \theta_l + \beta \cdot m_l$. When $\delta_h \neq \delta_l$, the most efficient separating equilibrium is the unique PBE that satisfies the D1 criterion. The process for finding the equilibrium is exactly identical to the method presented in the proof of Lemma 1. The conceptual complication is that when $\delta_h < \delta_l$, the low type makes higher effort and gets more viewer attention. Although type $\theta_h$ derives greater marginal utility from self-expression, it might mimic the low type when the low type gets more viewer attention. Formally, $(1 - \alpha) \cdot \theta_h < \alpha \cdot \theta_l$, although $\theta_h > \theta_l$.

The above cases correspond to three qualitatively different situations: when $\delta_h > \delta_l$, the game is qualitatively similar to the case without monetary incentives. Type $\theta_h$ chooses a higher level of effort. When $\delta_h < \delta_l$ and $(1 - \alpha) \cdot \theta_h > \alpha \cdot \theta_l$, the high type chooses a lower level of effort but gains higher utility from social signaling. In fact, it might intentionally lower effort to signal its type. Finally, when $\delta_h < \delta_l$ and $(1 - \alpha) \cdot \theta_h < \alpha \cdot \theta_l$, type $\theta_h$ chooses a lower effort, gets less attention as well as lower utility from social signaling. In each case, the equilibrium effort levels are the efficient effort levels if these levels satisfy the SS constraints. Otherwise, the equilibrium efforts are at the levels at which one SS constraint is binding.

Given the equilibrium effort levels, we can derive the surplus of each type and the average quality level accordingly.

When $m_h > m_l$, we have $\delta_h > \delta_l$ for any $\beta$. Therefore, increasing $\beta$ does not qualitatively change the expression for average quality. When $m_h < m_l$, we have $\delta_h > \delta_l$ for small $\beta$ and $\delta_h < \delta_l$ for intermediate levels of $\beta$. The average quality is discontinuous at $\delta_h = \delta_l$.

PROOF OF PROPOSITION 1: Proposition 1 describes the optimization problem of the website, where $\alpha$ is the decision variable, and the average quality of contents is the objective function. We prove Proposition 1 in two steps. First, we explicitly find the expression for the website’s objective function, which turns out to be a piece-wise function depending on the level of $\alpha$. Second, we discuss the optimal solutions. Observe that, in any separating equilibrium, the low type’s utility
is decreasing in \( \alpha \) while the high type’s utility is increasing in \( \alpha \) (Lemma 2). Further, when both types enter, the high type’s effort is increasing in \( \alpha \). (Lemma 1). The firm’s objective function is:

\[
\Pi(\alpha) = \begin{cases} 
\frac{\alpha}{\theta} + (1 - \alpha) \frac{\beta}{\mu} & \text{if } \mu (\alpha \theta_0 - (1 - \alpha) \beta_0) < (\theta_0 - \beta_0) \text{ and } F < \frac{\theta_0}{\mu} + \mu (1 - \alpha) \theta_t \\
\alpha \left( \frac{\beta}{\mu} + \sqrt{\mu (\alpha \theta_0 - (1 - \alpha) \beta_0)} \right) + (1 - \alpha) \frac{\beta}{\mu} & \text{if } \mu (\alpha \theta_0 - (1 - \alpha) \beta_0) > (\theta_0 - \beta_0) \text{ and } F < \frac{\theta_0}{\mu} + \mu (1 - \alpha) \theta_t \\
\frac{\theta_0}{\mu} & \text{if } F > \frac{\theta_0}{\mu} + \mu (1 - \alpha) \theta_t
\end{cases}
\]

From the above, it follows that the objective function is increasing in \( \alpha \) when \( F < \frac{\theta_0}{\mu} + \mu (1 - \alpha) \theta_t \). When \( \alpha \) increases such that \( F > \frac{\theta_0}{\mu} + \mu (1 - \alpha) \theta_t \), the average quality of contents may decrease due to exit of the low types (and the lack of need for signaling). Therefore, there are two candidates for the global optimum:

- \( \alpha^* = 1 \)
- \( \alpha^* = 1 - \frac{4F - \theta_0^2}{4\mu \theta_t} \)

When \( F \) is small, \( F > \frac{\theta_0}{\mu} + (1 - \alpha) \mu \theta_t \) is never satisfied. Therefore, the global optimum is at \( \alpha^* = 1 \). When \( \frac{\theta_0}{\mu} + \frac{\mu \theta_t}{2} > F > \frac{\theta_0}{\mu} \), the low type does not enter for high values of \( \alpha \). For such cases, determining the global optimum involves checking the condition

\[
\left( 1 - \frac{4F - \theta_0^2}{4\mu \theta_t} \right) \cdot \sqrt{\mu \left[ \frac{\theta_0}{\mu} - \frac{4F - \theta_0^2}{4\mu \theta_t} \cdot (\theta_0 - \theta_t) \right]} > \frac{\theta_0 - \theta_t}{2}.
\]

When this condition is satisfied, \( \alpha^* = 1 - \frac{4F - \theta_0^2}{4\mu \theta_t} \). Otherwise, \( \alpha^* = 1 \). Working through the algebra, it can be verified that the condition is satisfied exactly when self-expression is not important and type heterogeneity is large. \( \square \)

**Proof of Proposition 2:** Proposition 2 states the optimal \( \beta^* \) is a decreasing function of \( c \). We illustrate the proof with the more difficult case \( m_{\theta_h} < m_{\theta_t} \). We prove this by contradiction. Suppose that \( \exists c_1, c_2, c_1 > c_2, \beta^*(c_1) > \beta^*(c_2) \). Observe that the profit function can be written as \( \Pi(\beta, c) = E(\beta) - c \cdot C(\beta) \), where \( E \) is the effort function and \( c \cdot C(\beta) \) is the cost function. We find contradictions by discussing three cases:
• **Case 1:** $\beta^*(c_2) < \beta^*(c_1) \leq \hat{\beta}$. Thus, $E(\beta^*(c_1)) - c_1 \cdot C(\beta^*(c_1)) > E(\beta^*(c_2)) - c_1 \cdot C(\beta^*(c_2))$ and $E(\beta^*(c_2)) - c_2 \cdot C(\beta^*(c_2)) > E(\beta^*(c_1)) - c_2 \cdot C(\beta^*(c_1))$. Summing the inequalities, we obtain $-c_1 \cdot C(\beta^*(c_1)) - c_2 \cdot C(\beta^*(c_2)) > -c_1 \cdot C(\beta^*(c_2)) - c_2 \cdot C(\beta^*(c_1))$, which leads to $c_1 \cdot (C(\beta^*(c_1)) - C(\beta^*(c_2))) < c_2 \cdot (C(\beta^*(c_1)) - C(\beta^*(c_2)))$. From Lemma 3, $C(\beta)$ is increasing on $[0, \hat{\beta}]$. Therefore, $C(\beta^*(c_1)) - C(\beta^*(c_2)) > 0$ and $c_1 < c_2$. A contradiction.

• **Case 2:** $\hat{\beta} < \beta^*(c_2) < \beta^*(c_1)$. Since $C(\beta)$ is increasing on $(\hat{\beta}, \infty)$, the proofs follows the exact same procedure as in Case 1.

• **Case 3:** $\beta^*(c_2) \leq \hat{\beta}$ and $\hat{\beta} < \beta^*(c_1)$. We make a first observation: when $\beta' > \hat{\beta}$ and $\beta'' \leq \hat{\beta}$ and $E(\beta') = E(\beta'')$, we have $C(\beta') > C(\beta'')$. This result follows directly from the expressions derived in Lemma 3. Put differently, to achieve the same level of average effort, the cost is higher under the crowding out scenario.

Based on the first observation, we obtain a second observation: $C(\beta^*(c_1)) > C(\beta^*(c_2))$. We prove this by contraposition. Suppose $C(\beta^*(c_1)) < C(\beta^*(c_2))$. Then we have $E(\beta^*(c_1)) < E(\beta^*(c_2))$, otherwise $\beta^*(c_1)$ implies both lower cost and higher effort, and $\beta^*(c_2)$ is dominated. Since $E(0) < E(\beta^*(c_1)) < E(\beta^*(c_2))$ and $E(\beta)$ is a continuous function on $[0, \hat{\beta}]$, there always exist $0 < \beta' < \beta^*(c_2)$ such that $E(\beta') = E(\beta^*(c_1))$. We have $C(\beta') < C(\beta^*(c_1))$ from the first observation. Therefore $\beta'$ dominates $\beta^*(c_1)$. This contradicts the assumption that $\beta^*(c_1)$ is optimal under $c_1$.

We carry out the main proof based on the second observation. As in Case 1 and 2, we obtain $c_1 \cdot (C(\beta^*(c_1)) - C(\beta^*(c_2))) < c_2 \cdot (C(\beta^*(c_1)) - C(\beta^*(c_2)))$. Since $C(\beta)$ is increasing on $[0, \hat{\beta}]$, $C(\beta^*(c_2)) < C(\hat{\beta})$. Applying $C(\beta^*(c_1)) > C(\hat{\beta})$. Again we have $C(\beta^*(c_1)) - C(\beta^*(c_2)) > 0$ and $c_1 < c_2$. A contradiction.

---

11We omit the algebra here. For an intuitive argument, observe that the lower effort level is higher under the crowding out scenario (where type H makes lower effort) compared to the non-crowding out scenario (where type L makes lower effort). Since the lower effort is discounted in the average effort $(ae_h + (1 - \alpha)e_l)$ but not in cost $(e_h + e_l)$, the cost is higher under the crowding out scenario to achieve the same level of average effort.
To complete the proof for Proposition 2, we need to show that not only is the optimal solution decreasing in \( c \), but the optimal solution exists in each range of \( \beta \). This can be seen by constructing numerical examples. Figure 4 shown in the text serves as such an example.

\[ \square \]

**Proof of Proposition 3:**

Given that crowding-out does not take place in either case, we have that type \( \theta_h \) is the winner in both the across-the-board and the top-only case. In order to derive the exact expressions for \( \Pi_{ab}(\beta) \) and \( \Pi_{to}(\beta) \), we need to first determine whether the high type needs to incur extra effort for separation or not. We find that the high type is more likely to incur extra effort under the top-only regime.

In the across-the-board case, the high type does not need extra effort when \( \alpha \cdot \theta_h - (1 - \alpha) \cdot \theta_l < (\delta_h - \delta_l)^2 / 4 \). In the top-only case, the condition for “no extra effort” is \( \alpha \cdot \theta_h - (1 - \alpha) \cdot \theta_l < (\delta_h - \theta_l)^2 / 4 - \delta_h \cdot \beta \cdot \theta_l / 2 \). It is easy to see that the first condition is always satisfied when the second condition is satisfied. Thus, we may have one of three possible cases depending on the magnitude of \( \beta \):

- Under both regimes, the high type has to incur extra effort to separate.
- Only under the top-only regime, the high type has to incur extra effort to separate.
- The high type does not have to incur extra effort to separate under either regime.

We prove the above three cases one by one. For notational convenience, let \( X = \alpha \cdot \theta_h - (1 - \alpha) \cdot \theta_l \). When the high type has to incur extra effort in both regimes, then the effort levels under the across-the-board scheme are: \( e_h = \delta_l / 2 + \sqrt{X} \) and \( e_l = \delta_l / 2 \). At the same time, under the top-only regime, the effort levels are: \( e_h = \frac{\delta_l}{2} + \frac{\sqrt{\delta_l^2 - \theta_l^2 + 4X}}{2} \) and \( e_l = \frac{\theta_l}{2} \). Thus, the firm’s objective function is

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\[ \Pi_{atb}(\alpha, \beta) = \frac{\delta_{h}}{2} + \alpha \cdot \sqrt{X - c \cdot \beta} \cdot \left[ \frac{\delta_{l}}{2} + \sqrt{X} \right] - c \cdot \beta \cdot \frac{\delta_{l}}{2}, \text{ and} \]

\[ \Pi_{to}(\alpha, \beta) = \frac{\theta_{l}}{2} + \alpha \cdot \left[ \frac{m_{\theta_{l}} \cdot \beta}{2} + \sqrt{\frac{\theta_{l}^{2} - \theta_{l}^{2} + 4X}{2}} \right] - c \cdot \beta \cdot \left[ \frac{\delta_{l}}{2} + \sqrt{\frac{\delta_{l}^{2} - \theta_{l}^{2} + 4X}{2}} \right]. \]

Then

\[
D = \Pi_{to}(\alpha, \beta) - \Pi_{atb}(\alpha, \beta) \\
= \left\{ (\alpha - c \cdot \beta) \cdot \frac{\sqrt{\delta_{l}^{2} - \theta_{l}^{2} + 4X}}{2} \right\} - \left\{ (1 - \alpha) \cdot \frac{m_{\theta_{l}} \cdot \beta}{2} + (\alpha - c \cdot \beta) \cdot \sqrt{X - c \cdot \beta} \cdot \frac{\delta_{l}}{2} \right\} \\
= \left\{ (\alpha - c \cdot \beta) \cdot \frac{\sqrt{\delta_{l}^{2} - \theta_{l}^{2} + 4X - 4X}}{2} \right\} + \left\{ c \cdot \beta \cdot \frac{\delta_{l}}{2} - (1 - \alpha) \cdot \frac{m_{\theta_{l}} \cdot \beta}{2} \right\} \\
> \left\{ (\alpha - c \cdot \beta) \cdot \frac{\sqrt{\delta_{l}^{2} - \theta_{l}^{2} + 4X - 4X}}{2} \right\} + \frac{(1 - \alpha) \cdot \beta \cdot m_{\theta_{l}}}{2} \cdot \left( \frac{\delta_{l}}{\theta_{l}} - 1 \right) \\
> 0,
\]

where the first inequality holds because of our assumption on \( \alpha \) implies that \( c > (1 - \alpha) \cdot m_{\theta_{l}}/\theta_{l} \). The second inequality holds for \( \Pi_{atb}(\alpha, \beta) > 0, \) if \( \beta > \alpha/c, \) then \( \Pi_{atb}(\alpha, \beta) < 0. \) This is enough to conclude the claim of the proposition for this case.

When the high type only needs extra effort under the top-only regime, the effort levels are \( e_{h} = \delta_{h}/2 \) and \( e_{l} = \delta_{l}/2 \) in the across-the-board case, and \( e_{h} = \frac{\delta_{h}}{2} + \frac{\sqrt{\delta_{l}^{2} - \theta_{l}^{2} + 4X}}{2} \) and \( e_{l} = \frac{\theta_{l}}{2} \) in the top-only case. These give

\[ \Pi_{atb}(\alpha, \beta) = \alpha \cdot \frac{\delta_{h}}{2} + (1 - \alpha) \cdot \frac{\delta_{l}}{2} - c \cdot \beta \cdot \frac{\delta_{h}}{2} - c \cdot \beta \cdot \frac{\delta_{l}}{2}, \]

and
\[
\Pi_{to}(\alpha, \beta) = \frac{\theta}{2} + \alpha \cdot \left[ \frac{m_{\theta} \cdot \beta}{2} + \frac{\sqrt{\delta_l^2 - \theta_l^2 + 4X}}{2} \right] - c \cdot \beta \cdot \left[ \frac{\delta_l}{2} + \frac{\sqrt{\delta_l^2 - \theta_l^2 + 4X}}{2} \right].
\]

Thus,
\[
D = \Pi_{to}(\alpha, \beta) - \Pi_{atb}(\alpha, \beta)
= (\alpha - \beta \cdot c) \cdot \left( \frac{\delta_l}{2} + \frac{\sqrt{\delta_l^2 - \theta_l^2 + 4X} - \delta_h}{2} \right) + (1 - \alpha) \cdot \left( \frac{\theta_l - \delta_l}{2} + \beta \cdot c \cdot \frac{\delta_l}{2} \right).
\]

Since the high type incurs extra effort to separate, we have \( \frac{\delta_l + \sqrt{\delta_l^2 - \theta_l^2 + 4X} - \delta_h}{2} > 0 \). Further (as shown above), when \( \Pi_{atb}(\alpha, \beta) > 0 \), we have \( \beta < \alpha / c \).

Therefore,
\[
D = \Pi_{to}(\alpha, \beta) - \Pi_{atb}(\alpha, \beta)
= (\alpha - \beta \cdot c) \cdot \left( \frac{\delta_l}{2} + \frac{\sqrt{\delta_l^2 - \theta_l^2 + 4X} - \delta_h}{2} \right) - (1 - \alpha) \cdot \left( \frac{\theta_l - \delta_l}{2} + \beta \cdot c \cdot \frac{\delta_l}{2} \right)
> (\alpha - \beta \cdot c) \cdot \left( \frac{\delta_l}{2} + \frac{\sqrt{\delta_l^2 - \theta_l^2 + 4X} - \delta_h}{2} \right) + (1 - \alpha) \cdot \left( \frac{\theta_l - \delta_l}{2} + \beta \cdot c \cdot \frac{\delta_l}{2} \cdot \frac{\delta_l}{\theta_l} \right)
= (\alpha - \beta \cdot c) \cdot \left( \frac{\delta_l}{2} + \frac{\sqrt{\delta_l^2 - \theta_l^2 + 4X} - \delta_h}{2} \right) + (1 - \alpha) \cdot \left( \frac{\theta_l - \delta_l}{2} + \beta \cdot c \cdot \frac{\delta_l}{\theta_l} \right)
> 0,
\]

where the first inequality holds by our assumption on \( \alpha \) and \( c \). This concludes the proof of the claim for the second case.

When the high type does not need extra effort under either regime, the efficient effort levels under the across-the-board scenario are \( e_h = \delta_h / 2 \) and \( e_l = \delta_l / 2 \). At the same time, under the top-only scenario, the effort levels are \( e_h = \delta_h / 2 \) and \( e_l = \theta_l / 2 \). Thus,
\[ \Pi_{atb}(\alpha, \beta) = \alpha \cdot \frac{\delta_h}{2} + (1 - \alpha) \cdot \frac{\delta_l}{2} - c \cdot \beta \cdot \frac{\delta_h}{2} - c \cdot \beta \cdot \frac{\delta_l}{2}, \]

and

\[ \Pi_{to}(\alpha, \beta) = \alpha \cdot \frac{\delta_h}{2} + (1 - \alpha) \cdot \frac{\theta_l}{2} - c \cdot \beta \cdot \frac{\delta_h}{2}. \]

Therefore,

\[ D = \Pi_{to}(\alpha, \beta) - \Pi_{atb}(\alpha, \beta) = c \cdot \beta \cdot \frac{\delta_l}{2} - (1 - \alpha) \cdot \beta \cdot \frac{m_{\theta_l}}{2} > \frac{(1 - \alpha) \cdot \beta \cdot m_{\theta_l}}{2} \cdot \left[ \frac{\delta_l}{\theta_l} - 1 \right] > 0, \]

where the first inequality holds by our assumption on \( \alpha \) and \( c \). This concludes the proof of Proposition 3.

\[ \square \]

**Proof of Proposition 4:**

Following the assumption that crowding-out does not take place, we can apply the same technique we use in the proof of Proposition 1. The important insight is that the firm chooses \( \alpha^* < 1 \) only when the low type is deterred from participation for \( \alpha = 1 \). Our assumption guarantees whereby the high type emerges as winner, we know that the equilibrium surplus of the low type is the same under the *top-only* payment regime as it is for \( \beta = 0 \). This immediately gives our result concerning the cases when the entry decision of the low type is independent from the content promotion decision.

For an intermediate fixed cost of entry, \( \frac{\theta_l^2}{4} < F < \frac{\theta_l^2}{4} + \frac{\theta_h}{2} \), we construct examples for switching the content promotion strategy in either direction. To do so, we rely on the continuity of \( \Pi(\alpha, \beta) \) (the firm’s objective function) in \( \alpha \), and the concavity of \( \Pi(\alpha, \beta) \) in \( \beta \in [0, \hat{\beta}) \). We take the optimal content promotion fraction which already allows the low type to participate to be \( \alpha \approx 1 \) and look at the marginal returns to increasing \( \beta \) with respect to the gains to using the best
take all vs. balanced allocation strategies at $\beta = 0$. (For larger fractions of viewer attention directed to lower-quality contents, similar but slightly more involved calculations yield the sufficient conditions.) Below, we analyze two cases separately.

First, assume that under $\beta = 0$, the firm prefers the best take all strategy. Then we have $\theta_h - \theta_l - 2\sqrt{\theta_h} > 0$. When $\beta > 0$, then under the best take all strategy, the objective function of the firm is

$$\Pi_{\text{best-take-all}}(\alpha = 1, \beta) = (1 - c \cdot \beta) \cdot \frac{\delta_h}{2},$$

while under the balanced allocation strategy,

$$\Pi_{\text{balanced}}(\alpha \approx 1, \beta) \approx (1 - c \cdot \beta) \cdot \frac{\delta_l + \sqrt{\delta_l^2 - \theta_l^2 + 4\theta_h}}{2}.$$

Let $D = \Pi_{\text{balanced}}(\alpha \approx 1, \beta) - \Pi_{\text{best-take-all}}(\alpha = 1, \beta)$. Then

$$D \approx (1 - c \cdot \beta) \cdot \frac{\delta_l + \sqrt{\delta_l^2 - \theta_l^2 + 4\theta_h - \delta_h}}{2},$$

and so

$$\frac{\partial D}{\partial \beta} \bigg|_{\beta = 0} \approx -m_{\theta_h} + m_{\theta_l} + \frac{m_{\theta_h} \cdot \theta_l}{2\sqrt{\theta_h}} + c \cdot \left[ \theta_h - \theta_l - 2\sqrt{\theta_h} \right].$$

Thus, when

$$m_{\theta_h} > m_{\theta_l} + \frac{m_{\theta_h} \cdot \theta_l}{2\sqrt{\theta_h}} + c \cdot \left[ \theta_h - \theta_l - 2\sqrt{\theta_h} \right],$$

then there is a nonempty range of the entry cost $F$ for which the firm wants to switch to a balanced allocation from the best take all strategy upon introducing monetary incentives.

To analyze the other case, let us now assume that under $\beta = 0$, the firm prefers the balanced allocation strategy, implying $\theta_h - \theta_l - 2\sqrt{\theta_h} < 0$. Analyzing the relative benefits of switching to the best take all strategy under $\beta > 0$, we arrive to the same expressions. Thus, for $\alpha^* \approx 1$, the
firm prefers to induce crowding-out when

\[ m_{\theta_h} < m_{\theta_l} + \frac{m_{\theta_h} \cdot \theta_l}{2\sqrt{\theta_h}} + c \cdot \left[ \theta_h - \theta_l - 2\sqrt{\theta_h} \right], \]

for which it is again easy to construct a combination of \( \theta_h, \theta_l, m_{\theta_h}, m_{\theta_l}, \alpha, F \) parameters. This concludes the proof. \( \Box \)