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Business models for streaming platforms: content acquisition, advertising and users*

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Abstract

A streaming platform obtains contents from artists and offers commercial spaces to advertisers. Users value contents' variety and quality of the service and are heterogeneously bothered by ads. Two solutions can be proposed to users. If they pay a positive price, they subscribe to a commercial-free service with an upgrade of quality (*Premium*). Otherwise, they have free access to a service of a basic quality. We find that a wider audience gives incentives to the platform to increase both the advertising intensity and the quality upgrade in the *Premium*. As a consequence, some people

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move to the *Premium*. At the limit, the platform opts for a purely subscription-based business model as the audience reaches a certain level. The parsimonious model we propose is able to give a rationale to the emergence of different business models in the streaming market as well as to the (end of the) disputes between artists and the Spotify model.

JEL codes: L21, L82, M37

Keywords: Media, Advertising, Multi-Sided Markets, Platform, Second-degree price discrimination.

1 Introduction

The online world offers many business opportunities to companies that run platforms turning web-users into subscribers. In particular, online media markets have boomed dramatically, with many big players currently competing (e.g., Google, Amazon, Spotify, Apple, YouTube, Netflix). These players behave in different ways *vis-à-vis* each side of the market, with the consequence of a rich variety of business models. On the user side, Google and Apple Music opt for the offer of a paying subscription, YouTube follows an ad-based business model whereas Spotify presents a mixed model with users self-selecting into their preferred subscription (second-degree price discrimination).

Media platforms are characterized by the interaction of different groups of agents exhibiting cross-group externalities. Namely, a user enjoys more (less) a platform's service when the variety of contents (number of commercials) increases and, in turn, a content provider and an advertiser have stronger incentives to join a platform in which they can meet a wider audience. In terms of business strategy, this brings us to what Caillaud and Jullien (2003) defined as a chicken–and–egg problem: the company needs to find the most profitable way to attract a critical mass in each group. In the music streaming market, Eller (2015) reports that both Spotify and Apple Music offer at least a 30 million–song library. This makes them very attractive to users and, in turn, selling an artistic production to a platform "offering" a broad set of users is valuable to providers, who want their contents to reach the widest possible audience. Moreover, the value of subscribing the platform service for a user depends not only on the variety of contents but also on other features offered by the platform. The latter represent the quality of the platform service, brought by recommendation systems; creation, access off-line and sharing of playlists; synchronization on several devices; quality of page layout/video/sound.

On top of that, real streaming markets show different subscribing solutions, which prove to be different ways to account for these cross–group interactions. For instance, consider the cases of Spotify, Youtube and Deezer. Their free-of-charge solution, the so–called basic subscription, entails frequent commercial interruptions after a few songs. Somehow, users are compensated for the nuisance of ads with free access to music. Contextually, users are given the opportunity to upgrade to a paying solution with quality improvements and absence of commercial interruptions. This business model is commonly called *Freemium*.

Differently, in the purely subscription-based business model of Apple and Google Music, users pay a price and they are allowed to access the contents' catalogue available on the platform. The absence of commercials is usually associated with quality improvements similar to the ones proposed by the upgraded version of Spotify.[1] Hereafter, we will refer to this business model as *Premium*.

These platforms have been perceived with suspicion by artists, especially when the offer of contents is completely free-of-charge.[2] Indeed, artists may look at the streaming market as a threat to the sale of their artistic productions through alternative channels. Recent empirical articles such as Aguiar and Waldfogel (2018), Wlömert and Papies (2016), and Hiller (2016) show that streaming and purchasing tend to be substitutes. Differently, Aguiar (2017) and Aguiar and Martens (2016) give evidence of complementarity due to an effect described by Belleflamme (2016) as "discovery," that is, streaming is used by subscribers to discover high–value music and match value, leading to an ultimate increase in music

[1]These platforms have the precise intention to operate in the "premium" market only. For instance, in The Huffington Post, Kaufman (2016) mentions the following claim posted on Facebook by Hastings (Netflix CEO): "No advertising coming onto Netflix. Period. Just adding relevant cool trailers for other Netflix content you are likely to love."

[2]Among other artists, titles from Taylor Swift and the Beatles were unavailable for a long time on some or all streaming platforms, and the group Radiohead had long-standing disputes with Spotify concerning its business model. See Knopper (2015), Hassan (2016), Linshi (2014), and Forde (2015) for articles discussing these issues in online newspapers and magazines specialized in the digital-music industry.

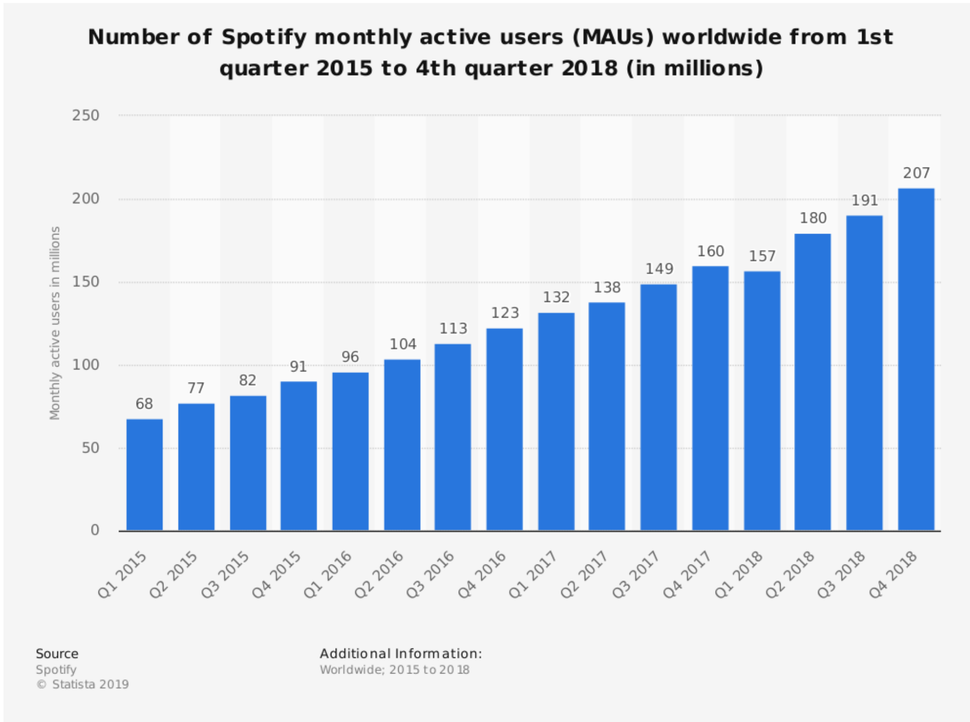


Figure 1: Spotify active users.

consumption.[3] Our model assumes artists to have heterogeneous outside options, and so accounts for the "cannibalization effect" and the fact that this effect may be different among artists.

This paper aims at giving a rationale to the following stylized facts related to streaming market. First, the disputes against the Spotify model have been resolved in the last few years, leading important artists to join the platform (e.g., Radiohead and Taylor Swift). Second, both the number of active users and the share of *Premium* users boomed dramatically in the same period, as documented in Figure 1 and 2. These two aspects are linked with each other and highlight the pivotal role of Spotify's market share. Indeed, the increase in the number of active users (200% in the period 2015-2018) has been associated with the joining decisions of important artists as well as with a boost of the share of users upgrading to the *Premium* subscription (more than 400% increase in the same period).

[3]For a test of discovery, see Datta et al. (2018).

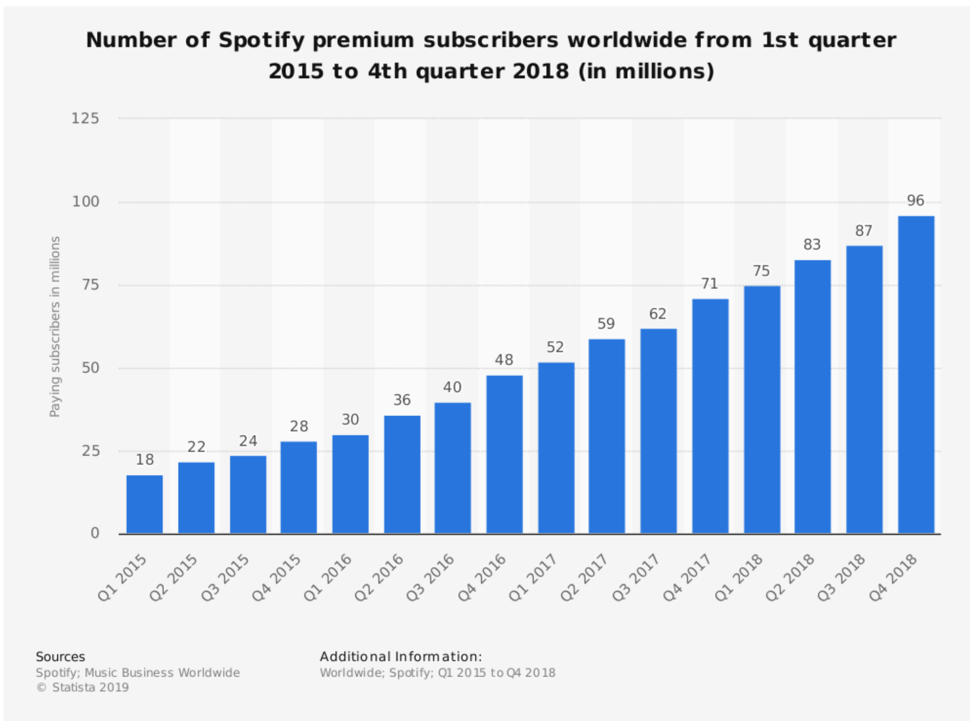


Figure 2: Spotify *Premium* subscriptions.

In the present paper, we provide a parsimonious model in which a monopolistic platform allows the interaction between users, advertisers and content providers. Users are assumed to receive utility from the variety of contents they can stream by subscribing to the platform's service and are heterogeneous according to their aversion towards advertisement. The platform decides on four dimensions. First, it pays per–user royalties to content providers, which are heterogenous with respect to their outside option. Second, it sets the advertising intensity. Moreover, it sets the subscription price for *Premium* users. Finally, it decides the quality upgrade offered in the *Premium* segment. Our results depend on an exogenous parameter which represents the share of people the platform is able to reach, i.e., its audience.

This share is key in two dimensions. On the one hand, a larger audience results in a lower royalty necessary to bring contents on board. As a consequence, a larger share of consumers results in a larger proportion of contents present in the platform at equilibrium. On the other hand, if the platform reaches a wide audience, offering only the paying subscription is always dominating. This is because a wider audience gives incentives to the platform to increase both the quality upgrade of the *Premium* (so to increase subscription price) and the advertising intensity (so to increase unitary profits from advertising). As a consequence, some people move to the *Premium* subscription. As a sufficient share of consumers can be reached by the platform, this mechanism leads to a situation in which it is optimal to opt for a purely subscription-based model, eliminating advertising and the free subscription.

In conclusion, the present paper explains the relationship between audience, content providers and business models in the streaming markets. All in all, our model predicts that a platform with a wide audience will only offer a *Premium* subscription, whereas a platform having access to a narrower share of consumers will offer a menu of subscriptions. This is in line with what happens in online markets, where a widening of the audience is usually accompanied to a gradual passage from an advertising-based to a subscription-based business model. Moreover, in our model, content providers would prefer a purely subscription-based system, which explains artists' reluctance to participate in the *Spotify model*. Our baseline model builds on the assumptions that the platform cannot set a positive price in the basic segment and on the impossibility to discriminate royalties among content providers. Relaxing these assumptions, we show that the positive relationship between the emergence of a *Premium* model and the size of the audience is confirmed, even though the parameter regions compatible with each scenario may obviously change. Importantly, we also show that whenever a menu of subscriptions is the best solution for a platform, the price of the basic subscription is optimally set to zero.

The rest of the article is organized as follows. The next section presents the related literature. Thereafter, the baseline model is introduced in Section 3 and Section 4 presents the analysis. Finally, Section 5 provides a discussion and Section 6 extends the baseline model before drawing the conclusions in Section 7.

2 Related Literature

In the digital world, the complexity of interactions among different groups of agents (through the mediation of platforms) led to the emergence of different successful business models. In order to give a rationale to these models, it is necessary to develop industry-specific setups. In this sense, the streaming-media market is characterized by users interested in quality of the platform's service and contents variety and advertisers who seek to sell their products. The media industry is one of the archetypal cases of two-sided markets, started by Rochet and Tirole (2003), Armstrong (2006), and Caillaud and Jullien (2003).

The business model (advertising-, subscription-based or mixed) of media platforms has been studied by many scholars both in economics and marketing. In particular, Ferrando et al. (2008), Godes et al. (2009), Kind et al. (2009), and Reisinger (2012) studied advertising and pricing in media markets. These studies do not consider price discrimination in the users' side, which is common practice leading to the emergence of a mixed (advertising and subscription) business model. Peitz and Valletti (2008) highlight the differences between free–to–air and paying media, whereas Calvano and Polo (2019) show how "pay" and "free–to–air" coexist in broadcasting markets, with two ex–ante identical platforms optimally opting for different business models. In our model, the emergence of paying and advertising segments is driven by content acquisition and quality upgrades of the platform service.

Content provision is analyzed by Weeds (2016) and Carroni et al. (2019). The former proposes models suitable to TV competition, where contents are often self-produced by a vertically differentiated platform competing downstream with a rival not owning the same content. The latter study acquisition of contents produced by an external provider. In our model external contents are acquired (through the payment of a royalty) because they create a positive externality to variety-loving users.

We identify preferences for quality and content variety as the main drivers in the choice of subscribers. Hagiu (2009) shows that the demand for "product variety is a key factor determining the optimal platform pricing structures". In our model, the preference for variety induces the platform to costly acquire as many contents as possible. On top of that, quality improvements (i.e., creation, access off-line and sharing of playlists, recommendation systems, synchronization on several devices, quality of page layout/video/sound, offer of HD videos) are important features that allow for versioning and give scope for the implementation of menu-pricing strategies (second-degree price discrimination).

Recent papers have studied within-side price discrimination in two-sided markets. Liu and Serfes (2013) study within-side perfect price discrimination of horizontally differentiated platforms showing how it can be detrimental for the two sides of the market. In a model related to media, Carroni (2018) shows that discriminating prices between old and new subscribers affects the multi-homing decisions of advertising firms. Differently from these two papers, our work considers second-degree price discrimination on the users' side, which is analyzed also by Jeon et al. (2019) and Lin (2020). In a general setup, Jeon et al. (2019) study within-side second-degree price discrimination, showing how discriminating on one side may help to solve possible tensions between incentive compatible contracts and optimal allocations on the other side of the market.

More closely related to our work are Thomes (2013) and Lin (2020). The first makes an economic analysis of streaming markets, studying the problem of a monopolistic platform offering a menu of qualities associated to different prices and advertising intensities. Consumers self select depending on their appreciation of quality. Differently, we consider consumers heterogeneously disturbed by advertising and variety lovers, endogenize the quality choice in the two segments and explicitly consider content acquisition. This allows us to take into consideration cross-side network effects and the role of the market size in the optimal decisions of the streaming platform. Lin (2020) considers a two-sided market with content versioning in which advertisers are offered a match with users.[4] He shows that the high-valuation consumers could receive more or fewer ads depending on the nuisance cost of advertising. Our paper is somehow complementary to his, as we mainly focus on the impact that the audience reachable by the platform has on the relationship with artists and on the endogenous emergence of a business model (subscription-based only or with versioning). We consider consumers who care about content variety and are heterogeneously bothered by ads and the choice of the basic access to the platform vs. the upgraded premium access depends on how much a user is bothered by advertising.

3 The Model

A monopolistic platform provides contents to a population of users normalized to 1. The latter are interested in the contents' variety and the quality of the service offered by the platform. The platform decides the quality of the service and sets prices to all sides of the market potentially interested in its service. Artists (hereafter content providers) own the copyrights of their contents and are offered a royalty for their artistic creation to be streamed by the platform. Advertisers pay a fee in order to show their commercials to users. Users either pay a subscription price or have free access to the platform's catalogue. In the free case, hereafter called *Basic*, consumers receive a service of basic quality q_b in exchange of the payment a basic price p_b and their activity into the platform is interrupted by commercials, which cause them a nuisance. In the paying case, they enjoy an upgrade to quality q_p by paying a higher price $p = p_b + \Delta$ and no commercial interruptions. We will refer to this ad-free subscription as *Premium*. To highlight more clearly the objectives of all agents involved in the model, let us present each side of the market separately.

Content Providers. A unitary mass of content providers face a trade–off when making their product available on the platform. On the one hand, they receive a per–user royalty r. On the other hand, content providers suffer a loss for other-than-streaming distribution channels (DVDs or CDs). This loss is more severe for very famous artists and is captured

[4] A similar approach with two-sided matching is followed by Gomes and Pavan (2016).

by an idiosyncratic parameter v. We consider $v \in \{v_L, v_H\}$, with $v_H > v_L > 0$. We assume that the proportion of low types is $\rho \in (0,1)$. Therefore, if one defines s as the share of subscribers, the profit of a content provider with outside option v will be:

$$\pi_{CP} = rs - v. \tag{1}$$

Advertisers. The modeling of the advertisers' side builds on Anderson and Coate (2005) and Peitz and Valletti (2008), who assume that platforms set the advertising intensity and advertisers decide whether to show their commercials to sell their products to users. Products are all sold at a zero marginal cost, without loss of generality. Each producer offers a product of quality α, uniformly distributed on the interval $[0, \bar{\alpha}]$, with $\bar{\alpha} \geq 1$. Each quality–α advertiser is monopolistic in the final–good market so that, once the commercial informs a user on product's characteristics and price, the latter is willing to buy a quality–α good at price α. As a consequence, each firm advertises price α, as lowering the price does not improve the probability of sale. Notice that the upper bound of the distribution is an indirect measure of profitability of the advertisers market as, for given distribution, the average quality (and thus the average profit) is higher. The access to the platform is necessary for each advertiser to inform platform's users about the existence of the product sold. The decision of an advertiser depends on how many subscribers can be met on the platform and on the amount paid to the platform to advertise the product, which is the endogenously determined fee f. Accordingly, when a share of users s_b can be reached by paying a fee f, the profit of a quality–α advertiser will be $\bar{\alpha}s_b - f$. Therefore, all firms with quality at least equal to f/s_b are willing to pay the fee f and, thus, the mass of firms willing to advertise is $D(f, s_b) = 1 - f/\bar{\alpha}s_b$, which is the demand curve for advertising. If the platform supplies a commercial spaces to advertisers, the fee clears the market, so that f is the one the equalizes demand and supply, i.e.,

$$f(a, s_b) = (1 - a)\bar{\alpha}s_b. \tag{2}$$

In what follows, we will refer to the mass of advertisers entering the platform, a, as the ad intensity.

Users. There is a unitary mass of users. A share $\gamma \in (0, 1]$ of them is reachable by the platform. Each user receives utility u from enjoying the contents and is disturbed by the presence of ads. We assume that users are interested in variety because they consume all contents on board. Utility positively depends on the variety of contents and on the quality of the service. We further assume that, if a commercials are displayed, each user suffers a disutility equal to $-\beta a$, where the parameter $\beta \sim U[0, 1]$ is the idiosyncratic distaste for advertisement. Hereafter, we will call βa the nuisance cost of advertisement. Defining n as the (endogenously determined) mass of contents present in the platform, a type–β agent who joins the platform gets utility:

$$u(\beta) = n + \begin{cases} q_p - p & \text{if premium,} \\ q_b - \beta a - p_b & \text{if basic,} \end{cases} \tag{3}$$

whenever $n > 0$ and zero otherwise. Notice that utility is zero if no content if offered. Without loss of generality, we normalize the basic quality to $q_b = 0$ and focus our analysis on the endogenous determination of the upgraded quality q_p, which we call q hereafter for the sake of simplicity.[5] In the baseline analysis of Section 4, we normalize the price p_b to zero in order to get intuitive results when the basic segment is purely ad-financed. In Section 6, we relax this hypothesis and show that the qualitative results of our model are valid also when we allow for $p_b \geq 0$. We show that whenever both the basic-quality segment and the upgraded-quality segment are active, the price is zero. Moreover, positive advertising intensity becomes less likely to be an outcome of the model as an equilibrium with only the *Basic* is not anymore an advertising-based segment. Indeed, since price p_b can be used to fully extract surplus, the *Basic* becomes a subscription offering basic quality at a lower-than-premium price.

The timing of the model is as follows. At stage 0, the platform decides the quality differential between the *Premium* and the basic subscription. At stage 1, the platform attracts contents offering the per-subscriber royalty r. At stage 2, the platform simultaneously sets the *Premium* subscription price p and the advertising intensity a. Given p and a, subscribers

[5] We could also have endogenously determined the basic quality q_b, but since our model has full market coverage, we would have trivially found a basic quality of zero.

choose the type of subscription to opt for and payoffs of all agents are realized.

4 Analysis

This section is devoted to the analysis of the model following a backward-induction reasoning. The first focus is on subscription-price and advertising-fee setting (stage 2, studied in Section 4.1) for given royalty chosen in the previous period. Then, the choice of the optimal royalty (stage 1, studied in Section 2) and the quality choice (stage 0, studied in Section 4) will depend on the anticipation of the future possible subgames.

4.1 Stage 2: Price and advertising intensity

Now, let us assume that the platform sets an upgraded quality q in stage 0 and attracts n contents in stage 1 and now decides how to maximize profits choosing the advertising intensity and the subscription price. The profit takes into account the money raised on *Premium* subscriptions (a share s_p in this case) as well as the advertising revenues. In particular, the profits of the platform are given by:

$$\Pi = \underbrace{s_p(p,a) \cdot p}_{premium} + \underbrace{f(a, s_b) \cdot a}_{advertising\ revenues}, \tag{4}$$

where the fee $f(a, s_b)$ is the one determined in equation (2). At the end of last stage, the decision of the users is on the type of subscription (*Premium* or *Basic*). Comparing the utilities expressed in equation (3), the *Basic* subscription is preferred to the *Premium* one for all agents who have β such that:

$$q + n - p < n - \beta a \Rightarrow \beta < \hat{\beta} \equiv \frac{p-q}{a}, \tag{5}$$

Notice also that users prefer *Premium* subscriptions to no subscription if $p \leq n + q$. In this case, it also holds that all agents with $\beta \in [0, \hat{\beta})$ will subscribe *Basic* and all agents with $\beta \in [\hat{\beta}, 1]$ will subscribe *Premium*. Thus, for a given price p and an advertising intensity a, the demand for subscriptions in the *Premium* and in the basic segment will be, respectively:

$$s_p = \left(1 - \frac{p-q}{a}\right)\gamma \text{ and } s_b = \frac{(p-q)\gamma}{a}. \tag{6}$$

Plugging s_b and s_p into the profit function in equation (4), the maximization problem of the platform becomes:

$$\begin{aligned} \max_{p,a} \Pi = \max_{p,a} \left[p \cdot \left(1 - \tfrac{p-q}{a}\right) + (1-a)\bar{\alpha}(p-q)\right]\gamma \\ \text{s.t. } q \le p \le n + q \\ \text{s.t. } 0 \le a \le \bar{\alpha} \end{aligned} \tag{7}$$

The first element of the objective function represents the profits made on subscriptions, whereas the second one are the advertising revenues. As mentioned earlier, $\bar{\alpha}$ is a rough measure of profitability of the advertising market and, indeed, it results in a higher weight given by the platform to this market segment. The constraint on the price is necessary for having a non–empty set of *Premium* subscriptions. Indeed, when the constraint is violated, the price exceeds the utility given to *Premium* consumers, with the consequence that only basic subscribers join the platform.[6] Moreover, the advertising intensity is bounded to be positive and not too high, otherwise the platform makes profits only on subscriptions. In the second case, if $a = 1$, we fall in a situation in which the advertising intensity is so high that the market–clearing fee becomes zero, so that the platform has no incentives to attract basic subscribers. The solutions to the maximization problem of the platform are summarized in the following Lemma.

Lemma 1. *Let* $\tilde{a}(q, \bar{\alpha}) = \frac{\bar{\alpha}+1+\sqrt{\bar{\alpha}(\bar{\alpha}+12q+2)+1}}{6\bar{\alpha}}$. *Three cases can arise:*

1. *if* $q < \frac{\bar{\alpha}-2}{4}$, *then the platform offers only the* Basic *subscription and sets* $a^* = 1/2$,
2. *if* $q > \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}} \equiv \underline{q}$, *only the* Premium *subscription is offered at price* $p^*(n, q)$,
3. *in all other cases, the platform offers both the* Basic *and the* Premium *subscription. The price is* $\tilde{p}(q, \bar{\alpha})$ *and the advertising intensity is* $\tilde{a}(q, \bar{\alpha})$,

where $p^*(n, q) = n + q$ *and* $\tilde{p}(q, \bar{\alpha}) = \frac{6q+(1-\bar{\alpha})\tilde{a}}{3}$.

[6] Imposing this constraint is optimal for the platform, as we will discuss below, and also guarantees that all agents reachable by the platform, γ, become subscribers in either *Basic* or *Premium*.

Proof. See appendix A.1 for the formal proof. ■

Lemma 1 highlights the optimal strategy in the last stage. Unsurprisingly, the decision of the platform is in fact endogenously determining the business model and it depends on two main factors. The first is the profitability of advertising: as $\bar{\alpha}$ increases, the platform can collect a higher fee for given intensity (see equation (2)) and therefore, when it reaches a certain level, only the *Basic* subscription emerges. In other words, the business model of the platform is purely ad-based. The second is the quality chosen at the beginning of the game which increases the subscription price. This is because the *Premium* segment becomes more attractive to subscribers, so that they are willing to pay a higher price for the upgraded subscription. Moreover, this makes the *Premium* segment more attractive also to the platform. As a result, the platform will increase the advertising intensity and thus the nuisance for *Basic* subscribers, in order to move people to the *Premium* segment. At the limit, this would translate directly into the offer of the *Premium* subscription only when the quality differential reaches a threshold value (point 2 in Lemma 1). This is because all subscribers prefer to have access to the upgraded *Premium* quality.

Differently, the number of contents attracted increases the value of the platform to the subscribers, regardless the subscription chosen. When both subscriptions are offered, subscription price and advertising intensity simply reflect the extent of strategic substitutability between the two segments, which responds to quality differentials only. However, when $q \geq \underline{q}$, the substitution effect is not there, and the subscription price increases with n.

4.2 Stage 1: Royalty

Let us now analyze stage 1. The platform sets the royalty r anticipating its impact on profits. A content provider would make a title available on the platform if r is sufficient to compensate for the cannibalization effect, i.e., $rs - v \geq 0 \Leftrightarrow v < r\gamma$. The platform has the following alternatives. It can either fix a low royalty and attract only low types, or fix a higher royalty and induce also the entry of the famous artists. In the first case, $r_L^* = v_L/\gamma$ is sufficient to induce $n = \alpha$ content providers to join the platform. Differently, to reach the second goal the platform has to set $r_H^* = v_H/\gamma$, so that also high types are attracted.

We can conclude the following:

Lemma 2. *Two cases can arise:*

1. *if* $q < \underline{q}$ *or* $q \geq \underline{q}$ *and* $\gamma \leq \bar{\gamma} \equiv \min\left\{\frac{v_H - \rho v_L}{1-\rho}, 1\right\}$, *the optimal royalty is* $r_L^* = v_L/\gamma$ *and* $n_L^* = \alpha$,

2. *if* $q \geq \underline{q}$ *and* $\gamma > \bar{\gamma}$, *the optimal royalty is* $r_H^* = v_H/\gamma$ *and* $n_H^* = 1$.

Proof. Proof is in Appendix A.2. ■

Lemma 2 states the optimal royalty choice. Recall that the value of n will affect the prices are stated in Lemma 1. Again, the quality differential drives the main results. When it is small ($q < \underline{q}$), the seller has incentives to set a small royalty so to attract only content providers with a low outside option. This result is the direct consequence of the substitution effect discussed after Lemma 1. The only objective for the platform is to minimize the cost of attracting at least low types. In other words, the seller faces a between-segment competition when setting the subscription price, so that a marginal increase of contents cannot translate into a higher subscription price. This induces the seller to set the minimal royalty compatible with providing a sufficient variety.

When $q > \underline{q}$, only the *Premium* subscription is offered and the share of subscribers accessible by the platform turns out to be the most relevant aspect. When the platform can reach few subscribers (low γ), a content provider would require a large unitary royalty. This makes content attraction too costly. As a consequence, only low-v content providers join the platform (Point 1 of Lemma 2). Oppositely, when γ is large enough, the platform gives access to a large audience, with the consequence that a relatively smaller royalty is sufficient to attract also content providers with a large outside option (Point 2 of Lemma 2).

4.3 Stage 0: Quality

At the beginning of the game, the platform sets the optimal quality q in order to maximize the profit minus the royalty expenditures. We consider quadratic costs of quality provision, i.e., $C(q) = \frac{q^2}{2}$.[7] For ease of exposition, let us state two different Lemmas in which we report case by case the optimal quality. In the first one, the optimal quality is equal to zero and it will leads to the offer of a *Basic* subscription only.

Lemma 3. *Let* $\bar{\rho} = \min\{\frac{\bar{\alpha}^4+4\bar{\alpha}^3-10\bar{\alpha}^2-4\bar{\alpha}+1}{32\bar{\alpha}^2}, 1\}$.

If $\bar{\alpha} \in \left[2, 2+\frac{1}{3}\left(2\sqrt{3}-3\right)\right]$ *and* $\rho < \bar{\rho}$, *the optimal equilibrium quantity is set to zero provided that* $\gamma \in \left(\frac{2\bar{\alpha}-1}{2\bar{\alpha}} + \sqrt{\frac{3(\bar{\alpha}-2)}{4\bar{\alpha}}}, \max\{\frac{2\bar{\alpha}-1}{2\bar{\alpha}} + \sqrt{\frac{\bar{\alpha}-2}{\bar{\alpha}}}, 1\}\right)$. *In this case, the platform offers only the* Basic *subscription.*

Proof. In Appendix A.3. ■

Lemma 3 highlights the conditions under which the platform wants to set a quality difference equal to zero between the *Basic* and the *Premium* segment. Putting together this result with the ones of Lemma 1, we note that under this choice only the *Basic* segment will be active, and the platform does not offer the *Premium* segment. It is important to notice that the parameter region in which only the *Basic* subscription is offered is very limited. In particular, the *Basic* segment becomes more and more profitable with respect to the *Premium* segment as long as the advertising market becomes sufficiently profitable, i.e., $\bar{\alpha} \geq 2$. However, once the advertising market is potentially very profitable, offering the menu *Basic*-*Premium* grants the platform with more flexibility and the ad based solution is often dominated by the offer of the menu. In other words, it is profitable to move people highly disturbed by ads to the *Premium* segment, making them pay a positive price.

Let us now state the optimal quality when this is positive. Different optimal qualities can arise depending on the value of ρ: we refer the reader to Appendix A.3 for the explicit cutoff values $\bar{\rho}$ and $\underline{\rho}$.

Lemma 4. *Consider all parameter regions not considered in Lemma 3. We have two cases:*

[7] Assuming quadratic costs is very convenient and has a strong impact on the optimal choice of the quality of the *Premium* segment. In general, when the cost structure has a more general form $C(q) = kq^2$, the parameter k would be very important, leading to higher quality when $k < 1/2$ and lower when $k > 1/2$. In the first case, there are corner solutions in which all contents are on board that we do not find with our analysis.

(i) if $\rho < \min\{\underline{\rho}, \bar{\rho}\}$*, then the optimal quality is*

$$q^* = \frac{2\bar{\alpha}\gamma^2 - 2\bar{\alpha}\gamma + \gamma + \sqrt{4\bar{\alpha}^2\gamma^4 - 8\bar{\alpha}^2\gamma^3 + \bar{\alpha}^2\gamma^2 + 4\bar{\alpha}\gamma^3 + 2\bar{\alpha}\gamma^2 + \gamma^2}}{3}.$$

(ii) if $\rho > \min\{\underline{\rho}, \bar{\rho}\}$*, then the optimal quality is* $\underline{q}$*.*

Proof. Proof is in Appendix A.3. ■

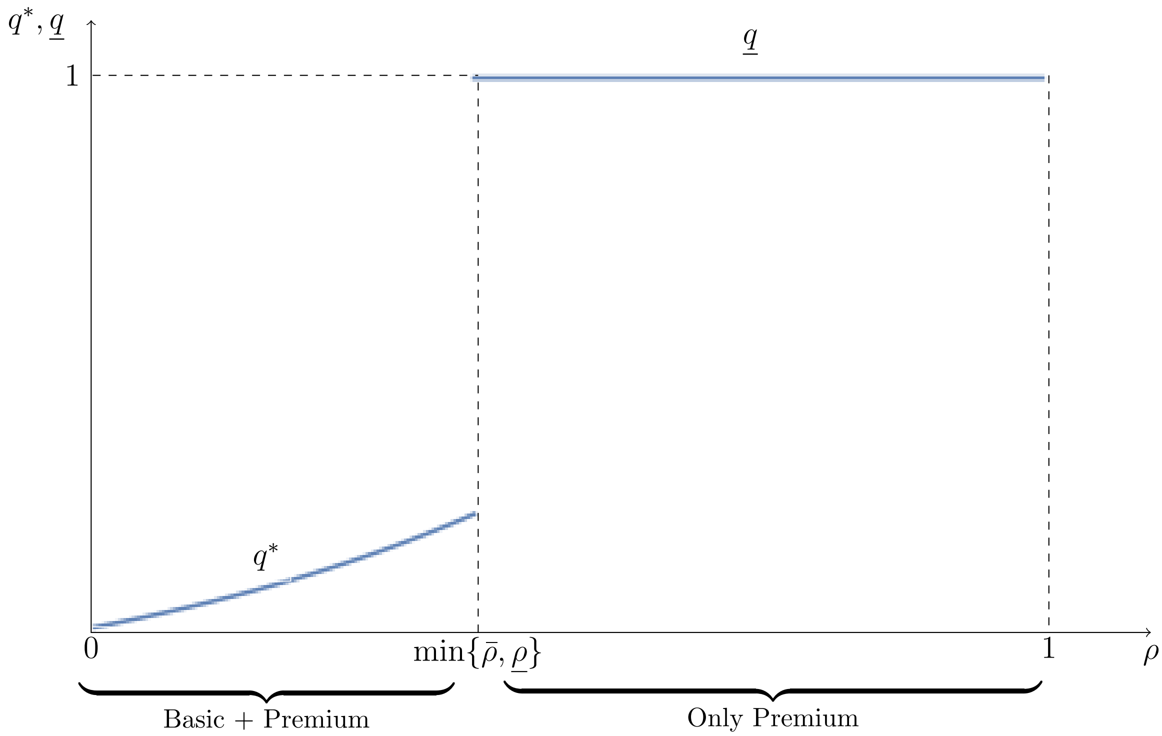


Figure 3: Optimal quality of the *Premium* segment as a function of ρ. Here we depict the case in which $\bar{\alpha} < 2$.

The mechanism behind the result of Lemma 4 is straightforward and depends on the extent to which q affects platform's profits. If the platform opts for a subscription-based model offering only *Premium*, profits are not affected by quality levels enough to compensate the associated cost, so that the platform wishes to provide the minimal quality (which is equal to $\underline{q}$ by Lemma 1). Differently, if the platform offers a menu *Premium*+*Basic*, q represents the quality differential between the *Premium* and the *Basic* segment. Therefore, a higher q moves people from the *Basic* to the *Premium* segment. For this reason, a marginal increase in q has a stronger impact on profits with respect to the "*Premium*-only" case, making the optimal q "internal". The share of low-type content providers is what ultimately determines which solution is preferred. As this share increases, the menu is more costly with respect to offering *Premium* only. As a result, once a certain level of ρ is reached, the platform wants all people to be in the *Premium* segment but, in order to induce them to move from the *Basic*, the quality needs to be fixed at least equal to $\underline{q}$. This jump is depicted in Figure 3.

5 The role of audience

Our analysis reveals that the platform's choice of quality is the main driver for the emergence of the business model. In particular, the profitability of the advertising market pushes the platform to move people to the *Basic* segment, whereas the quality upgrade offered in the *Premium* subscription is what moves users to the paying segment. At the limit, an increase in the upgraded quality makes the *Basic* segment fade away. Moreover, there exist cases in which offering only the paying subscription is always dominating. The impact of this choice on content provision, price and advertising intensity is stated in the following proposition, that combines Lemmas 1, 2, 3 and 4.

Proposition 1. *We observe three different parameter regions.*

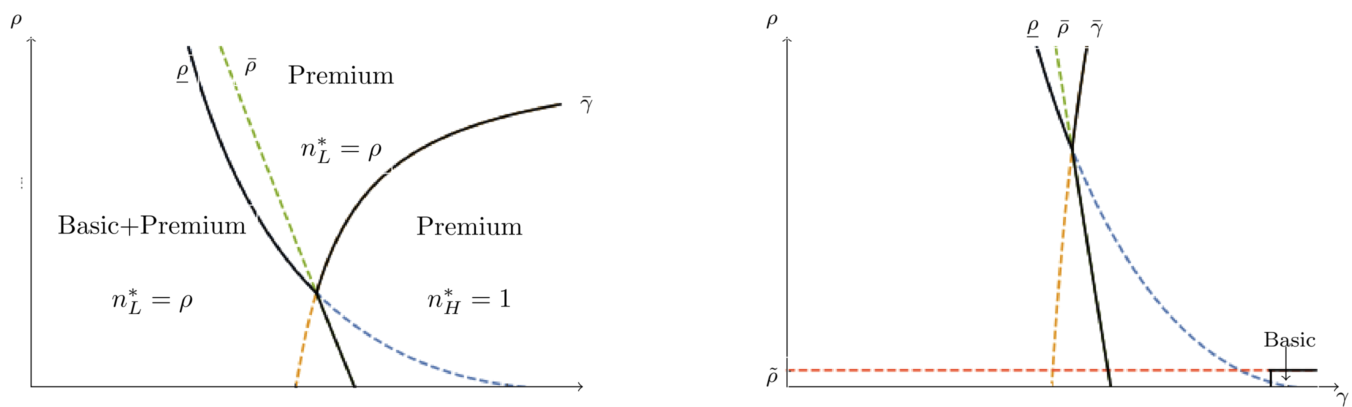
1. *If conditions in Lemma 3 are satisfied, then the platform offers only the* Basic *subscription and only low-type content providers enter the platform ($n_L^* = \rho$). The advertising intensity will be $a^* = 1/2$.*

2. *If conditions in point* (*i*) *of Lemma 4 are satisfied, the platform offers a menu of* Premium *and* Basic *subscriptions and only low-type content providers enter the platform ($n_L^* = \alpha$). The price will be $\tilde{p}(q^*)$ and the advertising intensity will be $\tilde{a}(q^*)$.*

3. *If conditions in point* (*ii*) *of Lemma 4 are satisfied, the platform offers only the* Premium *subscription. Moreover:*

(a) *when* $\gamma < \bar{\gamma}$ *only low-type content providers enter the platform* ($n_L^* = \rho$) *and the price will be* $p^*(\rho, \underline{q})$,

(b) *when* $\gamma > \bar{\gamma}$, *all contents providers enter the platform* ($n_H^* = 1$) *and the the price will be* $p^*(1, \underline{q})$.



Case with $\bar{\alpha} < 2$. We depict $\rho \in [0, 1]$ and $\gamma \in [0, 1]$.

Case with $\bar{\alpha} \in \left[2, 2 + \frac{1}{3}\left(2\sqrt{3} - 3\right)\right]$. We depict $\rho \in [0, .4]$ and $\gamma \in [0, 1]$.

Figure 4: Cases of different business models.

As already discussed after Lemma 3, the region in which *Basic* is offered as a unique solution to consumers is very tiny. As it can be observed in Figure 4-Right Panel, it can be the case only when the audience is quite close to 1 and the proportion of low-type content providers is small. This scenario represents cases in which the business model is purely ad-based and offering no high-type contents.

In the parameter regions in which the unique offer of a *Basic* subscription is not optimal, we can note two important results. On the one hand, it shows that as the audience increases, the platform has stronger incentives to attract contents, in particular the ones with higher outside option v_H. Looking at Figure 4, this mechanism is observed going from above to below the curve $\bar{\gamma}$ and it is due to the fact that a broader audience makes the platform more attractive to artists, so that a lower royalty is sufficient to obtain their contents. On the other hand, also price and advertising intensity increase in response to a wider audience. This trivially depends on the fact that the optimal quality upgrade increases in γ and it has a positive impact on price and advertising intensity, whenever a *Premium+Basic* solution is implemented.

Our results give a rationale to some stylized facts of streaming markets. On the one hand, some artists have been reluctant to the Spotify model. This is well documented by the tensions between Spotify and the frontman of the Radiohead, Tom Yorke, and Taylor Swift, among others, before their titles were available on the platform. In terms of our model, as one can notice in Figure 4, the *Basic+Premium* solution will never induce v_H types to join the platform. Moreover, these high types are willing to join only if the share of people reached by the platform is sufficiently high. As a matter of fact, the choice of these artists to join Spotify is essentially linked to the audience reached. Indeed, Spotify's active users increased by 200% in the period 2015-2018. On the other hand, during the same period, the number of *Premium* subscribers increased by more than 400%, tendency that is in line with our finding that a broader audience makes the *Premium* more profitable than the *Basic*.[8] Although not fully able to reproduce the dynamics of these markets, the present model gives a static picture of the change in the optimal strategy that one would expect when the potential market of a platform increases.

6 Model extensions

The baseline model relies on two main assumptions which constrain the platform to a rather limited set of actions. In particular, the most important ones are the following. First, the platform cannot vary the price for the *Basic* subscription, which is assumed to be offered for free: this might be a too stringent constraint and our baseline model would require that the free segment arises endogenously. We provide this analysis in the next section. Moreover, the platform is not allowed to discriminate among artists, even though, in practice, royalties vary across albums and artists. We refer the reader to section 6.2 for the extension to discriminating royalties. In comparison with the baseline, these two extensions bring about new parameter regions while some others disappear, but our main result about the link between the audience reached and the emergence of a subscription-based *Premium* model

[8]Source https://www.statista.com/statistics/244995/number-of-paying-spotify-subscribers/.

are still valid.

6.1 Positive price in the basic segment

Differently from that of the baseline model in equation (4), the profit of the platform now becomes:

$$\Pi = \underbrace{s_p(p, p_b, a) \cdot p}_{premium\ subscriptions} + \underbrace{s_b(p, p_b, a) \cdot p_b}_{basic\ subscriptions} + \underbrace{f(a, s_b) \cdot a,}_{advertising\ revenues} \tag{8}$$

Similarly to the main model, all agents with $\beta \in [0, \frac{p-q-p_b}{a})$ will subscribe *Basic* and all agents with $\beta \in [\frac{p-q-p_b}{a}, 1]$ will subscribe *Premium*. Defining as Δ the price difference between the *Basic* and the Premium, $p = p_b + \Delta$, so that the demand for subscriptions in the *Premium* and in the *Basic* segment will be, respectively:

$$s_p = \left(1 - \frac{\Delta - q}{a}\right)\gamma \text{ and } s_b = \frac{(\Delta - q)\gamma}{a}. \tag{9}$$

Plugging s_b and s_p into the profit function in equation (8), the maximization problem of the platform becomes:

$$\max_{\Delta, a, p_b} \Pi = \gamma \frac{a\Delta + (\Delta - q)((1-a)a\bar{\alpha} - \Delta)}{a} + p_b\gamma$$
$$\text{s.t. } q \leq \Delta < q + a \text{ and } n - \beta a - p_b \geq 0 \; \forall \; \beta < \frac{\Delta - q}{a}$$

The constraint on the price difference is necessary for having a non–empty set of *Basic* and *Premium* subscriptions. Moreover, the utility of the basic subscribers should be higher than zero, and this is the only condition that the platform needs to fulfill setting the price p_b. The price charged to basic subscribers is used as a surplus-extraction device whereas the price difference between segments is used to move people from one to the other. In the following Lemma, we report the optimal prices: The presence of three cases in Lemma 1 is confirmed also allowing for a positive price in the *Basic* segment. We report the counterpart of Lemma 1 below.

Lemma 5. *Let* $\tilde{a}(q, \bar{\alpha}) = \frac{\bar{\alpha}+1+\sqrt{\bar{\alpha}(\bar{\alpha}+12q+2)+1}}{6\bar{\alpha}}$. *Three cases can arise:*

1 If $q < \frac{\bar{\alpha}-2}{4}$, *only the* Basic *segment is active, with* $p_b^* = n$ *and* $a^* = 0$.

2 $q > \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}} \equiv \underline{q}$, *only the* Premium *subscription is offered at price* $p^*(n,q)$*,*

3 *If* $q \in \left(\frac{\bar{\alpha}-2}{4}, \frac{\bar{\alpha}^2+\bar{\alpha}+1}{4\bar{\alpha}}\right)$, *we have two cases:*

3a. *If* $n < \frac{(\bar{\alpha}^2+2\bar{\alpha}+1)}{9\bar{\alpha}}$ *and* $q < \tilde{q}$, *then* $p_b^* = 0$ *and the* Premium *price is* $\tilde{p}(q,\alpha)$.

3b. *If* $n > \frac{(\bar{\alpha}^2+2\bar{\alpha}+1)}{9\bar{\alpha}}$ *or* $n < \frac{(\alpha^2+2\alpha+1)}{9\bar{\alpha}}$ *and* $q > \tilde{q}$, *then* $p_b^* > 0$ *and* $p^*(n,q) = n + q$.

where

$$\tilde{q} = \frac{1}{4} + \frac{1}{8\bar{\alpha}} + \frac{\bar{\alpha}}{8} + \sqrt{\frac{(\bar{\alpha}+1)^2(\bar{\alpha}(\bar{\alpha}-8n+2)+1)}{\bar{\alpha}^2}} - \frac{3n}{2}.$$

Proof. See Appendix A.4 for the formal proof. ∎

The result in Lemma 5 is very similar to that of the baseline model. There are two important differences. First, when the number of contents is sufficiently high, the price in the *Basic* segment is positive, as noted in point 3b. When this is the case, the price in the premium segment is always extracting fully the subscriber surplus and the price difference is used to move people. Intuitively, the price difference between segments rather than the price in the *Premium* segment is the tool used by the platform to manage the cross-segment competition. The second important difference is that whenever only the *Basic* segment is active, the price p_b can be used to fully extract surplus, and the advertising intensity becomes zero. As stated in point 1, this renders the basic segment as a low-quality segment rather than an advertising-based segment as in the baseline model.

Before stating the subgame-perfect equilibrium configurations, it is worth noticing that case 3b is an out-of-equilibrium subgame when we consider the optimal quality setting, so that we can conclude the following.

Lemma 6. *If the* Basic *and the* Premium *segment are both active, the price* p_b^* *is always equal to zero.*

Proof. See Appendix A.5. ∎

The intuition of this result is that the essential difference between a model with a menu of subscriptions and the *Premium* model becomes less important here. Indeed, the platform has an additional tool to extract surplus with respect to the baseline model. As a consequence, the cross-segment competition which characterizes the menu is undermined by the fact that the platform is able to extract more surplus, making the two business models qualitatively closer. As a result, this induces the platform to make the similar quality choices in all cases, making the menu boil down to an ad-free model. This is not the case when the p_b^* is endogenously equal to zero. All in all, Lemma 6 not only justifies our choice of setting $p_b^* = 0$ but it also gives a rationale to the emergence of free subscriptions ad-based that we observe in many digital markets.

To conclude the section, the results in Lemma 5 and Lemma 6 allow us to provide the following proposition, which represents the counterpart of Proposition 1 of the baseline model.

Proposition 2. *Let* $\hat{\rho} = \frac{v_H}{v_L} - \frac{\gamma}{v_L} + \frac{\Lambda}{v_L} - \frac{(q^*)^2}{2v_L}$ *with* $\Lambda \equiv \frac{\gamma\left(\bar{\alpha}^3 + \bar{\alpha}^2(A(q^*) - 36q + 3) + \bar{\alpha}(2A(q^*) + 3)(6q^* + 1) + A(q^*) + 1\right)}{54\bar{\alpha}}$.

1. *If* $\gamma > \frac{\bar{\alpha}^2 + 2\bar{\alpha} + 1}{8\bar{\alpha}}$*:*
   (a) Basic *and* Premium *emerge when* $\rho < \min\{\bar{\rho}, \underline{\rho}, \frac{\bar{\alpha}^2 + 2\bar{\alpha} + 1}{8\bar{\alpha}}\}$,
   (b) *only* Premium *emerges when* $\rho > \min\{\bar{\rho}, \underline{\rho}, \frac{\bar{\alpha}^2 + 2\bar{\alpha} + 1}{8\bar{\alpha}}\}$.
2. *If* $\gamma < \frac{\bar{\alpha}^2 + 2\bar{\alpha} + 1}{8\bar{\alpha}}$*:*
   (a) Basic *and* Premium *emerge when* $\rho > \min\{\frac{\gamma - v_H}{\gamma - v_L}, \frac{\bar{\alpha}^2 + 2\bar{\alpha} + 1}{9\bar{\alpha}}, \hat{\rho}\}$,
   (b) *only* Basic *emerges when* $\rho < \min\{\frac{\gamma - v_H}{\gamma - v_L}, \frac{\bar{\alpha}^2 + 2\bar{\alpha} + 1}{9\bar{\alpha}}, \hat{\rho}\}$.

Proof. See Appendix A.6. ■

Proposition 2 states that a larger audience results in the emergence of a business model based on *Premium* subscriptions. Differently, a relatively smaller audience leads the platform to offer either both subscriptions letting the users to decide their preferred option or a *Basic* subscription only. As it can be observed in Figure 5, the difference with respect to the baseline model is that the parameter region compatible with the emergence of a *Basic* subscription only is much larger, whereas the region compatible with the offer of *Premium* and *Basic* shrinks to a smaller area. However, differently from the baseline model, the business model based only on the *Basic* results in the offer a basic quality service at a basic price, without advertising nuisance. This is why this solution is not always dominated by the offer of a menu *Basic+Premium* as in the baseline model.

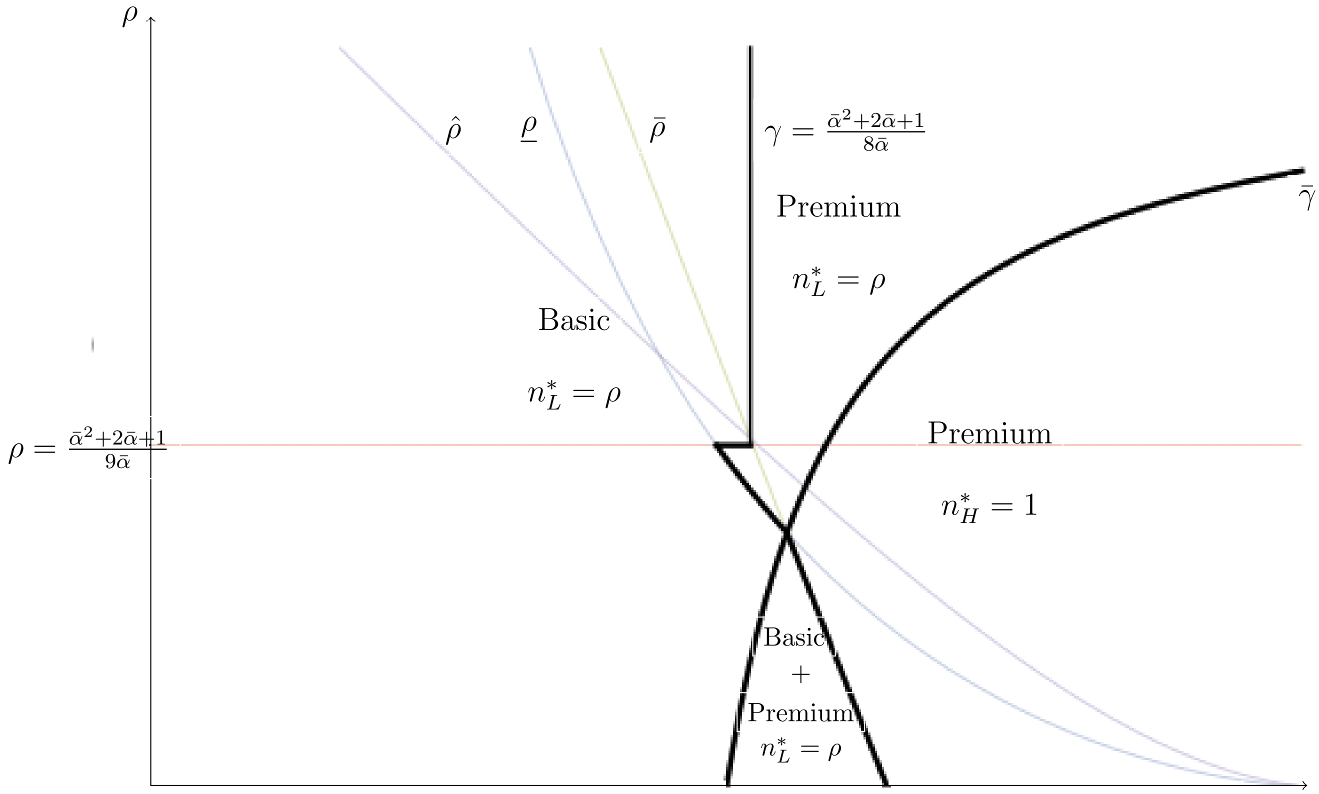


Figure 5: Cases of different business models when allowing $p_b > 0$.

6.2 Discriminating royalties

In the real world, artists are not paid the same, but high value artists, who are more important for users and generate a higher value are often paid more. In particular, recent literature in multi-sided markets focuses on the role of important agents who have market power and thus have the possibility to obtain more remunerative dealings with platforms (Biglaiser et al., 2019; Biglaiser and Crémer, 2020; Carroni et al., 2019). In the present section, we allow the platform to offer different royalties according to the heterogeneity of content providers.

In order to provide this analysis, let us consider the case described in Section 6.1.[9] We

[9]Note that this is the case in which allowing for discriminating royalties has an impact on the choice of

modify stage 1 as follows. The platform sets the optimal royalty anticipating the effect that this would have on the profits and taking into account royalty expenditures, which are given by $r \cdot n \cdot s$. Under discriminating royalties, it is possible to offer a royalty equal to r_L^* to low-value content providers (in proportion ρ) and equal to r_H^* to high-value content providers (in proportion $1-\rho$). In this way, all contents will be present in the platform, i.e. $n^* = 1$, and each content provider is compensated for the outside option v. Therefore, the profit under this strategy becomes:

$$\Pi_{bas}^d = (\gamma - v_L)\rho + (1-\rho)(\gamma - v_H) = \gamma - \rho v_L - (1-\rho)v_H$$

when only the basic segment is active and this profit is surely higher than the profit under non-discriminating royalties Π_{bas}. Differently, when only the premium segment is active, we have:

$$\Pi_{pre}^d = \gamma \underline{q} + (\gamma - v_L)\rho + (1-\rho)(\gamma - v_H) = \gamma + \underline{q} - \rho v_L - (1-\rho)v_H - \frac{\underline{q}^2}{2}$$

Equivalently to the non-discriminating case, the *Premium* is preferred to the basic if $\gamma > \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{8\bar{\alpha}}$, whereas the *Basic* only solution is preferred for a lower γ. Given that the profits in both cases are higher than those that the platform would obtain under non discriminating fees, the parameter region in which *Basic&Premium* emerges is reduced. Indeed, the profits under the discriminating case is lower than under the non-discriminating case, as

$$\Pi_{free}^d - \Pi_{free}^* = \Lambda - \rho v_L - (1-\rho)v_H - \frac{(q^*)^2}{2} - \left(\Lambda - \rho v_L - \frac{(q^*)^2}{2}\right) = -(1-\rho)v_H < 0.$$

As a consequence, comparing the profits, the results in Proposition 2 change as follows.

Proposition 3. *Assume that the platform discriminates royalties between high and low outside option content providers. We can identify three parameter regions:*

1. *If* $\gamma > \bar{\bar{\gamma}} \equiv \max\left\{\frac{\bar{\alpha}^2+2\bar{\alpha}+1}{8\bar{\alpha}}, \Lambda - \underline{q} + (1-\rho)v_H - \left(\frac{q^{*2}}{2} - \frac{\underline{q}^2}{2}\right)\right\}$*, only the* Premium *subscription is offered;*

the platform in a wider range of parameters. Indeed, the price $\tilde{p}$ and $\tilde{\alpha}$ that are set when both segments are active reflect inter-segment competition and are thus not affected by the variety of contents.

2. *if* $\gamma < \underline{\underline{\gamma}} \equiv \min\left\{\frac{\bar{\alpha}^2+2\bar{\alpha}+1}{8\bar{\alpha}}, \Lambda + (1-\rho)v_H - \frac{q^{*2}}{2}\right\}$*, both the* Basic *and* Premium *subscription are offered;*

3. *if* $\gamma \in \left[\underline{\underline{\gamma}}, \bar{\bar{\gamma}}\right]$*, only the* Basic *subscription is offered.*

To conclude, the main results of the baseline model are confirmed. Although the size of the parameter regions compatible with a *Basic&Premium* model is smaller than the Basic-only or *Premium* only models relative to the non-discriminating case, the analysis confirms the link between a larger size of the audience and the emergence of a *Premium* model.

7 Conclusions

Streaming markets, which have experienced an important boom in the last decade, have raised attention on new, important questions in economics. First, players entered the markets following different business models. For example, Google, Apple, and Netflix entered the streaming market by offering only ad-free solutions. On the contrary, companies like Spotify, Deezer, and Hulu opted for mixed business models. Secondly, these streaming platforms often have a complicated relationship with content providers, who may suffer a cannibalization effect when making their artistic productions (almost) freely accessible within the platforms.

The present model gives a rationale to these stylized facts. On the one hand, we are able to explain the emergence of different business models. The model predicts that a platform with a wide audience will only offer a *Premium* subscription, whereas a smaller platform would instead offer a menu of subscriptions. On the other hand, we highlight the fact that content providers would prefer a subscription-based system, which explains artists' reluctance to participate in the *Spotify model*.

Appendix A

A.1 Proof of Lemma 1.

The interior solution of the problem in (7) is given by

$$\tilde{p} = \frac{1}{18}\left(\frac{(1+\bar{\alpha})\left(1+\bar{\alpha}+\sqrt{\bar{\alpha}(\bar{\alpha}+12q+2)+1}\right)}{\bar{\alpha}} + 6q\right)$$

and

$$\tilde{a} = \frac{1+\bar{\alpha}+\sqrt{\bar{\alpha}(\bar{\alpha}+12q+2)+1}}{6\bar{\alpha}}$$

Notice that we need conditions for the constraints to be non-binding. On the one hand, if $q < \frac{\bar{\alpha}-2}{4}$, then $\tilde{p} - q > \tilde{a}$. On other hand, an interior solution requires $q > \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}$, otherwise $\tilde{p} < q$. Moreover, $\tilde{p} < n+q$ only if the number of contents offered by the platform is sufficiently high $n > \underline{n} \equiv \frac{2(1+\sqrt{3q+1})}{9} - \frac{2q}{3}$. When $q \geq \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}$, $\tilde{a} \geq \bar{\alpha}$, so that all agents subscribe *Premium* and pay the price leaving them with zero utility, i.e., $p^* = n + q$.

The profits then change depending on n and q. In particular, when: *(i)* $q \geq \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}$, we plug p^* and $a = 1$ into the profit function; *(ii)* when $\frac{\bar{\alpha}-2}{4} < q < \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}$, we plug $\tilde{p}$ and $\tilde{\alpha}$ into the profit function; *(iii)* when $q < \frac{\bar{\alpha}-2}{4}$, we plug $a^* = 1/2$ and $p = q + a^*$. In sum, profits are given by:

$$\Pi(n,q) = \begin{cases} \Pi_{pre} = (n+q)\gamma & \text{if } q > \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}} \\ \Pi_{free} = \frac{\gamma\left(\bar{\alpha}^3+\bar{\alpha}^2(A-36q+3)+\bar{\alpha}(2A+3)(6q+1)+A+1\right)}{54\bar{\alpha}} & \text{if } q \in \left(\frac{\bar{\alpha}-2}{4}, \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}\right) \\ \Pi_{bas} = \frac{1}{4}\gamma(\bar{\alpha} - 4q(\bar{\alpha}+4q-2)) & \text{if } q < \frac{\bar{\alpha}-2}{4} \end{cases} \tag{10}$$

with $A = \sqrt{\bar{\alpha}(\bar{\alpha}+12q+2)+1}$.

A.2 Proof of Lemma 2

In stage 1, the platform sets the optimal royalty anticipating the effect that this would have on the profits expressed in (10) and taking into account royalty expenditures, which are given by $r \cdot n \cdot s$. Notice that $s = \gamma$ and

$$n = \begin{cases} 0 & \text{if } r < r_L^*, \\ \rho & \text{if } r \in [r_L^*, r_H^*), \\ 1 & \text{if } r \geq r_H^*. \end{cases}$$

We have two cases:

1. Assume $q > \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}$. In this case, the platform has two alternatives:

   (a) setting $r = r_L^*$, which attracts a mass ρ of contents, giving a profit net of royalty expenditures equal to

   $$\Pi_{pre} - r \cdot n \cdot s = (\rho + q)\gamma - r_L^* \cdot \rho \cdot \gamma = (\rho + q)\gamma - \rho v_L$$

   (b) setting $r = r_H^*$, which attracts a mass 1 of contents, giving a profit net of royalty expenditures equal to

   $$\Pi_{pre} - r \cdot n \cdot s = (1 + q)\gamma - r_H^* \cdot \gamma = (1 + q)\gamma - v_H$$

   Solution (a) is preferred to solution (b) if $\gamma < \frac{v_H - \rho v_L}{1-\rho}$ and for all γ when $\frac{v_H - \rho v_L}{1-\rho} > 1$. As a result, the royalty is r_L^*, so that $n^* = \rho$ content are present in the platform and the subscription price is equal to $p^*(\rho, q) = \rho + q$. If $\gamma < \min\left\{\frac{v_H-\rho v_L}{1-\rho}, 1\right\} \equiv \bar{\gamma}$, solution (b) is chosen, so that the royalty is r_H^*, all contents (mass $n^{**} = 1$) are present in the platform and the subscription price is equal to $p^*(1, q) = 1 + q$. This completes the proof of the first two points of Lemma 2.

2. Assume $q < \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}$. In this case, Π_{free} and Π_{bas} do not depend on n, therefore net profit is always decreasing in r. Therefore, $r^* = r_L^*$, with the consequence that $n^* = \rho$. The price will be $\tilde{p}(q)$ and the advertising intensity $\tilde{a}(q)$.

A.3 Proof of Lemmas 3, 4

Given the results in Lemma 2, the platform profit (net of royalty expenditures and cost of providing quality) is:

$$\Pi(q) = \begin{cases} (1+q)\gamma - v_H - \frac{q^2}{2} & \text{if } q \geq \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}} \text{ and } \gamma > \bar{\gamma} \\ (\rho+q)\gamma - \rho v_L - \frac{q^2}{2} & \text{if } q \geq \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}} \text{ and } \gamma \leq \bar{\gamma} \\ \frac{\gamma\left(\bar{\alpha}^3+\bar{\alpha}^2(A-36q+3)+\bar{\alpha}(2A+3)(6q+1)+A+1\right)}{54\bar{\alpha}} - \rho v_L - \frac{q^2}{2} & \text{if } q \in \left(\frac{\bar{\alpha}-2}{4}, \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}\right) \\ \frac{1}{4}\gamma(\bar{\alpha} - 4q(\bar{\alpha}+4q-2)) - \rho v_L - \frac{q^2}{2} & \text{if } q \leq \frac{\bar{\alpha}-2}{4} \end{cases} \tag{11}$$

The platform has three alternatives:

1. Set $q \geq \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}$. The quality that satisfies FOCs is $q = \gamma < \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}$. Therefore the constraint is binding and the optimal quality will be $\underline{q} = \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}$. The correspondent profits would be:

$$\Pi^*_{pre} = \begin{cases} (1+\underline{q})\gamma - v_H - \frac{(\underline{q})^2}{2} & \text{if } \gamma > \bar{\gamma} \\ (\rho+\underline{q})\gamma - \rho v_L - \frac{(\underline{q})^2}{2} & \text{if } \gamma \leq \bar{\gamma} \end{cases} \tag{12}$$

2. Set $q \in \left(\frac{\bar{\alpha}-2}{4}, \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}\right)$. In this case, deriving the objective function with respect to q, we get:

$$\frac{\partial \Pi(q)}{\partial q} = \frac{\gamma\left(\sqrt{\bar{\alpha}(\bar{\alpha}+12q+2)+1}+1-2\bar{\alpha}\right)}{3} - q \tag{13}$$

which is increasing until

$$q^* = \frac{2\bar{\alpha}\gamma^2 - 2\bar{\alpha}\gamma + \gamma + \sqrt{4\bar{\alpha}^2\gamma^4 - 8\bar{\alpha}^2\gamma^3 + \bar{\alpha}^2\gamma^2 + 4\bar{\alpha}\gamma^3 + 2\bar{\alpha}\gamma^2 + \gamma^2}}{3},$$

and decreasing above. Notice that q^* is always internal in the interval. The correspondent profit is:

$$\Pi^*_{free} = \Lambda - \rho v_L - \frac{(q^*)^2}{2} \tag{14}$$

with $\Lambda \equiv \frac{\gamma\left(\bar{\alpha}^3+\bar{\alpha}^2(A(q^*)-36q+3)+\bar{\alpha}(2A(q^*)+3)(6q^*+1)+A(q^*)+1\right)}{54\bar{\alpha}}$.

3. Set $q \leq \frac{\bar{\alpha}-2}{4}$. Notice that $\Pi_{free} > \Pi_{bas}$ for any q when $2 > \bar{\alpha} > 1$. Therefore, this case can arise only when $\bar{\alpha} \geq 2$, and we have an optimal quality equal to 0 given that the profit is monotonically decreasing in q. Profit is $\Pi^*_{bas} = \frac{\gamma\bar{\alpha}}{4} - \rho v_L$.

Comparison between *Basic* only and *Premium* only. First compare the profits made in the third alternative with the ones made in the first alternative. We have two cases:

(i) $\gamma \leq \bar{\gamma}$, then $\Pi^*_{bas} > \Pi^*_{pre}$ if $\gamma < \tilde{\gamma} \equiv \min\left\{\frac{\bar{\alpha}^4+4\bar{\alpha}^3+6\bar{\alpha}^2+4\bar{\alpha}+1}{32\bar{\alpha}^2\rho+16\bar{\alpha}^2+8\bar{\alpha}}, 1\right\}$ and the opposite is true otherwise.

(ii) $\gamma > \bar{\gamma}$ then $\Pi^*_{bas} > \Pi^*_{pre}$ if $\gamma < \tilde{\gamma}' \equiv \left\{ \frac{\bar{\alpha}^4+4\bar{\alpha}^3+6\bar{\alpha}^2+4\bar{\alpha}+32\bar{\alpha}^2(v_H-\rho v_L)+1}{48\bar{\alpha}^2+8\bar{\alpha}}, 1 \right\}$.

Comparing the three cutoffs $\bar{\gamma}$, $\tilde{\gamma}$ and $\tilde{\gamma}'$, we get:

- (I) If $v_H - \rho v_L > \frac{(\bar{\alpha}+1)^4(1-\rho)}{8\bar{\alpha}(\bar{\alpha}(4\rho+2)+1)}$, then $\tilde{\gamma} \geq \tilde{\gamma}' \geq \bar{\gamma}$. In this case, we have two regions:
  - I.a $\gamma < \bar{\gamma}$, where $\Pi^*_{pre} > \Pi^*_{bas}$.
  - I.b $\gamma < \bar{\gamma}$, where$\Pi^*_{bas} > \Pi^*_{pre}$.
- (II) If $v_H - \rho v_L < \frac{(\bar{\alpha}+1)^4(1-\rho)}{8\bar{\alpha}(\bar{\alpha}(4\rho+2)+1)}$, then $\bar{\gamma} \geq \tilde{\gamma}' \geq \tilde{\gamma}$. In this case, we have three regions:
  - II.a $\gamma < \tilde{\gamma}$, where $\Pi^*_{pre} > \Pi^*_{bas}$.
  - II.b $\gamma < \tilde{\gamma}$, where $\Pi^*_{bas} > \Pi^*_{pre}$.

Comparison between *Basic* only and Basic&Premium. Now we compare the profits made under the *Basic* only solution (alternative 3) and the solution with both *Premium* and *Basic* (alternative 2). The previous paragraph has demonstrated that $\Pi^*_{bas} > \Pi^*_{pre}$ if $\gamma < \min\{\tilde{\gamma}, \bar{\gamma}\}$. However, whenever $\bar{\gamma} < 1$ and $\tilde{\gamma} < 1$, we have that $\Pi^*_{bas} < \Pi^*_{free}$. Therefore, the only case in which Π^*_{bas} can be higher than Π^*_{free} is when $\bar{\gamma} = \tilde{\gamma} = 1$. This can happen only if $\rho < \tilde{\rho} \equiv \min\{\frac{\bar{\alpha}^4+4\bar{\alpha}^3-10\bar{\alpha}^2-4\bar{\alpha}+1}{32\bar{\alpha}^2}, 1\}$. Notice also that $\Pi^*_{bas} > \Pi^*_{frem}$ when $\gamma \in \left(\frac{2\bar{\alpha}-1}{2\bar{\alpha}} + \sqrt{\frac{3(\bar{\alpha}-2)}{4\bar{\alpha}}}, \max\{\frac{2\bar{\alpha}-1}{2\bar{\alpha}} + \sqrt{\frac{\bar{\alpha}-2}{\bar{\alpha}}}, 1\} \right)$. Notice that $\frac{2\bar{\alpha}-1}{2\bar{\alpha}} + \sqrt{\frac{3(\bar{\alpha}-2)}{4\bar{\alpha}}} < 1$ only if $\bar{\alpha} < 2 + \frac{1}{3}\left(2\sqrt{3}-3\right)$. Therefore, we can conclude that *Basic* only can emerge only if $\bar{\alpha} \in \left[2, 2 + \frac{1}{3}\left(2\sqrt{3}-3\right)\right]$ and $\rho < \tilde{\rho}$. Thus, in this region, the optimal quality is $q^* = 0$.

Comparison between *Premium* only and Basic&Premium. To conclude the proof, we need to understand what happens in all other regions. In these regions we have to compare Π^*_{pre} with Π^*_{free}. Notice that the first profit takes a different value depending on γ. For simplicity, define $\Lambda = \Pi^*_{free} + \rho v_L$. We have two cases:

A If $\gamma < \bar{\gamma}$, we have $\Pi^*_{pre} > \Pi^*_{free}$ when $\rho > \underline{\rho}$, with $\underline{\rho} = \Lambda - \Pi^*_{pre}$. The opposite is true otherwise.

B If $\gamma > \bar{\gamma}$, we have $\Pi^*_{pre} > \Pi^*_{free}$ when $\rho > \tilde{\rho}$, with

$$\tilde{\rho} = \frac{32\bar{\alpha}^2\Lambda - 8\bar{\alpha}(\bar{\alpha}+1)^2\gamma + (\bar{\alpha}+1)^4}{32\bar{\alpha}^2\gamma}.$$

The opposite is true otherwise.

To conclude the proof, note that the optimal quality is $\underline{q}$ when $\Pi^*_{pre} > \Pi^*_{free}$ and q^* when $\Pi^*_{pre} < \Pi^*_{free}$.

A.4 Proof of Lemma 5

First note that the optimal price in the basic segment is:

$$p_b(\Delta, a) = \max\{n - a\frac{\Delta - q}{a}, 0\} = \max\{n - \Delta + q, 0\}, \tag{15}$$

which is the maximal price compatible with the constraint that the utility for the marginal basic subscriber is greater than or equal to zero. Differentiating the profit with respect to a and Δ, we have:

$$\frac{\partial \Pi}{\partial \Delta} = \frac{a(1+\bar{\alpha}-a\bar{\alpha}) - 2\Delta + q}{a}$$
$$\frac{\partial \Pi}{\partial a} = \frac{(q-\Delta)\left(a^2\bar{\alpha} - \Delta\right)}{a^2}.$$

First- and second-order conditions are satisfied only with $a = \tilde{a}$ as in Appendix A.1 and with $\Delta^* = \frac{(1+\bar{\alpha})\tilde{a}+q}{3}$. We need again conditions similar to those of the baseline model for the constraints to be non-binding. On the one hand, if $q < \frac{\bar{\alpha}-2}{4}$, then $\Delta^* - q > \tilde{a}$, so that only the *Basic* subscription is offered and the profit is given by $(p_b + a(1-a)\bar{\alpha})Prob(n - p_b - \beta a > 0) = p_b(\frac{n-p_b}{a}) + \bar{\alpha}(1-a)(n-p_b)$, which is trivially maximized by setting $a^* = 0$ and $p^*_b = n$. On other hand, an interior solution requires $q < \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}$, otherwise $\Delta^* < q$. Whenever $q > \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}$, only the *Premium* subscription is offered and the optimal $p^* = n + q$ is the same as in point 2 of Lemma 1.

For the interior solution, plugging Δ^* and a^* into (15), we obtain:

$$p_b^* = \max\left\{n + \frac{2q}{3} - \frac{(1+\bar{\alpha})(1+A+\bar{\alpha})}{18+\bar{\alpha}}, 0\right\}, \tag{16}$$

with $A = \sqrt{\bar{\alpha}(\bar{\alpha}+12q+2)+1}$. Moreover, given that the price in the premium segment is equal to $p_b^* + \Delta^*$. Defining

$$\tilde{q} = \frac{1}{4} + \frac{1}{8\bar{\alpha}} + \frac{\bar{\alpha}}{8} + \sqrt{\frac{(\bar{\alpha}+1)^2(\bar{\alpha}(\bar{\alpha}-8n+2)+1)}{\bar{\alpha}^2}} - \frac{3n}{2},$$

we can identify two cases:

1. If $n < \frac{(\bar{\alpha}^2+2\bar{\alpha}+1)}{9\bar{\alpha}}$ and $q < \tilde{q}$, then $p_b^* = 0$ and $p^*(n,q) = \Delta^*$.
2. If $n > \frac{(\bar{\alpha}^2+2\bar{\alpha}+1)}{9\bar{\alpha}}$ or $n < \frac{(\alpha^2+2\alpha+1)}{9\bar{\alpha}}$ and $q > \tilde{q}$, then $p_b^* > 0$ and $p^*(n,q) = n+q$.

Notice that the analysis when we are in case 1 here is already treated in the analysis of the baseline model. We report here the profit in case 2:

$$\Pi(n,q) = \begin{cases} \Pi_{pre} = (n+q)\gamma & \text{if } q > \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}} \\ \Pi_{free}(p_b^* > 0) = n\gamma + \gamma\frac{\bar{\alpha}(\bar{\alpha}(\bar{\alpha}+A)+6q(9+2A-6\bar{\alpha})-2)-(\bar{\alpha}+2)(A+1)}{54\bar{\alpha}} & \text{if } q \in \left(\frac{\bar{\alpha}-2}{4}, \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}\right) \\ \Pi_{bas} = n\gamma & \text{if } q < \frac{\bar{\alpha}-2}{4} \end{cases} \tag{17}$$

A.5 Proof of Lemma 6

Assume p_b^* in equation (16) to be positive, i.e., consider the case in point 3b of Lemma 5. Plugging p_b^*, $\tilde{a}$ and $p^* = n+q$ into the profit function (net of royalties and cost of quality provision), we get:

$$\Pi(q) = \frac{\gamma(\alpha(\alpha(\alpha+A)+6q(-6\alpha+2A+9)-A+54-3)-2(A+1))}{54\alpha} - rn\gamma - \frac{q^2}{2},$$

where A is defined at page 27. Note that the royalty is independent from q as in the baseline and, also, that we need $q \in \left(\frac{\bar{\alpha}-2}{4}, \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}\right)$. The second derivative of the objective function with respect to q is:

$$\frac{\partial^2\Pi(q)}{\partial^2 q} = \gamma + \frac{\bar{\alpha}\gamma\,(\bar{\alpha}-2A+12q+1)}{3A}, \tag{18}$$

which is positive in the interval $\left(\frac{\bar{\alpha}-2}{4}, \frac{\bar{\alpha}^2+2\bar{\alpha}+1}{4\bar{\alpha}}\right)$. Therefore, the function is maximized in one of the two extremes, leading either to case 1 of Lemma 5 or case 2 of Lemma 1. This completes the proof.

A.6 Proof of Proposition 2

In stage 1, the platform sets the optimal royalty anticipating the effect that this would have on the profits expressed in (17) and taking into account royalty expenditures, which are given by $r \cdot n \cdot s$. Notice that $s = \gamma$ and

$$n = \begin{cases} 0 & \text{if } r < r_L^*, \\ \rho & \text{if } r \in [r_L^*, r_H^*), \\ 1 & \text{if } r \geq r_H^*. \end{cases}$$

There are two things to note. First, if the two segments are both active, i.e., when the profit is Π_{free}, the royalty setting is the same as that of the baseline model, with $r = r_L^*$ and thus $n^* = \rho$. Given that the variety of contents is limited only to $n^* = \rho$ when the two segments are active and $p_b = 0$, a corollary of Lemma 5 and Lemma 6 is that if $\rho > \frac{\left(\bar{\alpha}^2+2\bar{\alpha}+1\right)}{9\bar{\alpha}}$, then one of the two segments (either the *Basic* or the Premium) cannot arise at equilibrium. Therefore, when $\rho > \frac{\left(\bar{\alpha}^2+2\bar{\alpha}+1\right)}{9\bar{\alpha}}$, we have just to compare the profits made under *Basic* Only and the profits made under *Premium* only.

For the other two cases, Considering the profits in equation (17), one can note that $\frac{\partial \Pi_{pre}}{\partial n} = \frac{\partial \Pi_{bas}}{\partial n} = \gamma$, therefore the platform has two alternatives:

1. setting $r = r_L^*$, which attracts a mass ρ of contents, giving a profit net of royalty expenditures equal to

$$\Pi - r \cdot n \cdot s = (\rho + q_y)\gamma - r_L^* \cdot \rho \cdot \gamma = (\rho + q_y)\gamma - \rho v_L$$

with $y = pre, bas$ and $q_{pre} = q > 0 = q_{bas}$.

2. setting $r = r_H^*$, which attracts a mass 1 of contents, giving a profit net of royalty expenditures equal to

$$\Pi - r \cdot n \cdot s = (1 + q_y)\gamma - r_H^* \cdot \gamma = (1 + q_y)\gamma - v_H$$

Alternative 1 is preferred if $\gamma < \bar{\gamma}$, and alternative 2 otherwise.

Going to the quality-setting stage 0, the results are the same of the baseline model. Thus the only thing that changes when we compare the profits in the three scenarios is that the profit under *Basic* becomes equal to $\max\{\rho\gamma - v_L, \gamma - v_H\}$.For the comparison between *Premium* only and *Basic&Premium* we can refer the reader to the baseline model and, to complete the proof, we just need to compare the *Basic* only case with the other two alternatives, as the profit Π_{bas} has changed.

Comparison between *Basic* only and *Premium* only. Comparing the profit in (12) with $\max\{\rho(\gamma - v_L), \gamma - v_H\}$, we find that *Basic* is preferred if $\gamma < \min\left\{\frac{\bar{\alpha}^2+2\bar{\alpha}+1}{8\bar{\alpha}}, 1\right\}$, whereas *Premium* is preferred otherwise.

Comparison between *Basic* only and Basic&Premium. In this comparison, we need to consider two cases:

- If $\gamma < \bar{\gamma}$, then the profit under only *Basic* is $\rho(\gamma - v_L)$ and $\Pi_{free} = \Lambda - \rho v_L - \frac{(q^*)^2}{2}$ as expressed in (14). The difference between the former and the latter is increasing in ρ and takes value zero when:
$$\rho = \frac{\Lambda}{\gamma} - \frac{(q^*)^2}{2\gamma},$$
which is lower than zero for all $\bar{\alpha} \geq 1$ and $0 < \gamma < 1$. In this parameter region, the *Basic* is always preferred.

- If $\gamma > \bar{\gamma}$, the profit under only *Basic* is $\gamma - v_H$ and the difference is again positive in ρ. The two profits equate at:
$$\hat{\rho} = \frac{v_H}{v_L} - \frac{\gamma}{v_L} + \frac{\Lambda}{v_L} - \frac{(q^*)^2}{2v_L}$$

To conclude the proof, it is just sufficient to note that the choices are between *Basic* and *Basic&Premium* when $\gamma < \min\left\{\frac{\bar{\alpha}^2+2\bar{\alpha}+1}{8\bar{\alpha}}, 1\right\}$ and between *Premium* and *Basic&Premium* when $\gamma > \min\left\{\frac{\bar{\alpha}^2+2\bar{\alpha}+1}{8\bar{\alpha}}, 1\right\}$.

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