Market Structures and the Distribution of Content*

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I study how market structure influences the distribution of entertainment products. Producers compete for consumer attention through horizontal differentiation across “genres”. I show that the combination of pricing frictions and ex-ante producer uncertainty over own quality is necessary and sufficient for market inefficiency. When both frictions are present, production is inefficiently concentrated in high-demand, homogeneous, genres. I also study how alternative market structures interact with these frictions. In particular, a monopolist using subscription pricing produces inefficiently diverse content and recommendation systems can improve on the decentralized equilibrium by selectively suppressing content.

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1 Introduction

Entertainment products are ubiquitous and highly valued. Although they share many characteristics with other consumption goods, there are several key distinctions that make their markets unique. As in many industries, there is a large degree of both horizontal and vertical differentiation across cultural products. Important to the production of these products is is the asymmetry in these dimensions of differentiation. While a producer intentionally decides what type of song to write, or what genre of movie to produce, they cannot perfectly predict the quality of the work they produce. Previous work has emphasized the significance of ex-ante uncertainty over quality in these industries. For instance, in the music industry, Aguiar and Waldfogel (2018) provide evidence that quality is largely unpredictable. In the movie industry, the mantra of "Nobody Knows Anything" about which movies will perform well, is prevalent.[1]

These markets also feature a shockingly small degree of price competition. Despite the large degree of competition for attention, the price of different goods remains relatively flat. Movie ticket prices rarely depend on the show; the vast majority of songs on iTunes cost \$0.99 regardless of their popularity. Even when differential pricing exists, it is largely independent of the quality of the underlying good. Hennig-Thurau, Houston, et al. (2019), for instance, argue that most variance in pricing comes through the medium of consumption (e.g., hard-cover vs. paperback) rather than the quality of goods themselves.

I study how these two market frictions—producer uncertainty and exogenous pricing—interact to influence how producers sort horizontally across genres. In particular, I highlight how both frictions together are necessary and sufficient for there to be a failure in this market. I further show that when both frictions are present, a decentralized competitive equilibrium leads to an inefficient lack of diversity in production: producers concentrate inefficiently in high-demand genres.

In my model, producers choose what "genre" of good to produce. This choice captures horizontal differentiation of products. Information frictions are controlled by the timing at which producers observe their quality: producers observe their quality

[1] This phrase comes from screenwriter William Goldman. See Hennig-Thurau, Houston, et al. (2019) for a discussion of the history of the mantra and its impact on the industry.

	Ex-ante Realization of Quality	Ex-post Realization of Quality
Competitive Pricing	No Inefficiency	No Inefficiency
Fixed Pricing	No Inefficiency above fixed price	Allocative Inefficiency

Table 1: Summary of Theorem 1.

either before or after they choose their genre of production.[2] After this initial sorting, producers possibly compete on price with other producers in their genre. If pricing frictions are present, producers are price takers and do not compete on price. On the other side of the market are consumers, heterogeneous over both which genre from which they consume content, and *how much* of these products they are willing to consume. This second dimension of consumer preferences is an upper bound on their quantity of consumption (consumers are heterogeneous in how much time they are able to spend watching TV or listening to music).

My first main result (Theorem 1, summarized in Table 1) shows that information and pricing frictions together are necessary and sufficient for there to be a failure in this market. If either producers were able to compete through pricing *or* producers knew their own quality before choosing what type of product to produce, then the market operates efficiently. However, if producers are uncertain about their quality and the market price of goods is given exogenously, producers inflict an externality on other firms that they do not internalize. My second main result (Theorem 2) characterizes the nature of this inefficiency: producer concentrate too heavily in high-demand genres. This means that the competitive equilibrium features too little diversity of content relative to the socially optimal level.

After characterizing this market failure, I show how different aspects of the market influence this failure. I first show that the more that the exogenous market price depends on realized product quality, the larger this concentration. Thus, the flat pricing widely observed in these industries encourages product diversity. Holding total

[2]Regardless, there is no ex-post uncertainty over quality, only possible sex-ante uncertainty. This distinguishes my model from previous studies on recommendation systems, which focus on platform's ability to improve welfare through providing information and decreasing search costs.

demand constant, I show that genres with a larger proportion of "super-fans" always receive fewer producers in the competitive equilibrium. When the total mass of producers is small, this also holds in the centralized allocation of producers. In contrast, when producers are abundant, genres with more super-fans optimally receive larger attention. I also show that the right tail of the quality distribution has important implications for the optimal allocation of producers. In particular, as the right tail of the quality distribution shrinks, optimal product diversity increases.

Digitalization has led to a radical change in how consumers experience cultural products. The rise of streaming services has radically changed how consumers consume products. Instead of purchasing individual pieces of content, consumers are now able to purchase access to a bundle of content and consume any content in the bundle at zero marginal price. A natural question is how these changes in market structure interact with existing market frictions to shape the distribution of products.

My final results explore alternative market structures. I first show that centralizing production, maintaining the fixed market price, leads to more diverse content than in the decentralized equilibrium. Depending on the market price, this monopolist producer may produce content that is more or less diverse than is optimal. I also show that if a monopolist producer prices goods using subscription pricing, it produces inefficiently diverse content. Finally, I study a recommendation system which connects consumers to products, but does not directly control production. The recommendation system in my model influences producers by selectively *suppressing* content. By suppressing mediocre content in high-demand genres, the recommendation system discourages producers from over-producing in these genres. This encourages producers to produce a wider range of content than they would in the competitive equilibrium, increasing welfare.

1.1 Related Literature

There exists a mainly empirical literature studying how digitalization has affected cultural industries. A major theme in this literature is the trade-off between digitization leading to increased piracy and decreased profits, and how technological developments have decreased the cost of entry. Waldfogel (2013) studies exactly these two completing forces in the case of the movie industry, and Aguiar and Waldfogel (2016) studies these forces in the music industry. Piolatto and Schuett (2012) studies how piracy disproportionately hurts small producers. Most related to my study in spirit is Aguiar and Waldfogel (2018), which evidences quality uncertainty in the production of music, and shows that this uncertainty has large welfare implications. There is also a small literature studying how streaming services have influenced the music industry. Gambato and Sandrini (2025a) and Gambato and Sandrini (2025b) study producer incentives in streaming services, including the impact of promotional services. Aguiar and Waldfogel (2021) provides evidence of significant power of streaming services to promote certain products, and Aguiar, Waldfogel, and Waldfogel (2021) measures bias in Spotify promotion of new music.

My paper also contributes to the growing literature on the economic impact of recommendation systems. Most work studying the impact of these intermediary platforms has focused on how these platforms leverage informational asymmetries to influence consumer behaviour. Empirically, Lee and Musolff (2025) studies the impact of Amazon's Buybox on consumption and consumer surplus. Calvano et al. (2025) studies how algorithmic recommendations affect the distribution of consumption choices and market concentration, but do not focus on producer incentives. Most related is Chen, Li, and Preuss (2025), which studies the scope of recommendation systems to influence producer effort on social media platforms. While I also study the ability of recommendation systems to influence producer behaviour, I focus on producer sorting across horizontally differentiation, whereas Chen, Li, and Preuss (2025) assumes that producers are exogenously anchored to a product type in order to focus on effort choices.

At a technical level my paper speaks to the contest literature with noisy output. Since producers are uncertain about their quality ex-ante in my model, genre decisions are related to sorting across one of multiple contests. Drugov and Ryvkin (2020) and Ryvkin and Drugov (2020) study entrant effort in single noisy contests. Grossmann (2021) and Deng et al. (2025) study concurrent contests with deterministic output. While at a high-level my model is related to this literature, my focus is different. Instead of focusing on the design of contests, I study the implications of noisy output on producer sorting across contests, with an exogenous prize structure.

Outline of Paper. Section 2 studies a simple example to outline the forces in the main model. Section 3 develops the full model and Section 4 presents the main result.

I study the nature of allocative inefficiency in Section 5. Other results are presented in Section 6 and alternative market structures are introduced in Section 7. Section 8 concludes.

2 Motivating Example

In this section I present a stylized example to fix ideas.

Producers and Products. There are two producers and two product types, which I refer to as "genres". Producers are ex-ante identical, but there is uncertainty over their production technology. Each producer's quality v is distributed according to the uniform distribution on $[1, 2]$, and is independent across producers.[3]

Consumers. Demand differs for the two genres. Mass $\mu > \frac{1}{2}$ of consumers consume content in genre 1, and mass $1 - \mu$ consume content in genre 2. Within each genre, each consumer consumes at most one product, and receives utility from consumption equal to the product's quality net the price of the good.

Market Frictions. There are two possible frictions in this market. The first possible friction is that firms are uncertain of their own quality. In many creative ventures, firms do no know the quality of the goods that they produce until after production is complete. This is captured in this example by controlling when producers' quality is revealed. Producers either observe both producers' technologies before committing to the type of product they produce or only observe the technologies after the choice of genre is made (i.e., once the product is produced).

The second friction in the market is fixed pricing. In many markets, firms are unable to differentiate their products by price due to widely-used pricing heuristics, or due to pricing being controlled by a centralized intermediary. In order to capture this possibility, I separately study the environment when firms are able to directly price their goods in response to competition (i.e., there is no fixed pricing), and when firms are price takers. In the latter setting, the market price is taken to be $p = 1$.

There are hence four different settings under study. Since each game is distinct, the actions of producers and their timing depend on the setting. I defer a formal

[3]For the motivating example, I ignore the probability-zero probability that producers' realized values are the same.

explanation of timing to the appendix.[4] The following proposition presents the main result of this example: both frictions are necessary for there to be a market failure. Moreover, when the two coexist, the market failure takes a particular firm: producers concentrate too heavily in the larger genre.

Proposition 1.

(i) If pricing is competitive or producers observe their quality before committing to a genre, there exists an equilibrium of the game that maximizes total expected surplus.

(ii) If there are pricing frictions and producers are uncertain of their quality, the market may operate inefficiently:

(a) If $\mu > \frac{2}{3}$, in the unique equilibrium both producers produce in genre 1.

(b) If $\mu < \frac{9}{10}$, both producers producing in genre 1 is strictly inefficient.

When pricing is competitive, firms internalize the impact of competition: if both firms enter the same genre they are forced into a pricing war, decreasing profits. This does not depend on whether firms observe qualities before or after they commit to a genre. This leads producers to sort efficiently. When pricing is fixed, but producers' know qualities, the producer with the higher quality captures the larger market, while the producer with the lower quality is effectively forced to produce in the smaller market. This is also efficient: the higher-quality good is consumed by more agents.

However, the combination of these two forces leads to the possibility of market failure. If demand is concentrated in genre 1, but not too concentrated—$\mu \in \left(\frac{2}{3}, \frac{9}{10}\right)$—the unique equilibrium of the game is inefficient. This inefficiency relies on how the two frictions interact. When a producer is uncertain over their own quality, they are unaware of whether they are of higher value than their opponent. Since the market price is fixed, firms do not internalize the externality that comes from their displacement of other products.

Although in this simple example allocative inefficiency exists only for specific values of μ, in the general model allocative inefficiency generically persists when both

[4] In this setting, timing can be important because there are only two producers. In the full model assumptions on timing do not affect the results.

frictions are present. The general model additionally allows me to demonstrate in a more nuanced way the ways in which market structure, consumer heterogeneity, and the distribution of quality influence allocative inefficiency. Later in the paper I will return to this simple setting to motivate additional results.

3 Model

I now describe the general framework that I will use to build upon the analysis of the motivating example.

Producers' Choice of Genre and Quality Realization. There is a unit mass of ex-ante identical producers. These producers each produce one good, which is differentiated both along a horizontal "genre" dimension, and a vertical "quality" dimension. There are $G \geq 2$ genres. I abuse notation and also use $G = \{1, ..., G\}$ to denote the set of genres. Each producer chooses which genre $g \in G$ in which to produce.

A producer's quality v is realized according to a continuous distribution F. Each producer's quality is realized independently. As in the motivating example, I consider two regimes: producers either observe their quality before or after choosing which genre to enter.[5] Let $\overline{F}(v) = 1 - F(v)$ denote the survival function of the distribution, and f its density. I assume that F has increasing hazard rates:

Assumption 1. F has increasing hazard rates: $\frac{f(v)}{\overline{F}(v)}$ is strictly increasing in v on its domain.

Consumers. There is a unit mass of consumers. A consumer is defined by a two dimensional type: the genre which he consumes, and the maximum quantity of content that he is able to consume (his "time" constraint). A consumer type is hence a tuple $(g, t) \in \Theta := G \times \mathbb{R}_+$.

Let $T \in \Delta\Theta$ denote the distribution of consumer types. From this, derive the distribution of demand for genre g. That is, let $T_g(t)$ denote the mass of consumers who are willing to consume at most t units of content from genre g:

$$T_g(t) = T\Big(\{(g', t')|g' \neq g, \text{ or } g = g, t' \leq t\}\Big), \quad \text{for all} \quad t \geq 0$$

[5]Unlike in the motivating example, firms need only observe their own quality: Since there is a mass of producers, the distribution of quality is deterministic, so this is unimportant.

In particular, $T_g(0) = T(G \setminus \{g\} \times \mathbb{R}_+)$ is the mass of consumers who consume no content of genre g. As for the distribution over quality, let $\overline{T}_g(t) = 1 - T_g(t)$ denote the survival function of consumer demands for genre g. It will be useful to define $c_g := \overline{T}_g(0)$, the possible consumers of genre g. I assume that apart from its atom at zero, T_g admits a density $\frac{dT_g}{dt}(t)$ which is full support on $[0, \bar{t}_g]$ for some $\bar{t}_g \in \mathbb{R}_+$.[6]

Consumer Preferences. The gross utility that a consumer of type (g, t) receives from consuming a good from genre g is proportional to its quality: he receives $v \cdot dv$ from a good with quality v. This implies that if the marginal price of all goods is zero, a consumer of type (g, t) will consume the mass t highest-quality goods in genre g, or consume all goods in genre g that are of positive quality. Explicitly, let μ_g denote the measure of content in genre g. To find the value at which his time constraint binds, first solve for $v_t(\mu_g)$ such that

$$\mu_g([v_t(\mu_g), \infty)) = t$$

In order to simplify notation, I write v_t when the measure μ_g is clear from the context. If no such v_t satisfies the equation, define it as $-\infty$. The consumer hence consumes all goods in genre g of quality above $\max\{0, v_t\}$. Since his utility is proportional to the quality of the goods that he consumes, his utility is then

$$\int_{\max\{0, v_t\}}^{\infty} v d\mu_g(v)$$

When the price of goods is non-zero, a consumer chooses those goods that give him the highest net utility. Suppose that in genre g, goods of quality v cost $p_g(v)$. Then, the consumer will compare those goods that give him the highest net utility $v - p_g(v)$. Let ν_g denote the distribution of surplus (net utility), derived immediately from μ_g. The consumer's threshold $s_t(\nu_g)$ solves

$$\nu_g([s_t, \infty)) = t,$$

[6] Although writing the density as $\frac{dT_g}{dt}$ is clunky, it is helpful to reserve t to indicate time as opposed to the density. This assumption can also be relaxed to $\frac{dT_g}{dt}(t)$ being positive in a neighbourhood of zero.

resulting in total net utility for the consumer of

$$\int_{\max\{0,s_t\}}^{\infty} s d\nu_g(s)$$

Prices. As in the motivating example, I consider two pricing regimes: competitive and fixed pricing. When pricing is competitive, firms observe their competition and set prices individually in order to maximize profits. Producers choose their price after entering a genre and observing their competition. In particular, producers always know their own quality when making pricing decisions. The second pricing regime is that of fixed pricing. Here, there is a given market price p for all goods in the market, regardless of genre.[7]

Producer Profits. Producers maximize profits. Suppose that a producer knows its quality v. Facing decisions of other producers, the distribution of surplus in each genre $(\nu_g)_g$ is fixed. The producer's anticipated profits in genre g are then

$$D_g(v, p; \nu_g) = \int_0^{\infty} p \cdot \mathbb{1}\left\{s_t(\nu_g) \leq v - p\right\} dT_g(t)$$

Producers make genre and pricing decisions to maximize this anticipated demand. If they are uncertain over their own quality, they maximize the expectation of this object.

Summary of Settings. Given the two market frictions under study, there are four settings to consider: Producer certainty with competitive (CC) or fixed (CF) pricing, and producer uncertainty with competitive (UC) or fixed (UF) pricing.

3.1 Actions, strategies, and equilibria in each setting

Depending on the setting, producers have different possible actions. Moreover, their strategies also depend on the information that they have at time of decision making.

Complete information, fixed pricing (CF). When pricing is fixed at level p, the timeline of the game is straightforward. Producers simultaneously observe their quality, and then choose which genre to enter. Consumers then observe qualities, and

[7] In Section 6, I also allow this fixed market price to depend on the value of the goods $p(v)$.

make consumption decisions. Hence, a population strategy can be described by

$$\Psi : \mathbb{R} \to \Delta G$$

A strategy induces a distribution of surplus

$$\nu_g^{\Psi}((-\infty, s])) = \int_{-\infty}^{s+p} \Psi(v) f(v) dv$$

Definition 1. An equilibrium of the CF regime is a population strategy Ψ^{CF} where

$$g \in \operatorname{supp}\left(\Psi^{CF}(v)\right) \Rightarrow g \in \operatorname*{argmax}_{g} D_g(v, p; \nu_g^{\Psi^{CF}})$$

Producer Uncertainty, competitive pricing (UC). The timing in this regime is as follows: producers make genre choices without observing quality, then observe their quality and choose prices to maximize their expected revenue. After prices are chosen, consumers observe the measure of content and the prices of these goods, and maximize their utility from consumption.

A population strategy thus has two components: a distribution over content $\psi \in \Delta G$, and a pricing function in each genre $p_g : \mathbb{R} \to \mathbb{R}_+$, combined in the vector $p = (p_1, ..., p_G)$.[8] When there is uncertainty, the distribution of quality is proportional to the distribution F: $\mu_g^{\psi}((-\infty, v]) = \psi_g F(v)$.

Definition 2. An equilibrium of the UC regime is a population strategy (ψ^{UC}, p^{UC}) where

$$\begin{aligned} &g \in \operatorname{supp}(\psi_g) \Rightarrow g \operatorname*{argmax}_{g} \mathbb{E}\left[D_g(v, p_g^{UC}(v); \nu_g^{(\psi^{UC}, p^{UC})})\right] \\ &p_g^{UC}(v) \in \operatorname*{argmax}_{p} D_g\left(v, p; \nu_g^{(\psi^{UC}, p^{UC})}\right), \quad \text{for all} \quad g \in G, v \in \mathbb{R} \end{aligned}$$

I call an equilibrium *monotonic* if p_g^{UC} is increasing, for each g.

Complete information, competitive pricing (CC). Here, producers first observe their quality and then choose their genre. Producers then observe the compe-

[8] I restrict attention to pure pricing decisions, but this restriction is not necessary.

tition in their genre, and commit to a price.

In this setting, there is again a pricing function for each genre $p_g : \mathbb{R} \to \mathbb{R}_+$, and a population strategy $\Psi : \mathbb{R} \to \Delta G$. The distribution of surplus is computed as above, in a straightforward manner.

Definition 3. An equilibrium of the CC regime is a population strategy (Ψ^{CC}, p^{CC}) where

$$g \in \operatorname{supp}(\Psi(v)) \Rightarrow g \in \operatorname*{argmax}_g D_g(v, p_g^{CC}(v); \nu_g^{(\psi^{CC}, p^{CC})}), \quad \text{for all} \quad v \in \mathbb{R}$$
$$p_g^{CC}(v) \in \operatorname*{argmax}_p \left(\max_g D_g \left(v, p; \nu_g^{(\psi^{CC}, p^{CC})} \right) \right), \quad \text{for all} \quad g \in G, v \in \mathbb{R}$$

I call an equilibrium (Ψ^{CC}, p^{CC}) *monotonic* if p_g^{CC} is increasing, for each g.

This is similar to the definition of equilibrium in the incomplete information, competitive pricing regime, except that genre decisions are made with complete information, and pricing decisions are made with future genre choices in mind.

Producer uncertainty, fixed pricing (UF). Since pricing is fixed in this regime, and producers are uncertain over their quality, the population strategy can be described solely by the allocation of producers in each genre: $\psi \in \Delta G$.

Definition 4. An equilibrium of the UF regime is a population strategy $\psi^{UF} \in \Delta G$ where

$$g \in \operatorname{supp}(\psi) \Rightarrow g \in \operatorname*{argmax}_g \mathbb{E} \left[D_g(v, p(v); \nu_g^{\psi^{UF}}) \right]$$

4 The Main Result

Throughout the paper, I take the information available to producers as an exogenous constraint on the market. The efficient benchmark thus depends on this information: the planner is constrained by the same information as producers at the time of assignment.

Complete information. When producer quality is known at the time of selection, the planner is able to direct producers to different genres according to their realized quality. That is, the planner chooses a function $\Psi : \mathbb{R} \to \Delta G$. I say that Ψ^* is *efficient* if it maximizes the total surplus in the economy across all functions Ψ.

Producer uncertainty. When producer quality is uncertain at the time of assignment, the planner's choice is heavily constrained. It can only choose the fraction of producers that are assigned to each genre: $\psi \in \Delta G$. Similar to the case of perfect information, I say that ψ^* is *efficient* if it maximizes total surplus across all measures ψ.

4.1 The Result

As in the motivating example, the combination of pricing and information frictions leads to allocative inefficiency.

Theorem 1. *Fix a market price p for the fixed equilibrium. Efficient Ψ^* and ψ^* exist. ψ^* is unique, and Ψ^* is unique almost everywhere on $(0, \infty)$.*

(i) For any equilibrium $\Psi^{CF}(v)$, $\Psi^{CF}(v) = \Psi^*(v)$ for almost all $v > p$.

(ii) There exists a unique monotonic equilibrium (ψ^{UC}, p^{UC}). For this equilibrium, $\psi^{UC} = \psi^*$.

(iii) There exists a monotonic equilibrium (Ψ^{CC}, p^{CC}) such that $\Psi^{CC}(v) = \Psi^*(v)$ for each $v > 0$.

(iv) ψ^{UF} is unique. If $|\operatorname{supp} \psi^*| > 1$, generically $\psi^{UF} \neq \psi^*$.

Discussion of result. The lack of inefficiency in (i)-(iii) despite the presence of frictions is driven by two distinct forces driving the market towards efficiency. The first is the internalization of business-stealing externalities through pricing. If there is excess competition in a genre, the Bertrand-like nature of competition drives down profits, making the genre less attractive to producers. Since consumers purchase many products, this competition is not as extreme as in other settings with perfect substitution across goods. Here, the competition is just enough for efficient sorting. The second force is the alignment of producer incentives and efficiency. When producers know their quality, they know which of their competitors they are preferred to. They are hence able to perfectly anticipate demand. The best producers produce in to the genres with the highest demand c_g, and their competitors anticipate this.

However, this is exactly what a social planner would do to maximize total surplus: have the best goods consumed by the most consumers. This sorting force continues down the market.

These two forces independently push producers to sort efficiently. In order for inefficiencies to arise in the market, both forces must be removed. This explains why it is exactly the combination of producer uncertainty and fixed pricing that leads to a failure of the market. The restrictions in part (iv) rule out uninteresting edge cases. First, the requirement that $|\operatorname{supp}\psi^*| > 1$ is necessary to rule out degenerate cases where $\psi^* = \delta_g$ for some $g \in G$.[9] Second, genericity is with respect to the distribution of type T. It is necessary to rule out settings such as $T_g = T_{g'}$ for all g, g' (where $\psi_g^* = \psi_g^p = \frac{1}{G}$ for all g, p).

5 Uncertainty and Pricing Frictions: Allocative Inefficiency

In this section I study the inefficiencies that arise when the two frictions—producer uncertainty and fixed pricing—interact. For the remainder of this section, I focus on the UF setting. I first explicitly characterize the (unique) equilibrium of this game and the efficient allocation. I then discuss the differences between the two.

5.1 Equilibrium

Facing competition $\psi \in \Delta G$, a producer's expected profits from entering genre g are

$$p \cdot \int_0^\infty \min\left\{\overline{F}(p), \frac{t}{\psi_g}\right\} dT_g(t)$$

If $\psi_g = 0$, then producers face no competition in genre g. This means that all consumers of type (g, t) will be willing to consume their product, for any t. Their product will be consumed by all agents if its realized quality is above the fixed market price p. Expected profits in this case are given by $p\overline{F}(p)c_g$. If $\psi_g > 0$, then consumers are constrained and become picky about which goods they consume. The probability that an individual producer's good is consumed by a constrained consumer with time constraint t is $\frac{t}{\psi_g}$, since a product must be in the upper t mass of content to be consumed. As ψ_g becomes large, the probability of being consumed by any individual consumer decreases. Other genres then become relatively attractive, and producers

[9] As I show below, $\psi^* = \delta_g$ implies that $\psi^{UF} = \delta_g$ for the same $g \in G$, so that the two agree.

will shift away from genre g.

A competitive equilibrium, then, is an allocation of producers such that each producer is operating in a genre that maximizes its expected profits.

Definition 5. A competitive equilibrium at price $p \geq 0$ is an allocation of producers $\psi \in \Delta G$ such that

$$\psi_g > 0 \Rightarrow g \in \operatorname{argmax} \int_0^{\infty} \min\left\{\overline{F}(p), \frac{t}{\psi_g}\right\} dT_g(t)$$

If $\psi_g > 0$, then some mass of producers is operating in genre g. Hence, it must be that genre g maximizes expected profits across all genres. This does not necessarily imply that profits are the same across all genres. If demand is sufficiently low in genre g, it may not be sufficiently attractive to producers even in the face of zero competition. In this case, $\psi_g = 0$.

Since p is constant, I drop the leading p from the definition in order to extend the definition to a price of $p = 0$. This setting represents those in which producers benefit from consumption, but consumers do not directly pay producers (e.g., through advertising revenue). Given that profits in any genre g are strictly decreasing in ψ_g, there is at most one competitive equilibrium.

Lemma 1. *For any $p \geq 0$, a unique competitive equilibrium allocation exists. Denote this allocation of producers $\psi^p \in \Delta G$.*

Of importance is the set of genres that receive some producers in the unique competitive equilibrium. I call these genres "active" since some content is being produced in these genres.

Definition 6. Given a price $p \geq 0$, define the set of *active* genres in the competitive equilibrium at price p as $A^p := \left\{g \in G | \psi_g^p > 0\right\}$.

5.2 The Efficient Allocation

I now solve explicitly for the efficient allocation of producers across genres. Since the market price is no factor, consumers derive positive net utility from consuming any product whose valuation is positive. Consider first the effect of increasing the mass of producers ψ_g in a given genre g. More specifically, consider how a consumer of type (g, t)'s utility increases in ψ_g. Defining $W(x) := \int_{\overline{F}^{-1}(x)}^{\infty} vf(v)dv$, this consumer's utility is given by

$$\psi_g W\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\}\right)$$

There are two cases to consider.

Case 1: $t > \psi_g \overline{F}(0)$**.** Here, the consumer's time constraint does not bind. Hence, he is willing to consume any new content whose realized value is positive so that his marginal increase in utility is equal to

$$\int_0^{\infty} vf(v)dv$$

Case 2: $t \leq \psi_g \overline{F}(0)$**.** In this case, the consumer's time constraint does bind. There are two differences between this case and case 1. First, the consumer only consumes new content whose realization is above his threshold of consumption $\overline{F}^{-1}\left(\frac{t}{\psi_g}\right)$. Second, if he does consume this new content, he must replace existing consumption. He does so by first stopping to consume the content that is exactly at his threshold; content of value $\overline{F}^{-1}\left(\frac{t}{\psi_g}\right)$. Hence, his increase in utility is given by

$$\int_{\overline{F}^{-1}\left(\frac{t}{\psi_g}\right)}^{\infty} \left(v - \overline{F}^{-1}\left(\frac{t}{\psi_g}\right)\right) f(v)dv$$

Define

$$M(x) := \int_{\overline{F}^{-1}(x)}^{\infty} \left(v - \overline{F}^{-1}(x)\right) f(v)dv$$

Putting together the two cases above, we have the following result.

Lemma 2. *The efficient allocation of producers ψ^* is the allocation of producers such that*

$$\psi_g^* > 0 \Rightarrow g \in \operatorname{argmax} \int_0^{\infty} M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g^*}\right\}\right) dT_g(t).$$

If F satisfies Assumption 1, M is strictly convex.

The discussion above shows that M captures the marginal increase in utility for consumers due to an increase in ψ_g. This first-order condition pins-down the optimal allocation since individual consumer utility is concave in ψ_g.

Definition 7. Define the set of active genres in the efficient allocation $A^* := \left\{g \in G | \psi_g^* > 0\right\}$.

5.3 Allocative Inefficiency: Theorem 1(iv)

Given the discussion above, the reason for why there is allocative inefficiency when both market frictions are present is clear. In the equilibrium allocation,

$$\int_0^\infty \min\left\{\overline{F}(p), \frac{t}{\psi_g}\right\} dT_g(t)$$

is equal across all active genres. In the efficient allocation, on the other hand,

$$\int_0^\infty M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\}\right) dT_g(t)$$

is equal for all active genres. By Lemma 2, M is strictly convex (and in particular, not linear). Since the distributions T_g have no ex-ante relationship, there is no reason why equality across one expectation would imply equality for the other expectation. Hence, the two allocations generally differ.

5.4 The Form of the Failure

Theorem 1 highlights the robust existence of allocative inefficiency in markets where producers are unaware of their own quality at the time of their production choice and pricing frictions are present. However, it provides no insight into what form the market failure takes. In this section I show that the theory admits consistent predictions in terms of how this failure manifests. In particular, allocative inefficiency leads to a smaller range of products in competitive equilibrium than is socially optimal.

Definition 8. I say that allocation from setting S features *less range* than S' if $A^S \subseteq A^{S'}$.

This ordering of allocations is incomplete: if A^S and $A^{S'}$ are not nested then they cannot be compared. Importantly, the strictness of this definition captures exclusively settings where moving from market structure S to market structure S' leads to a widening of produced content, without losing any genres.

Theorem 2. *For all F and T satisfying Assumption 1 and Assumption 2,*

(i) If $0 \leq p < p'$ the competitive equilibrium with price p' features less range than that with price p: $A^{p'} \subseteq A^p$;

(ii) All competitive equilibria have less range than the platform's optimal allocation: for all $p \geq 0$, $A^p \subseteq A^*$.

Each inclusion may be strict.

This result highlights the specific ways in which producers deviate from the socially efficient allocation of production. In particular, it predicts that competitive equilibria are too concentrated, relative to the socially efficient level: content is not sufficiently diverse. I first describe the intuition, and then give an outline of the proof of the result.

When individual producers choose genres, they maximize expected profits. They do not internalize the effect that a high-value realization of their quality has on lower-value producers. If producer quality is known, then these low-value producers will respond by moving to a less-competitive genre. When quality is not known ex-ante, producers are hence driven to compete too much in genres where demand is high, because the profits following a realization of high quality is very large.

The platform behaves differently than these producers in two regards. First, hedges against uncertainty as it controls the entire mass of producers. Second, and more importantly, it internalizes the impact of this displacement through M. When a genre is concentrated, the platform benefits little from increasing production in that genre, since it leads to displacement of already high-quality goods. This leads the platform to produce a wider range of content than individual producers in competitive equilibrium.

Proof Outline. In both equilibria and the efficient allocation, genres are "added" in order of c_g. This means that in all cases comparing range is possible (i.e., there will be nesting). To see (i), expected profits at ψ^p are given by (after normalizing by p)

$$\int_0^\infty \min\left\{\overline{F}(p), \frac{t}{\psi_g}\right\} dT_g(t) = \overline{F}(p)\overline{T}_g\left(\psi_g\overline{F}(p)\right) + \int_0^{\psi_g\overline{F}(p)} \frac{t}{\psi_g} dT_g(t)$$

A genre g' is active if and only if

$$\overline{F}(p) \cdot c_{g'} > \overline{F}(p)\overline{T}_g\left(\psi_g \overline{F}(p)\right) + \int_0^{\psi_g \overline{F}(p)} \frac{t}{\psi_g} dT_g(t)$$

for some (equivalently, all) active g. We can rewrite this as

$$c_{g'} > \overline{T}_g\left(\psi_g \overline{F}(p)\right) + \frac{1}{\overline{F}(p)} \int_0^{\psi_g \overline{F}(p)} \frac{t}{\psi_g} dT_g(t)$$

While the left-hand side is constant in p, it can be shown that the right-hand side is increasing in p. Hence, it becomes harder for this condition to be satisfied as p increases. The intuition is straightforward: as the price p increases, it becomes harder for producers to be "above the bar". This decreases relative concentration in high-demand genres since fewer of my competitors will be above the bar. At the same level of production in a genre, then, the genre is relatively more attractive. This decreases the congestion effect that pushes producers to explore new genres.

By (i), it is sufficient to check (ii) in the case of $p = 0$. At an allocation ψ, a genre would become active in the $p = 0$ competitive equilibrium if and only if

$$\overline{F}(0)c_{g'} > \int_0^{\infty} \min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\} dT_g(t)$$

In the integrated optimal allocation, a genre is active if and only if

$$M(\overline{F}(0)) \cdot c_{g'} > \int_0^{\infty} M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\}\right) dT_g(t)$$

Now, $\min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\} dT_g(t)$ represents the distribution of a random variable distributed on the interval $[0, \overline{F}(0)]$. Similarly, $c_{g'} \circ \overline{F}(0) + (1 - c_{g'}) \circ 0$ is also a random variable distributed on the same interval. If the first condition holds, then the mean of the first random variable is smaller than the mean of the second. Since M is strictly convex with $M(0)$, this implies that if the first condition holds then the second condition holds.

6 The Effects of Other Market Characteristics

In this section I present additional results to show how allocative inefficiency changes as the market changes. I first show how allocative inefficiency changes when the fixed price depends on realized quality. I then perform comparative statics on the distribution of consumer preferences T_g and on the distribution of quality F.

6.1 Quality-Dependent Fixed Pricing

Theorem 1(iv) and Theorem 2 show that when prices are fixed and flat, ex-ante uncertainty over producer quality leads to inefficiencies in producer sorting. It is natural to ask what role flat pricing plays in driving this market inefficiency. I motivated a market with inflexible flat pricing by its well-documented presence in these industries.[10] Intermediaries (e.g., record stores and movie theatres) set prices, and do so without necessarily considering the effects these prices have on producer incentives. Intuition suggests that if firms captured (some of) the value of their product through price discrimination, allocative inefficiencies would lessen. I show in this section that the opposite occurs.

Motivating Example, cont. *Suppose now that in the fixed-pricing regime, the market price of a good depends on its quality: let $p(v) = \alpha v$ for some $\alpha \in (0, 1)$.*

Proposition 1, cont. *Suppose that pricing is fixed but variable ($p(v) = \alpha v$) and producer quality is uncertain. If $\mu > \frac{9}{14}$, then in the unique equilibrium both producers produce in genre 1. In particular, $\frac{9}{14} < \frac{2}{3}$.*

When producers charge higher prices for higher-value goods, the degree of allocative inefficiency *increases*. Theorem 2 shows that producers are too concentrated in equilibrium. This means that they over-serve high-demand genres, so that consumers in these genres consume content that is of higher value than is socially optimal. When prices depend on realized quality, producers place *more* weight on these consumers: conditional on the producer's product being consumed by these consumers, it must be of high value, so that the product commands a large price. On the other hand, under-served genres are attractive in the competitive equilibrium because there is little competition. But little competition means that products are consumed even

[10] See Hennig-Thurau, Houston, et al. (2019).

if they are of low-value and hence command a low price. This intuition and result extends beyond the motivating example into the framework of the main model.

Definition 9. A pricing function $P : \mathbb{R} \to \mathbb{R}_+$ is called *admissible* if P is differentiable with $P'(v) \in [0, 1]$ for all v and $P(0) \geq 0$.

Admissibility ensures that net utility is increasing in the quality of the good. While in many markets it is common for higher-quality goods to be priced so as to dissuade consumption by some consumers, this is unlikely to occur in content markets. Admissible pricing functions represent a deviation from flat pricing that maintains the spirit of consumers consuming the best content that is available to them.

Admissibility ensures that there exists a minimum quality $\underline{v}_P \in \mathbb{R}_+$ such that $v \geq P(v)$ if and only if $v \geq \underline{v}_P$. Call this value the "base price" of pricing function P. With this language it is possible to reinterpret the pricing function as containing a minimum price $\underline{v}_P$, and then some additional quality surcharge $P(v) - \underline{v}_P$ above this price.

Proposition 2. *For any admissible pricing function P, there exists a unique competitive equilibrium allocation of producers ψ^P. Fix two admissible pricing functions P_1, P_2 with $\underline{v} := \underline{v}_{P_1} = \underline{v}_{P_2}$. If $\frac{P_2(v)}{P_1(v)}$ is increasing on $[\underline{v}, \infty)$, then the competitive equilibrium under pricing function P_2 features less range than that under P_1: $A^{P_2} \subseteq A^{P_1}$.*

Proposition 2 shows that increasing the quality surcharge decreases the range of products that are produced in the equilibrium. Hence, the more that firms are able to extract the value of their good, the more the competitive equilibrium is pushed away from the socially optimal allocation. An important corollary of Proposition 2 is that adding any price differentiation to the flat-price competitive equilibrium will decrease the range of products that are offered.

Corollary 1. *For any admissible P, the competitive equilibrium under P features less range than the flat-price equilibrium at P's base price: $A^P \subseteq A^{\underline{v}_P}$. That is, $A^P \subseteq A^{\underline{v}_P} \subseteq A^0 \subseteq A^I$ for all admissible P.*

In this section I have showed the prevalence of allocative inefficiency when producers are uncertain over their own quality. In the following section I perform comparative statics on the primitives of the model in order to show how these primitives influence the allocation of producers across genres.

6.2 The effect of "super-fans."

An important dimension of difference across genres is the degree of heterogeneity within a genre. Consider two genres g, g' with the same total demand: $\mathbb{E}_{T_g}[t] = \mathbb{E}_{T_{g'}}[t]$. If $T_{g'}$ is a mean-preserving spread of T_g, the population of consumers who consume content of genre g is more heterogeneous than those who consume content from genre g'. In particular, there will be more "super-fans" in genre g'—consumers who consume a large amount of content—and also more consumers who consume only a small amount, or no, content.

In the competitive equilibrium, increasing heterogeneity in consumers through a mean-preserving spread results in some consumers consuming more and other consumers consuming less. The increased consumption is now of lower-value goods than the demand that is lost, however. This suggests that more producers will produce in genre g than in genre g': super-fans dampen the attractiveness of a genre.

For the efficient allocation, the story is more nuanced. Due to the concavity of W, a more heterogeneous population of consumers means that at the same level of production $\psi_g = \psi_{g'}$, genre g' will produce lower profits than genre g. When the mass of producers is small, this suggests that, analogous to the competitive equilibrium, there are more producers assigned to genre g. However, when the mass of producers is large, the result flips, and g' receives more attention. The reasoning is as follows: high-demand consumers necessarily consume low-value goods. Increasing the mass of producers in a genre benefits these high-demand consumers more than it benefits low-value consumers, both because they consume more of the new content (because of their higher overall demand) and because they replace worse content. Convexity of M implies that this increase in benefit is increasing in the demand of consumers, so that by spreading out the mass of consumers, the genre becomes more attractive to the platform. These results are summarized in the following proposition.

In the model, I fix the mass of producers to be one, for ease of exposition. For the following result, I denote the mass of producers by m and allow it to vary.

Proposition 3. *Consider two genres g, g' with $T_{g'}$ a mean-preserving spread of T_g.*

(i) More producers produce in genre g than genre g' in every competitive equilibrium: $\psi_g^p \geq \psi_{g'}^p$ for all admissible $p \geq 0$.

(ii) If $\overline{T}_{g'}(0) < \overline{T}_g(0)$, then there exists $\underline{m}$ such that for all $m \leq \underline{m}$, $\psi_g^* \geq \psi_{g'}^*$; but

(iii) There exists an $\overline{m}$ such that, for all $m > \overline{m}$, $\psi_g^* \leq \psi_{g'}^*$.

Proposition 3 highlights the nuance in the degree of concentration across market structures. As discussed in the proof sketch of Theorem 2, c_g is a sufficient statistic for the order in which different genres are activated, in both competitive equilibria and the efficient allocation.[11] However, Proposition 3 shows that once a genre is active, how much attention it receives depends finely on the distribution of demand within that genre, and the market structure. Competitive equilibria rewards genres where many producers consume a small amount of the good, and those in which consumers are similar to one another. The behaviour in the efficient allocation is more nuanced: the planner behaves like the competitive equilibrium when its resources m are small, but directs attention towards genres with many "super-fans", in order to benefit from their consumption of a large amount of content if the mass of producers m is large.

6.3 The role of the distribution of realized quality F.

By Theorem 1, when prices are fixed, uncertainty over quality is necessary and sufficient for allocative inefficiency to exist. It is hence important to understand how changes in this underlying uncertainty affect the allocation of producers in different market structures. An important feature of the distribution of quality realization that will be important is the weight of the tails of the distribution. In this section, I show that when the right tail of F is thin, the efficient allocation is more diverse, relative to when the tails of F are thick.

At a high level, when the tails of F are thin, $\overline{F}^{-1}\left(\frac{t}{\psi_g}\right)$ converges quickly, as a function of ψ_g. When F has thicker tails, $\overline{F}^{-1}\left(\frac{t}{\psi_g}\right)$ converges more slowly. When the tails of F are small, in its tails, an extremely large increase in ψ_g is necessary to move the upper quantile of the measure by a small amount. On the other hand, if the tails of F are thick, even in the tails of the distribution there is significant mass, so that the upper quantiles are far apart. I show first how these changes influence outcomes in the setting of the motivating example.

Motivating Example, cont. *Suppose that the distribution of quality is now uniform*

[11] By order, I mean as a function of increasing the mass of producers m.

over $[1, b]$, for some $b > 1$. As b increases, the tails of the distribution expand. As $b \to 1$, the distribution of quality is more concentrated.

Proposition 1, cont.

(ii) Consider now how outcomes in the uncertain-producer fixed-pricing setting changes as b changes.

(a) If $\mu > \frac{2}{3}$, there is a unique equilibrium of the flat-price scheme where both producers produce in genre 1.

(b) If $\mu > \frac{3+3b}{4+5b} \in \left[\frac{3}{5}, \frac{2}{3}\right]$, then there is a unique equilibrium of the variable-price scheme where both producers produce in genre 1.

(c) If $\mu < \frac{3}{2} \cdot \frac{1+b}{1+2b} \in \left[\frac{3}{4}, 1\right]$, both producers producing in genre 1 is strictly inefficient.

When pricing is flat, the effect of changing the distribution of quality has no effect on the equilibrium allocation of producers. However, in the variable-price equilibrium and in the efficient allocation, increasing the size of the tails increases the level of concentration.

The translation into how the efficient allocation incorporates tail weight is as follows. For intuition, imagine increasing the mass of producers m from zero (as in Section 6.2). The efficient allocation first focuses on the genre g that has the largest overall demand c_g. As m increases, all producers are assigned to this genre g until the benefit from increasing ψ_g decreases to the point that other genres become sufficiently attractive. When the tails of F are thin, this decrease happens quickly by the above observation: consumer value thresholds increase slowly, so that their utility increase from increasing ψ_g is small. On the other hand, if the tails of F are thick, this benefit decreases more slowly: there is sufficient mass in the tails for the efficient allocation to benefit from continuing to increase ψ_g. This suggests that as the tails of F increase in mass, the efficient allocation concentrates its effort on fewer genres.

In the competitive equilibrium, the effect depends dramatically on how sensitive pricing is to realized quality. If pricing is flat, as long as $\overline{F}(p)$ doesn't change, changing the weight of the tails has no effect on producer incentives. However, if price increases with quality, a similar force encourages producers in the same direction as the platform: the benefit of high-quantile realizations increases, increasing concentration.

These results are summarized in the following proposition. In order to capture the effects of increasing the tail weight of the distribution, I consider a transformation to quality that "spreads-out" its realizations: a transformation $\tau(v)$ such that τ is convex. In what follows, let A^S_τ denote the active set in market structure S following the transformation τ (and similarly ψ^S_τ).

Proposition 4. *Fix a transformation of quality $v \mapsto \tau(v)$ with τ strictly increasing and $\tau(0) = 0$, such that F_τ also has increasing hazard rates. Let $P(v) = \alpha v$ for some $\alpha \in (0, 1)$.*

(i) If τ is convex, product range decreases: $A^* \supseteq A^*_\tau$ and $A^P \supseteq A^P_\tau$.

(ii) If τ is concave, product range increases: $A^* \subseteq A^*_\tau$ and $A^P \subseteq A^P_\tau$.

(iii) This change has no effect on the $p = 0$ competitive equilibrium: $\psi^0 = \psi^0_\tau$.

The assumption that $\tau(0) = 0$ is to ensure that $\overline{F}(0) = \overline{F}_\tau(0)$ so that the two settings are directly comparable. Proposition 4 highlights an interesting tension between flat pricing and price-dependent pricing. As observed in Proposition 2, allowing firms to differentiate based on price drives an additional wedge between the competitive equilibrium and the platform-optimal allocation. This result shows that this isn't due to producers more closely mimicking the efficient allocation when pricing is flat. Instead, flat-pricing simply maximizes the agnosticism of producers towards underlying uncertainty. On the other hand, when producers do internalize the distribution of quality, their behaviour changes in the same way as the efficient allocation's in response to changes in underlying uncertainty.

7 Other Market Structures

As highlighted above, the market structure of these industries has changed radically with digitalization. Given the inefficiencies present in the market, it is natural to ask how these changes to the market structure will interact with these existing market frictions. In this section I explore several alternative market structures, and show how each leads to unique allocative inefficiencies.

7.1 Monopolist Producer

The above model assumes that producers are of measure zero. In practice, many creative projects are funded and produced by large firms (e.g., the "Big Three" music labels). I now consider how the allocation of producers changes when there is a single monopolist assigning many small producers across genres. This single firm still faces individual uncertainty over producer quality and the fixed market price p, but is able to hedge against uncertainty in quality realization because it receives profits from each individual producer. The firm's problem is:

$$\max_{\psi} \sum_{g \in G} \psi_g \int_0^{\infty} p \min\left\{\overline{F}(p), \frac{t}{\psi_g}\right\} dT_g(t)$$
$$\text{s.t. } \psi \in \Delta G$$

Importantly, the firm's revenue from consumers with t with $t \leq \psi_g \overline{F}(p)$ does not increase when ψ_g increases. Unlike in the decentralized equilibrium where producers do not internalize the effects of business-stealing, here the effect of business-stealing is internalized, but in an extreme way. Given the fixed market price, the firm does not care whether the products that it produces are of extremely high quality, or barely acceptable. Hence its incentive to continue production in a genre decays much more quickly than in the efficient allocation or the competitive equilibrium. As above, I allow for the continuous extension at $p = 0$.

Proposition 5. *There exists a unique allocation $\psi^{M,p} \in \Delta G$ that maximizes the monopolist's profits. Let $A^{M,p} := \left\{g \in G | \psi_g^{M,p} > 0\right\}$. Then*

(i) $A^p \subseteq A^{M.p}$*;*

(ii) If $0 \leq p \leq p'$, $A^{M.p'} \subseteq A^{M.p}$*;*

(iii) $A^* \subseteq A^{M.0}$*; and*

(iv) There exists a price $\overline{p} \geq 0$ *such that for all* $p \geq \overline{p}$, $A^{M.p} \subseteq A^*$*.*

The first result says that, given a fixed market price, a monopolist producer will producer more diverse content than in the corresponding decentralized equilibrium. As in the decentralized equilibrium, however, as the market price increases, products become more concentrated. Finally, the last two results show that in this setting there may be inefficiently too little, or inefficiently too much range, depending on the market price.

In practice, these markets feature a mixture of small and large firms. Proposition 5 and Theorem 2 show how the market behaves at the extremes of decentralization and centralization. Taken together, these results predict that as market concentration increases between the extremes, diversity of content will also increase.

7.2 Subscription Services

Now ubiquitous, subscription services for consuming content are relatively new. Under this model, consumers pay a fixed fee for unlimited access to the content on the subscription service. I here consider a monopolist platform, who assigns producers across genres and then sells genre-specific subscriptions to consumers. The platform aims to maximize its revenue. Its problem is equivalent to

$$\begin{aligned} &\max_{t_g,\psi} \sum_{g\in G} \psi_g W\left(\frac{t_g}{\psi_g}\right)\overline{T}_g(t_g) \\ \text{s.t. } & t_g \in [0, \psi_g \overline{F}(0)] \\ & \psi \in \Delta G \end{aligned}$$

Since the platform must set a single price for each genre, setting a price is equivalent to choosing a consumer threshold t_g, such that all consumers (g, t) with $t \geq t_g$ purchase the subscription. This threshold consumer receives total utility $\psi_g W\left(\frac{t_g}{\psi_g}\right)$ from consuming the subscription, and so this is the price that the platform charges for access to this genre.[12] In order for the solution to be well-behaved in this context, stronger assumptions are needed on the distributions T_g:

Assumption 2. T_g is *regular*. That is,

$$t - \overline{T}_g(t) \Big/ \frac{dT_g}{dt}(t)$$

is weakly increasing in t on the support of T_g. Moreover, apart from zero, T_g is twice

[12] It is without loss to consider $t_g \leq \psi_g \overline{F}(0)$, since each consumer with $t > \psi_g \overline{F}(0)$ consumes all acceptable content.

differentiable.

Proposition 6. *Suppose that Assumption 2 holds. There exists a unique* $(\psi^{S.M}, t^{S.M}) \in \Delta G \times \mathbb{R}_+^G$ *that maximizes the platform's profits. Letting* $A^{S.M} := \{g \in G | \psi_g^{S.M} > 0\}$, $A^* \subseteq A^{S.M}$.

When the platform relies on subscriptions, the content that is produced is inefficiently *diverse*. As in Section 7.1, the platform using a subscription service internalizes the duplication of effort that comes from increasing the allocation of producers to a genre. However, the main mechanism pushing for diverse content in this market structure is different. Unlike in the case of a monopoly producer concerned with duplicating acceptable content, the monopolist using subscription pricing recoups some of the benefit from this increased production. Holding the consumer base t_g fixed, the price that the monopolist charges increases in ψ_g.

Instead, consumer heterogeneity is the driver that leads the subscription monopolist to produce inefficiently diverse content. When $\psi_g = 0$, consumer heterogeneity within genre g does not matter at the margin: (almost) all consumers within the genre have the same utility for $\psi_g \approx 0$. However, when ψ_g is large, many consumers are constrained, leading to large variety in consumer willingness to pay for the subscription. This suggests that the monopolist has an increased incentive to increase the allocation of producers to small genres, since consumers look "more similar" in these genres. This leads to inefficient diversity in content produced in equilibrium.

7.3 Recommendation System

In many settings, platforms act as intermediaries without directly coordinating production. These intermediaries act as *recommendation systems*, matching consumers with content for them to consume. In this section I show how recommendation systems' ability to artificially suppress content can influence producer incentives in order to increase overall welfare.

In this setting, a recommendation system is simply a black-box which connects consumers to products. In the baseline competitive equilibrium, there are no informational frictions: consumers are always able to find and consume the content that gives them the highest utility. Hence, unlike in other models of recommendation systems where the primary purpose of recommendation systems is to expose consumers to products that they wouldn't otherwise see, in my model the recommendation serves the opposite role. To see how the recommendation system can be beneficial in this setting, consider again the motivating example of Section 2.

Motivating Example, cont. *Consider an intermediary who can artificially suppress content. This intermediary can commit to rejecting a product from the market, based on the product's genre and quality. In the flat pricing scheme, if* $\mu \gtrsim \frac{2}{3}$*, by rejecting content in genre 1 below some threshold* $\tau \geq 1$*, the platform decreases expected profits from genre 1. If* τ *is sufficiently large, this risk of suppression encourages produces to diversify across the two genres. Whether this increases consumer utility is ambiguous. There is a welfare loss relative to the first-best because realizations of quality in* $[1, \tau]$ *for the producer who produces in genre 1 will be rejected. However, if* $\mu < \frac{9}{10}$*, then there are also welfare gains because the decentralized equilibrium is inefficient. As long as* τ *is not too large, this second force dominates and suppressing content improves welfare.*

By committing to selectively *not* recommend (i.e., suppress) some content, the platform influences producer incentives. This allows the recommendation system to indirectly shift the allocation of producers across genres. Since the decentralized equilibrium is inefficient, the suppression of content—which has a first-order effect of destroying surplus—may increase overall welfare by resulting in a more efficient allocation of producers across genres. Notice, however, that there is scope for a recommendation system to influence production in this way only if there is ex-ante uncertainty over quality. If producers knew their quality ex-ante, then any suppression of content results in a decrease in overall welfare, as producers are already sorting efficiently.

In my setting, a recommendation system is simply a collection of "sub-genres" $\mathcal{S}$. Each sub-genre s consists of (i) a genre g_s, to which content produced in the sub-genre belongs, and (ii) a recommendation function $r_s : \mathbb{R} \times \mathbb{R}_+ \to [0, 1]$. The recommendation function $r_s(v, t)$ is the probability of a consumer of type (g_s, t) is shown a specific piece of content with quality v from the sub-genre. In order to map directly into settings where these recommendation systems persist, I assume that producers generate profits proportional to the mass of consumers that consume their content.[13]

The timing is as follows. The platform commits to a recommendation system $\mathcal{S}$, observed by producers. Producers then make genre choices, and their quality is realized. The platform then bundles goods according to r_s. Consumers consume the products in their bundle, and producer profits are realized.

I focus on the scope for the recommendation system to increase total surplus. Hence, the objective of the recommendation is to maximize consumer welfare, subject to incentive compatibility constraints on producers, and the recommendation functions r_s.

Definition 10. A recommendation system is a set of sub-genres $\mathcal{S}$ and an allocation $\tilde{\psi} \in \Delta\mathcal{S}$ such that

$$\sum_{g \in G} \int_0^\infty \left(\int_{\max\{v_g(t),0\}}^\infty v d\mu_{g,t}(v) \right) dT_g(t)$$

such that

$$\begin{aligned} d\mu_{g,t}(v) = &\sum_{s=(g,r_s)} \tilde{\psi}_s r_s(v,t) f(v) dv, \quad \text{for all} \quad v, g \\ \mu_{g,t}([v_g(t),\infty)) = &t, \quad \text{for all} \quad g, t \\ \tilde{\psi}_s > 0 \iff s \in &\operatorname*{argmax}_{s \in \mathcal{S}} \int_0^\infty \left(\int_{\max\{0,v_g(t)\}}^\infty r_s(v,t) f(v) dv \right) dT_g(t) \end{aligned}$$

The recommendation system aims to maximize the total utility of consumers in its platform, subject to the constraints that (i) consumers are only able to consume content that they are recommended, and (ii) producers produce the content that yields the highest expected profits.

Lemma A.7 in the appendix shows that every optimal mechanism behaves like a recommendation system where the platform defines a *genre-specific* minimum threshold of content, and recommends any content above this minimum threshold to all consumers. Hence, the optimal suppression of content takes the form of content curation: it may be difficult for a product to be accepted onto the platform, but once

[13] Spotify, for instance, pays producers based off of their "stream-share", which due to the large number of total streams, effectively grows linearly in an artist's own streams.

a product is accepted it becomes available to all consumers. Equipped with this straightforward (albeit nuanced) maximization problem, I now state the major result of this section.

Proposition 7. *Fix an optimal mechanism* (p^R, ψ^R) *and the corresponding active set* $A^R = \{g | \psi_g^R > 0\}$.

(i) It is possible that the optimal mechanism strictly improves on the $p = 0$ *competitive equilibrium;*

(ii) $A^0 \subseteq A^R \subseteq A^*$.

Both inclusions in (ii) may be strict.

The intuition for this result is the same as the intuition from the motivating example. By suppressing content in a high-demand genre, producers' incentives may disproportionately shift them towards producing in a smaller genre. Due to the inefficiency of the original sorting, this benefit may be large enough to offset the loss from suppressed content. However, there are limits to this effect. It is never optimal for the recommendation system to produce more diverse content than is efficient. This is intuitive: it is inefficient, and for the recommendation system to encourage producers to produce this content would require the recommendation system to suppress additional content—both forces suggest that decreases welfare.

8 Conclusion

Entertainment products are ubiquitous, and important for consumer welfare. Understanding how prevailing market structures interact with producer incentives is integral to understanding and predicting how the distribution of products will evolve as market structures continue to change. I construct a straightforward model of producer incentives and show that ex-ante uncertainty over own quality together with pricing frictions drives an allocative market failure: producers sort across product types inefficiently. I show that this allocative inefficiency manifests in the form of increased concentration: there is too little diversity in products. I also show how alternative market structures influence this inefficiency. In particular, I show that a recommendation system is able to overcome some of this inefficiency by selectively suppressing some content. By suppressing content in high-demand genres, the recommendation system encourages producers to explore the genres inefficiently ignored in competitive equilibrium.

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A Proofs

A.1 Proof of Theorem 1

In this section I prove Theorem 1.

Existence and Uniqueness of Efficient Allocations. I first show the existence and relevant uniqueness of ψ^* and Ψ^*.

Complete Information Case. The following conversion will be useful throughout the proofs. In each genre, consider that $T_g(t)$ is the mass of consumers that will consume up to t units of content in genre g. Due to the lack of spillovers from the consumption of content, define the residual demand curve in each genre as follows:

$$D_g(d) = \overline{T}_g(d)$$

A good for which there is mass d of other goods in genre g with higher value will face $D_g(d)$ demand for its good. Note that $D_g(0) = c_g$.

It is efficient to send the highest quality producers to the genre for which there is the largest residual demand. That is, let

$$D(d) = \sum_{g \in G} D_g(d)$$

Since there is a unit mass of consumers, $D(0) = 1$. Moreover, by the full support assumptions on T_g, D is strictly decreasing on its domain (and so it has an inverse). It is efficient for a good of quality $v = \overline{F}^{-1}(q)$ to garner demand $D^{-1}(q)$ as long as $v > 0$. To find the efficient allocation, demand must decrease at the same rate in each genre. Let $x = D^{-1}(\overline{F}(v))$.

$$\Psi_g^*(v) = \begin{cases} 0 & \text{if} \quad D_g(x) = 0 \\ \frac{1/D_g'(x)}{\sum_{g':D_g'(x)>0} 1/D_{g'}'(x)} & \text{if} \quad D_g(x) > 0 \end{cases}$$

Incomplete Information Case. It is sufficient to show that Lemma 2 holds.

Proof of Lemma 2. Define

$$\tilde{M}_g(\psi_g) := \int_0^\infty M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\}\right) dT_g(t)$$

It is easy to see that $\tilde{M}_g$ is strictly decreasing as a function of ψ_g. Hence, there is exactly one allocation ψ such that the condition holds.

Recall the definition of $W(x) = \int_{\overline{F}^{-1}(x)}^\infty vf(v)dv$. Aggregate utility across consumers in a genre with ψ_g producers is

$$\psi_g \int_0^\infty W\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\}\right) dT_g(t)$$

It is hence sufficient to show that $\psi_g W\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\}\right)$ is concave as a function of ψ_g, for all t. As shown in the main text,

$$\frac{\partial}{\partial \psi_g} \psi_g W\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\}\right) = M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\}\right)$$

Notice in particular that there is continuity in the derivative at $t = \psi_g \overline{F}(0)$. For $t > \psi_g \overline{F}(0)$, the second derivative is clearly zero. For $t < \psi_g \overline{F}(0)$ it is sufficient to show that M is increasing. Since we must also show that M is strictly convex, I prove a stronger statement, which will be useful elsewhere.

Lemma A.1. If f has full-support, W, M are both continuous and continuously differentiable on $[0,1]$. Moreover, $W(0) = M(0) = 0$, and $W(\overline{F}(0)) = M(\overline{F}(0))$. Both functions are increasing. Finally, W is concave and M is convex if and only if f has increasing hazard rates. M is concave if and only if f has decreasing hazard rates.

Proof. This is straightforward computation. Continuity comes from the continuity of $\overline{F}^{-1}(x)$. The equalities at 0 and $\overline{F}(0)$ are easily seen from observation.

The properties of W are straightforward. It can be seen that

$$W'(x) = \overline{F}^{-1}(x)$$

Since $\overline{F}$ is decreasing in v, its inverse is also decreasing. Hence W is concave. Note that this is independent of properties of f.

I now prove the properties of M. Define $\iota(x) = \overline{F}^{-1}(x)$. Observe first that we can write $M(x) = \int_{\iota(x)}^{\infty} \overline{F}(v)dv$ (from a simple integration by parts). Now, write $I(u) = \int_{u}^{\infty} \overline{F}(v)dv$. Observe that $M(x) = I(\iota(x))$. So,

$$M'(x) = I'(\iota(x)) \cdot \iota'(x) = \frac{x}{f(\iota(x))}$$

notice that M is increasing as $x \in [0,1]$. Then,

$$M''(x) = \frac{f(\iota(x)) + xf'(\iota(x)) \cdot \frac{1}{f(\iota(x))}}{f(\iota(x))^2}$$

The sign of this object is determined by the sign of

$$f(\iota(x))^2 + xf'(\iota(x))$$

Substitute $v = \iota(x)$, so that $x = \overline{F}(v)$. Convexity is satisfied if and only if

$$\frac{f(v)}{\overline{F}(v)} + \frac{f'(v)}{f(v)} \geq 0$$

This condition is satisfied if and only if f has increasing hazard rates. This proves the claim. □

Since the objective of the designer is strictly concave in ψ_g for each g, it is sufficient to check first order conditions. This proves Lemma 2 and shows that ψ^* exists and is unique. $\square$

Proof of Theorem 1(i). Since prices are fixed at p regardless of the genre, producers choose genres to maximize the mass of consumers who consume their product. Moreover, since prices are fixed, consumers' prefer higher quality products. As producers know their value, they know the mass of producers who are preferred by consumers. Producers will hence sort into genres such that a producer of value $v > p$ will garner demand equal to $D^{-1}\left(\overline{F}(v)\right)$. This allocation is immediately seen to be identical to Ψ^* for all $v > p$, proving the claim. $\square$

Proof of Theorem 1(ii). I solve for the unique monotonic equilibrium by backwards induction. Fix a genre g and a mass of competition ψ_g in this genre. I show in the pricing subgame, expected profits in this genre are exactly

$$\int_0^\infty M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g^*}\right\}\right) dT_g(t)$$

If this is the case, then the competitive equilibrium allocation will correspond to the efficient allocation: the objective that producers aim to maximize is equal to the objective that a planner aims to maximize. In the remainder of this proof I drop subscripts on p_g, T_g, ψ_g for brevity.

Lemma A.2. In the unique monotonic equilibrium of the pricing game, the profits of a producer of quality v are

$$\Pi(v) = \int_0^v \overline{T}\big(\psi\overline{F}(z)\big)\, dz$$

Proof. I search for monotonic equilibria of the pricing game: producers with high values are consumed by more consumers. Hence, in equilibrium it must be that demand for a consumer of value v is equal to $\overline{T}\big(\psi\overline{F}(v)\big)$, assuming that $v \geq 0$.

Hence, profits for this producer are given by

$$p(v) \cdot \overline{T}\big(\psi\overline{F}(v)\big)$$

We aim to find $p(v)$ such that this is an equilibrium of the pricing game.

In order for the equilibrium to be monotone, we must have that $v - p(v)$ is weakly increasing in v. Assume for now that p is also strictly increasing where it is positive (and differentiable). A producer can hence be thought of as picking their surplus

$$s(v) = v - p(v)$$

Notice that choosing s and choosing p are equivalent. In particular, a deviation for a producer is equivalent to choosing the surplus promised by another producer type. That the pricing/surplus choices forms an equilibrium gives us that

$$v = \underset{z}{\operatorname{argmax}} \, (v - s(z)) \, \overline{T}\big(\psi \overline{F}(z)\big)$$

Consider profits for this quality realization v:

$$\Pi(v) = p(v)\overline{T}\big(\psi \overline{F}(v)\big) = \max_{z} \, (v - s(z)) \, \overline{T}\big(\psi \overline{F}(z)\big)$$

By the Envelope theorem, it must be that

$$\Pi'(v) = \overline{T}\big(\psi \overline{F}(v)\big)$$

Since the profits of quality realizations of value 0 must be zero, it is the case then that

$$\Pi(v) = \int_0^v \overline{T}\big(\psi \overline{F}(z)\big) \, dz$$

This also implies that prices are given by

$$p(v) = \frac{\int_0^v \overline{T}\big(\psi \overline{F}(z)\big) \, dz}{\overline{T}\big(\psi \overline{F}(v)\big)}$$

In particular, we have that

$$\frac{\partial}{\partial v} \left(v - p(v)\right) = \frac{\int_0^v \overline{T}\big(\psi \overline{F}(z)\big) \, dz \cdot \frac{dT}{dt} \left(\psi \overline{F}(v)\right) \cdot \psi f(v)}{\overline{T}\big(\psi \overline{F}(v)\big)^2} > 0$$

This implies that monotonicity is satisfied. I now show that no producer has an incentive to deviate.

By deviating, his profit from mimicking the surplus of type z is

$$\pi(z;v) = (v - s(z))\, \overline{T}\big(\psi \overline{F}(z)\big)$$

Let $\tilde{D}(z) := \overline{T}\big(\psi \overline{F}(z)\big)$ for brevity. We have that

$$\pi'(z;v) = -s'(z)\tilde{D}(z) + (v - s(z))\tilde{D}'(z)$$

Notice above that we derived $s'(z) = (z - s(z)) \cdot \frac{\tilde{D}'(z)}{\tilde{D}(z)}$. Recall also that $\tilde{D}'(z) > 0$. Hence,

$$\pi'(z;v) = -(z - s(z))\tilde{D}'(z) + (v - s(z))\tilde{D}'(z) = (v - z)\tilde{D}'(z)$$

Hence, π is maximized uniquely at $z = v$. This shows that we have an equilibrium. The above argument also shows that this is the unique monotonic equilibrium. □

Lemma A.3. The unique monotonic equilibrium of the pricing game yields efficient sorting of producers across genres.

Proof. It is sufficient to show that, given a mass of producers ψ_g producing in genre g, the expected profits of each producer in this genre are given by

$$\int_0^\infty \Pi(v) f(v) dv = \int_0^\infty M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\}\right) dT_g(t)$$

where by Lemma A.2

$$\Pi(v) = \int_0^v \overline{T}\big(\psi \overline{F}(z)\big)\, dz$$

Notice that this is truncated at 0 since profits below zero are zero (as products of negative value are not consumed). The result follows from a straightforward computation:

$$\int_0^\infty \Pi(v) f(v) dv = \int_0^\infty \int_0^v \overline{T}\big(\psi \overline{F}(z)\big)\, dz f(v) dv$$

$$
\begin{aligned}
&= \int_0^\infty \int_0^v \int_{\psi \overline{F}(z)}^\infty dT(t)\, dz f(v) dv \\
&= \int_0^\infty \int_{\psi \overline{F}(v)}^\infty \int_{\max\left\{0, \overline{F}^{-1}\left(\frac{t}{\psi}\right)\right\}}^v dz dT(t)\, f(v) dv \\
&= \int_0^\infty \int_{\max\left\{0, \overline{F}^{-1}\left(\frac{t}{\psi}\right)\right\}}^\infty \int_{\max\left\{0, \overline{F}^{-1}\left(\frac{t}{\psi}\right)\right\}}^v dz f(v) dv dT(t) \\
&= \int_0^\infty \int_{\max\left\{0, \overline{F}^{-1}\left(\frac{t}{\psi}\right)\right\}}^\infty \left(v - \max\left\{0, \overline{F}^{-1}\left(\frac{t}{\psi}\right)\right\}\right) f(v) dv dT(t) \\
&= \int_0^\infty M\left(\min\left\{\overline{F}(0), \frac{t}{\psi}\right\}\right) dT(t)
\end{aligned}
$$

This proves the claim. □

□

Proof of Theorem 1(iii). This proof relies on alternative timing, where producers commit to prices before committing to genres. The result also holds under the timing presented in the paper, but I have not yet typed the proof.

Since producers commit to prices before choosing genres, the choice of genre is effectively irrelevant. Producers hence set prices facing the aggregate demand curve D, and competition with measure $\mu(-\infty, v]) = F(v)$. The existence of a monotone equilibrium exists from the same argument as in the proof of (ii). That this monotone equilibrium corresponds to the efficient allocation follows from the same argument as in the proof of (i). Notice that when prices are chosen is important for this equilibrium to exist. □

Proof of Theorem 1(iv). Observe first that Lemma 1 is true since

$$
\int_0^\infty \min\left\{\overline{F}(p), \frac{t}{\psi_g}\right\} dT_g(t)
$$

is strictly decreasing in ψ_g, for all $g \in G$. Abusing notation, let $T = (T_1, ..., T_G) \in (\Delta\mathbb{R}_+)^G$. The statement of the result means that, in within the subset of $(\Delta\mathbb{R}_+)^G$ given by $\{T \in (\Delta\mathbb{R}_+)^G : |\operatorname{supp} \psi^*(T)| > 1\}$

the set of T such that $\psi^*(T) \neq \psi^p(T)$ is dense and open.

Since both

$$\int_0^\infty \min\left\{\overline{F}(p), \frac{t}{\psi_g}\right\} dT_g(t)$$

and

$$\int_0^\infty M \min\left\{\overline{F}(p), \frac{t}{\psi_g}\right\} dT_g(t)$$

are continuous, ψ^* and ψ^p will vary continuously with T. This also implies openness immediately. Denseness comes from the simple fact that M is strictly convex while $\min\left\{\overline{F}(p), \frac{t}{\psi_g}\right\}$ is piece-wise linear.

Suppose that at T,

$$\int_0^\infty \min\left\{\overline{F}(p), \frac{t}{\psi_g^p}\right\} dT_g(t) = \int_0^\infty \min\left\{\overline{F}(p), \frac{t}{\psi_{g'}^p}\right\} dT_{g'}(t)$$

and

$$\int_0^\infty M \min\left\{\overline{F}(0), \frac{t}{\psi_g^p}\right\} dT_g(t) = \int_0^\infty M \min\left\{\overline{F}(0), \frac{t}{\psi_{g'}^p}\right\} dT_{g'}(t)$$

Consider a small change in mass of T_g that spreads-out the distribution, but keeps

$$\int_0^\infty \min\left\{\overline{F}(p), \frac{t}{\psi_g^p}\right\} dT_g(t)$$

constant. Since this value is held constant, ψ^p cannot change. However, since M is convex,

$$\int_0^\infty M \min\left\{\overline{F}(0), \frac{t}{\psi_g^p}\right\} dT_g'(t) > \int_0^\infty M \min\left\{\overline{F}(0), \frac{t}{\psi_g^p}\right\} dT_g(t)$$

will be strictly increase. Hence, this new distribution T' will have $\psi^*(T') \neq \psi^p(T')$, proving that this set is dense. □

A.2 Proof of Theorem 2

In this section I present the proof of Theorem 2. Observe first the following.

Observation 1. *If $c_g > c_{g'}$, then $g' \in A$ implies that $g \in A$ for all $A = A^*, A^p$, $p \geq 0$.*

Proof of Theorem 2(i). Notice first that expected demand upon entering an inactive genre with price p is given by $c_g \overline{F}(p)$. Hence, either $A^p \subseteq A^{p'}$ or $A^{p'} \subseteq A^p$.

Consider the ex-ante demand for a given genre, given competitive equilibrium price p and mass of producers ψ, normalized by the probability of producing content whose quality is above the price (i.e., demand with no competition):

$$D_g(p, \psi) = \overline{T}_g(\psi \overline{F}(p)) + \frac{1}{\overline{F}(p)} \int_0^{\psi \overline{F}(p)} \frac{t}{\psi} dT_g(t)$$

It is straightforward to show that

$$\frac{\partial}{\partial \psi} D(p, \psi) < 0, \frac{\partial}{\partial p} D(p, \psi) > 0$$

Increasing competition of course drives down this demand. Interestingly, increasing the price has the opposite effect. The intuition is that, increasing the price causes the effect of competition to be mitigated: demand is more similar to baseline demand. These two observations will lead to the result. Suppose that $A^p \subseteq A^{p'}$ for $p < p'$. Then, there must be some $g \in A^p$ with $\psi_{g,p} \geq \psi_{g,p'}$. If $g' \in A^{p'}$, then it must be the case that

$$c_{g'} \overline{F}(p') > \overline{Q}_{p'} \iff c_{g'} > D_g(p', \psi_{g,p'})$$

It is sufficient to show that

$$c_{g'} \overline{F}(p) > \overline{Q}_p \iff c_g > D_g(p, \psi_{g,p})$$

But, we have that $D_g(p, \psi_{g,p}) \leq D_g(p, \psi_{g,p'}) < D_g(p', \psi_{g,p'})$. Hence, $A^{p'} \subseteq A^p$, proving the claim. $\square$

Proof of Theorem 2(ii). Suppose that there existed an $g \in A^0$ but $g \notin A^*$. This would imply that $A^* \subseteq A^0$ since genres are added in the same order by both. Then, it must be that

$$c_g\overline{F}(0) \geq \int \min\left\{\overline{F}(0), \frac{t}{\psi_{g'}^{CE(0)}}\right\} dT_{g'}(t)$$

for all $g' \in A^0$. Now, since $A^* \subseteq A^0$, it must be that there is some g' with $\psi_{g'}$ larger in the monopolist allocation than in the competitive equilibrium ($\psi^*_{g'} > \psi^0_{g'}$). Hence,

$$c_g\overline{F}(0) \geq \int \min\left\{\overline{F}(0), \frac{t}{\psi^*_{g'}}\right\} dT_{g'}(t)$$

Dropping the superscript, it is sufficient to show that

$$c_g M\left(\overline{F}(0)\right) \geq \int M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_{g'}}\right\}\right) dT_{g'}(t)$$

Recall that M is strictly convex. Hence, a mean-preserving spread of the distribution given by the distribution of demands in genre g' increases the value of the right hand side. Since this random variable is supported on $[0, \overline{F}(0)]$, the random variable that dominates all others in terms of mean-preserving spread is that which places mass only on $0, \overline{F}(0)$. Since $M(0) = 0$, this random variable achieves exactly the value of $c_g M(\overline{F}(0))$. This proves the claim. $\square$

A.3 Proofs for Section 6

Lemma A.4. Suppose that X, Y are two random variables, with X supported on $[0, U]$ and Y supported on $\{0, U\}$. Then, given two convex increasing functions φ, ψ with

$$\frac{\psi''}{\psi'}(u) \leq \frac{\varphi''}{\varphi'}(u)$$

for all $u \in [0, U]$, and $\varphi(0) = \psi(0) = 0$, then

$$\mathbb{E}\left[\varphi(X)\right] \geq \mathbb{E}\left[\varphi(Y)\right] \Rightarrow \mathbb{E}\left[\psi(X)\right] \geq \mathbb{E}\left[\psi(Y)\right]$$

Proof. The derivative condition implies that $\psi \circ \varphi^{-1}$ is concave. This implies that

$$\psi(u) \geq \frac{\varphi(u)}{\varphi(U)}\psi(U)$$

Taking expectations of both sides with respect to the random variable X yields

$$\mathbb{E}[\psi(X)] \geq \frac{\mathbb{E}[\varphi(X)]}{\varphi(U)}\psi(U)$$

Now, since Y takes values at only two points, $\mathbb{E}[\varphi(Y)] = p\varphi(U)$ for some p and $\mathbb{E}[\psi(Y)] = p\psi(U)$. This proves the claim. □

Proof of Proposition 2. Define

$$\Pi_i(x) = \int_{\overline{F}^{-1}(x)}^{\infty} P_i(v)f(v)dv$$

As in the proof of Theorem 2, genres are ordered by c_g, so either $A^{P_2} \subseteq A^{P_1}$ or $A^{P_2} \not\subseteq A^{P_1}$. If the latter held, then it would mean there was some $g \in A^{P_2}$ such that $\psi_g^{P_2} \leq \psi_g^{P_1}$, and some g' not active in the former but active in the latter. In particular, since $\underline{v}_{P_1} = \underline{v}_{P_2}$ this implies that

$$\mathbb{E}_g\left[\Pi_2\left(\min\left\{\overline{F}(\underline{v}), \frac{T}{\psi^*_{g,\tau}}\right\}\right)\right] < c_{g'}\Pi_2\left(\overline{F}(0)\right)$$

but

$$\mathbb{E}_g\left[\Pi_1\left(\min\left\{\overline{F}(0), \frac{T}{\psi^*_{g}}\right\}\right)\right] \geq c_{g'}\Pi_1\left(\overline{F}(0)\right)$$

Since $\psi^*_{g,\tau} \leq \psi^*_g$, this latter inequality means that

$$\mathbb{E}_g\left[\Pi_1\left(\min\left\{\overline{F}(0), \frac{T}{\psi^*_{g,\tau}}\right\}\right)\right] \geq c_{g'}\Pi_1\left(\overline{F}(0)\right)$$

I aim to apply Lemma A.4 to derive a contradiction. It is sufficient to show that, as in Lemma A.4, that

$$\frac{\Pi_1''(x)}{\Pi_1'(x)} \geq \frac{\Pi_2''(x)}{\Pi_2'(x)}$$

Now, straightforward computations yield

$$\begin{aligned}\Pi_i'(x) =& P_i\left(\overline{F}^{-1}(x)\right)\\ \Pi_i''(x) =& -\frac{P_i'\left(\overline{F}^{-1}(x)\right)}{f(\overline{F}^{-1}(x))}\end{aligned}$$

The condition hence becomes

$$\frac{P_2'\left(\overline{F}^{-1}(x)\right)}{P_2\left(\overline{F}^{-1}(x)\right)} \geq \frac{P_1'\left(\overline{F}^{-1}(x)\right)}{P_1\left(\overline{F}^{-1}(x)\right)}$$

Now, since P_2, P_1 are both positive and increasing, this is equivalent to $\frac{P_2(v)}{P_1(v)}$ being increasing on $[\underline{v}, \infty)$.

□

Proof of Proposition 3.

Proof of (i). It is sufficient to show that, for every ψ, we have

$$\int_0^\infty \min\left\{\overline{F}(p), \frac{t}{\psi}\right\} dT_{g'}(t) \leq \int_0^\infty \min\left\{\overline{F}(p), \frac{t}{\psi}\right\} dT_g(t)$$

As $\min\left\{\overline{F}(p), \frac{t}{\psi}\right\}$ is a concave function of t, for each $p, \psi \geq 0$, the claim follows from Jensen's inequality.

Proof of (ii). It is sufficient to show that, for ψ sufficiently small that

$$\int_0^\infty M\left(\min\left\{\overline{F}(0), \frac{t}{\psi}\right\}\right) dT_{g'}(t) \leq \int_0^\infty M\left(\min\left\{\overline{F}(0), \frac{t}{\psi}\right\}\right) dT_g(t)$$

As $\min\left\{\overline{F}(0), \frac{t}{\psi}\right\}$ converges in distribution to $\overline{F}(0) \cdot \mathbb{1}\{t > 0\}$ as $\psi \to 0$, the concave term dominates as long as $\overline{T}_{g'}(0) < \overline{T}_g(0)$.

Proof of (iii). It is sufficient to show that, for ψ sufficiently large, we have

$$\int_0^\infty M\left(\min\left\{\overline{F}(0), \frac{t}{\psi}\right\}\right) dT_{g'}(t) \geq \int_0^\infty M\left(\min\left\{\overline{F}(0), \frac{t}{\psi}\right\}\right) dT_g(t)$$

The intuition is that M is strictly convex, pushing the latter inequality to hold, but $\min\left\{\overline{F}(0), \frac{t}{\psi}\right\}$ is concave, pushing the former inequality to hold. Since $\psi \min\left\{\overline{F}(0), \frac{t}{\psi}\right\}$ converges in distribution to t as $\psi \to \infty$, the convex factor dominates when ψ is sufficiently large, proving the claim. $\square$

Proof of Proposition 4.

Proof of (i). Define M_τ to be

$$\int_{\overline{F}_\tau^{-1}(x)}^\infty \left(v - \overline{F}_\tau^{-1}(x)\right) f_\tau(v) dv$$

As in the proof of Theorem 2, genres are ordered by c_g, so either $A^* \supseteq A^*_\tau$ or $A^* \not\supseteq A^*_\tau$. If the latter held, then it would mean there was some $g \in A^*$ such that $\psi^*_{g,\tau} \leq \psi^*_g$, and some g' not active in the former but active in the latter. In particular, since $\overline{F}(0) = \overline{F}_\tau(0)$ this implies that

$$\mathbb{E}_g\left[M_\tau\left(\min\left\{\overline{F}(0), \frac{T}{\psi^*_{g,\tau}}\right\}\right)\right] < c_{g'} M_\tau\left(\overline{F}(0)\right)$$

but

$$\mathbb{E}_g\left[M\left(\min\left\{\overline{F}(0), \frac{T}{\psi^*_g}\right\}\right)\right] \geq c_{g'} M\left(\overline{F}(0)\right)$$

Since $\psi^*_{g,\tau} \leq \psi^*_g$, this latter inequality means that

$$\mathbb{E}_g\left[M\left(\min\left\{\overline{F}(0), \frac{T}{\psi^*_{g,\tau}}\right\}\right)\right] \geq c_{g'} M\left(\overline{F}(0)\right)$$

I aim to apply Lemma A.4 to derive a contradiction. It is sufficient to show that, as in Lemma A.4, that

$$\frac{M''(x)}{M'(x)} \geq \frac{M''_\tau(x)}{M'_\tau(x)}$$

This requires some straightforward computations. In the following, let $q = \overline{F}^{-1}(x)$. Observe that

$$M'(x) = \frac{1}{h\left(q\right)}$$
$$M''(x) = \frac{h'\left(q\right)}{xh\left(q\right)^3}$$

and

$$M'_\tau(x) = \frac{\tau'\left(q\right)}{h\left(q\right)}$$
$$M''_\tau(x) = \frac{h'(q)\tau'(q) - h(q)\tau''(q)}{xh(q)^3}$$

This is because quantiles are transferred: $\overline{F_\tau}^{-1}(x) = \tau\left(\overline{F}^{-1}(x)\right)$. The condition holds if

$$\frac{h'\left(q\right)}{xh\left(q\right)^2} \geq \frac{h'(q) - h(q)\frac{\tau''(q)}{\tau'(q)}}{xh(q)^2}$$

Since $h(q) > 0, \tau'(q) > 0$, it is easily seen that this condition is equivalent to

$$\tau''(q) \geq 0$$

Now, to compare pricing functions, the same argument goes through. Define

$$\Pi_P(x) = \alpha \int_{\overline{F}^{-1}(x)}^{\infty} vf(v)dv = \alpha W(x)$$

By the argument above, it is sufficient to show that

$$\frac{W''(x)}{W'(x)} \geq \frac{W''_\tau(x)}{W'_{\tau(x)}}$$

We have

$$
\begin{aligned}
W'(x) =& \overline{F}^{-1}(x) \\
W''(x) =& -\frac{1}{f\left(\overline{F}^{-1}(x)\right)} \\
W'(x) =& \overline{F}_\tau^{-1}(x) \\
W''(x) =& -\frac{1}{f_\tau\left(\overline{F}_\tau^{-1}(x)\right)}
\end{aligned}
$$

Now, $\overline{F}_\tau^{-1}(x) = \tau(\overline{F}^{-1}(x))$ and

$$
f_\tau\left(\overline{F}_\tau^{-1}(x)\right) = \frac{f\left(\overline{F}^{-1}(x)\right)}{\tau'\left(\overline{F}^{-1}(x)\right)}
$$

The condition hence becomes

$$
\frac{\tau'\left(\overline{F}^{-1}(x)\right)}{\tau\left(\overline{F}^{-1}(x)\right)} \geq \frac{1}{\overline{F}^{-1}(x)}
$$

Since τ is convex and increasing with $\tau(0) = 0$, this condition holds, proving the claim.

Proof of (ii). Part (i) immediately implies (ii) since τ^{-1} is concave.

Proof of (iii). Profits in genre g at allocation ψ_g are given by

$$
\int_0^\infty \min\left\{\overline{F}(p), \frac{t}{\psi_g}\right\} dT_g(t)
$$

This depends on F only through $\overline{F}(p)$. From a similar argument to Theorem 2, if $\overline{F}(p) > \overline{F}_\tau(p)$, genre g becomes relatively saturated more quickly under distribution F than under F_τ. Hence, as in the proof of Theorem 2, $A_\tau^p \subseteq A^p$. As well, this argument shows that for $p = 0$, the equilibrium allocation will not change. $\square$

A.4 Proofs for Section 7

A.4.1 Monopolist Proofs

Proof of Proposition 5. Recall the (normalized) problem of the monopolist:

$$\max_{\psi} \sum_{g\in G} \psi_g \int_0^{\infty} \min\left\{\overline{F}(p), \frac{t}{\psi_g}\right\} dT_g(t)$$
$$\text{s.t. } \psi \in \Delta G$$

Since the monopolist internalizes the business-stealing impact of duplicating effort in a genre, its first-order condition in a genre g is given by

$$\overline{F}(p)\overline{T}_g\left(\psi_g \overline{F}(p)\right)$$

Observe that this is decreasing in ψ_g, so that the problem is again concave and hence admits a unique solution. Moreover, we can write the solution to the problem as

$$\psi_G^{M,p} > 0 \Rightarrow g \in \operatorname*{argmax}_g \int_0^{\infty} \mathbb{1}\left\{\overline{F}(p) \le \frac{t}{\psi_g^{M,p}}\right\} dT_g(t)$$

Proof of (i). This follows from similar arguments as in Theorem 2. Since genres are added in the same order in both the decentralized equilibrium and the monopolist allocation, either $A^p \subseteq A^{M,p}$ or $A^{M,p} \subsetneq A^p$. In the latter case, there must be some $g \in A^{M,p}$ with $\psi_g^{M,p} > \psi_g^p$. But then, for the $g' \in A^p, g' \notin A^{M,p}$, we reach a contradiction. We must have

$$\int_0^{\infty} \min\left\{\overline{F}(p), \frac{t}{\psi_g^p}\right\} dT_g(t) < c_{g'}\overline{F}(p)$$

and

$$\int_0^{\infty} \mathbb{1}\left\{\overline{F}(p) \le \frac{t}{\psi_g^{M,p}}\right\} dT_g(t) \ge c_{g'}$$

but we also have

$$\int_0^{\infty} \min\left\{\overline{F}(p), \frac{t}{\psi_g^p}\right\} dT_g(t) > \overline{F}(p)\int_0^{\infty} \mathbb{1}\left\{\overline{F}(p) \le \frac{t}{\psi_g^{M,p}}\right\} dT_g(t)$$

This is clearly a contradiction.

Proof of (ii). This follows from a similar argument to the above: $\overline{F}(p)$ decreases in p and so genre saturation occurs more slowly the larger is p.

Proof of (iii). If we had $A^{M,0} \subsetneq A^*$, then there would exist g, g' such that the following contradiction would be reached:

$$\int_0^\infty M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g^*}\right\}\right) dT_g(t) < c_{g'} M\left(\overline{F}(0)\right)$$

and

$$\int_0^\infty \mathbb{1}\left\{\overline{F}(p) \leq \frac{t}{\psi_g^{M,p}}\right\} dT_g(t) \geq c_{g'}$$

with $\psi_g^* < \psi_g^{M,p}$ but we also have

$$\mathbb{1}\left\{\overline{F}(p) \leq \frac{t}{\psi_g^{M,p}}\right\} < \frac{1}{M(\overline{F}(0))} M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g^*}\right\}\right)$$

pointwise.

Proof of (iv). Observe that $A^* \supseteq \operatorname{argmax}_g c_g$. It is sufficient to show that there exists an $\overline{p}$ such that for all $p \geq \overline{p}$, $A^{M,p} \subseteq \operatorname{argmax}_g c_g$. Let $\overline{c}$ be the second largest unique element of $\{c_1, ..., c_G\}$ (unique to exclude duplicates of $\max_g c_g$) and let $\epsilon = \max_g c_g - \overline{c} > 0$. Let $\overline{p}$ be defined as

$$\overline{p} := \inf_p \left\{ \min_{\tilde{g} \in \operatorname{argmax}_g c_g} \overline{T}_{\tilde{g}}\left(\overline{F}(p)\right) > \overline{c} + \frac{\epsilon}{2} \right\}$$

Then, regardless of sorting across the genres in $\operatorname{argmax}_g c_g$, expected profits in each of the genres will be strictly larger than expected profits in any genre outside of $\operatorname{argmax}_g c_g$. This proves the claim. $\square$

A.4.2 Subscription Proofs

Proof of Proposition 6. I first show that there exists a unique $(\psi^{S.M}, t^{S.M})$. Here, the monopolist is constrained to offer a single price for the good. It then solves

$$\begin{aligned} &\max_{t_g, \psi_g} \sum \psi_g W\left(\frac{t_g}{\psi_g}\right) \overline{T}_g(t_g) \\ &t_g \in [0, \psi_g \overline{F}(0)] \\ &\sum \psi_g = 1, \quad \psi_g \geq 0 \end{aligned}$$

Notice first that after choosing quantities ψ, the optimal thresholds t_g are functions only of ψ_g. Hence, define

$$\Pi_g(\psi) = \max_{t \in [0, \psi_g \overline{F}(0)]} \psi W\left(\frac{t}{\psi}\right) \overline{T}_g(t)$$

Define now $t_g(\psi)$ as the optimal cutoff for the corresponding ψ. Observing that by the Envelope theorem, we have $\frac{\partial}{\partial \psi} \Pi_g(\psi_g) = M\left(\frac{t_g(\psi_g)}{\psi_g}\right) \overline{T}_g(t_g(\psi_g))$. As we show below, this function is decreasing, so that Π_g is concave. If this is the case, then the monopolist solves

$$M\left(\frac{t_g}{\psi_g}\right) \overline{T}_g(t_g) = \eta$$

for all x with $\psi_g > 0$.

Properties of the profit function. It is useful to determine properties of the profit function Π_g, and with it the properties of t_g. For the remainder, I drop the subscript g, but keep in mind that these are genre-specific still.

Observe first the first-order condition for t:

$$-\frac{dT}{dt}(t)\psi \int_{\overline{F}^{-1}\left(\frac{t}{\psi}\right)} v f(v) dv + \overline{F}^{-1}\left(\frac{t}{\psi}\right) \overline{T}(t) = 0$$

We can rewrite this as

$$\frac{\frac{dT}{dt}(t)}{\overline{T}(t)} = \frac{\overline{F}^{-1}\left(\frac{t}{\psi}\right)}{\psi W\left(\frac{t}{\psi}\right)} \tag{1}$$

A first important result is that there is only one solution to (1). It must also be the maximizer, since profits as $t \to 0, \infty$ go to zero.

Lemma A.5. If f has IHR and T is regular, then (1) has one solution.

Proof. Notice that a solution to 1 is equivalent to a solution to

$$t - \frac{\overline{T}(t)}{\frac{dT}{dt}(t)} = t - \frac{\psi W\left(\frac{t}{\psi}\right)}{\overline{F}^{-1}\left(\frac{t}{\psi}\right)}$$

This is as the right-hand side of 1 is never zero, as long as t is finite. By the regularity of T, the left-hand side is weakly increasing in t. Hence, it is sufficient to show that the right-hand side is decreasing in t, for a fixed ψ. Simply taking a derivative shows that

$$\frac{\partial}{\partial t}\left(t - \frac{\psi W\left(\frac{t}{\psi}\right)}{\overline{F}^{-1}\left(\frac{t}{\psi}\right)}\right) = -\frac{W\left(\frac{t}{\psi}\right)}{\overline{F}^{(-1)}\left(\frac{t}{\psi}\right)^2 f\left(\overline{F}^{(-1)}\left(\frac{t}{\psi}\right)\right)} < 0$$

This proves the claim. $\square$

That there is at most one solution is nice because it means that we may focus on local changes in t as ψ changes. This also means that it will be more straightforward to compute properties of Π, as local changes won't lead to global movements in t.

Lemma A.6. The optimal threshold t is increasing in ψ, and the profit function is increasing, and strictly concave, in ψ. That is,

$$\frac{\partial}{\partial \psi} t(\psi) > 0$$

and

$$\frac{\partial}{\partial \psi}\Pi(\psi) > 0, \frac{\partial^2}{\partial \psi^2}\Pi(\psi) < 0$$

As well, $\lim_{\psi \to \infty} t(\psi) = t^*$, where t^* maximizes $t\overline{T}(t)$.

Proof. By the envelope theorem, and the fact that there is a unique maximizer t, we can use the envelope theorem to compute the change in $t(\psi)$. We have

$$\frac{\partial}{\partial \psi} t(\psi) = - \left. \frac{\frac{\partial^2}{\partial \psi \partial t} \psi W\left(\frac{t}{\psi}\right) \overline{T}(t)}{\frac{\partial^2}{\partial t^2} \psi W\left(\frac{t}{\psi}\right) \overline{T}(t)} \right|_{t=t(\psi)}$$

Then,

$$\frac{\partial^2}{\partial \psi \partial t} \psi W\left(\frac{t}{\psi}\right) \overline{T}(t) = -\frac{dT}{dt}(t) M\left(\frac{t}{\psi}\right) + \frac{t}{\psi^2} \cdot \frac{\overline{T}(t)}{f\left(\overline{F}^{-1}\left(\frac{t}{\psi}\right)\right)}$$
$$\frac{\partial^2}{\partial t^2} \psi W\left(\frac{t}{\psi}\right) \overline{T}(t) = -\frac{\overline{T}(t)}{\psi f\left(\overline{F}^{-1}\left(\frac{t}{\psi}\right)\right)} - 2\overline{F}^{-1}\left(\frac{t}{\psi}\right) \frac{dT}{dt}(t) - \psi W\left(\frac{t}{\psi}\right) \frac{d^2T}{dt^2}(t)$$

Notice that since t must be a maximizer, $\frac{\partial^2}{\partial t^2} \psi W\left(\frac{t}{\psi}\right) \overline{T}(t) < 0$.[14] This means that it is sufficient to check that $\frac{\partial^2}{\partial \psi \partial t} \psi W\left(\frac{t}{\psi}\right) \overline{T}(t) > 0$.

To do so, recall that at $t(\psi)$, we have $\frac{dT}{dt}(t) \big/ \overline{T}(t) = \overline{F}^{-1}\left(\frac{t}{\psi}\right) \big/ \psi W\left(\frac{t}{\psi}\right)$. Write now $v = \overline{F}^{-1}\left(\frac{t}{\psi}\right)$. The sign of the cross-partial is then the same as the sign of

$$-\frac{v}{W\left(\overline{F}(v)\right)} M\left(\overline{F}(v)\right) + \frac{\overline{F}(v)}{f(v)} = -v + \frac{v^2 \overline{F}(v)}{W\left(\overline{F}(v)\right)} + \frac{\overline{F}(v)}{f(v)}$$

Now, v claim that this function is positive whenever f has IHR. To see this, observe that $W(\overline{F}(v)) = v\overline{F}(v) + \int_v^\infty \overline{F}(\tilde{v}) d\tilde{v}$. As well, write h as the hazard rate of f: $h(v) = \frac{f(v)}{\overline{F}(v)}$. Then the condition above is equivalent to

$$\frac{1}{h(v)} \geq v - \frac{v^2 \overline{F}(v)}{v\overline{F}(v) + \int_v^\infty \overline{F}(v) dv} = \frac{v \int_v^\infty \overline{F}(\tilde{v}) d\tilde{v}}{v\overline{F}(v) + \int_v^\infty \overline{F}(\tilde{v}) d\tilde{v}}$$

Now, from the definition of the hazard rate and the fact that it is increasing, we

[14] We show below that it cannot be identically zero.

have that

$$\overline{F}(\tilde{v}) = \overline{F}(v) \cdot \exp\left(-\int_v^{\tilde{v}} h(w)dw\right) \leq \overline{F}(v) \cdot \exp\left(-h(v)(\tilde{v} - v)\right)$$

whenever $\tilde{v} \geq v$, since h is increasing. Hence

$$\int_v^{\infty} \overline{F}(\tilde{v})d\tilde{v} \leq \frac{\overline{F}(v)}{h(v)}$$

Now, we must confirm that

$$v\overline{F}(v) + \int_v^{\infty} \overline{F}(\tilde{v})d\tilde{v} \geq v \int_v^{\infty} \overline{F}(\tilde{v})d\tilde{v} \cdot h(v)$$

We have

$$\begin{aligned}
&\int_v^{\infty} \overline{F}(\tilde{v})d\tilde{v} \leq \frac{\overline{F}(v)}{h(v)} \\
\Rightarrow &vh(v) \int_v^{\infty} \overline{F}(\tilde{v})d\tilde{v} \leq v\overline{F}(v) \leq v\overline{F}(v) + \int_v^{\infty} \overline{F}(\tilde{v})d\tilde{v}
\end{aligned}$$

This shows that the cross-partial evaluated at $t(\psi)$ is positive, so that $t(\psi)$ is increasing in ψ.

That the profit function is increasing in ψ is trivial. I now turn to proving that the profit function is concave in ψ. To do so, note that

$$\begin{aligned}
\frac{\partial^2}{\partial \psi^2}\Pi(\psi) =& \frac{\partial^2}{\partial \psi^2}\left(\psi W\left(\frac{t}{\psi}\right)\overline{T}(t)\right) + \frac{\partial}{\partial \psi}t(\psi) \cdot \frac{\partial^2}{\partial \psi \partial t}\psi W\left(\frac{t}{\psi}\right)\overline{T}(t) \\
=& -\frac{t^2}{\psi^3} \cdot \frac{\overline{T}(t)}{f\left(\overline{F}^{-1}\left(\frac{t}{\psi}\right)\right)} + \frac{\partial}{\partial \psi}t(\psi) \cdot \frac{\partial^2}{\partial \psi \partial t}\psi W\left(\frac{t}{\psi}\right)\overline{T}(t)
\end{aligned}$$

First, note that this isn't immediate. The first term is clearly negative, but by the discussion above the second term is positive. It will be a bounding exercise. Let

$$A := \frac{\partial^2}{\partial \psi \partial t}\psi W\left(\frac{t}{\psi}\right)\overline{T}(t) = -\frac{dT}{dt}(t)M\left(\frac{t}{\psi}\right) + \frac{t}{\psi^2} \cdot \frac{\overline{T}(t)}{f\left(\overline{F}^{-1}\left(\frac{t}{\psi}\right)\right)}$$

$$B := -\frac{\partial^2}{\partial t^2}\psi W\left(\frac{t}{\psi}\right)\overline{T}(t) = \frac{\overline{T}(t)}{\psi f\left(\overline{F}^{-1}\left(\frac{t}{\psi}\right)\right)} + 2\overline{F}^{-1}\left(\frac{t}{\psi}\right)\frac{dT}{dt}(t) + \psi W\left(\frac{t}{\psi}\right)\frac{d^2T}{dt^2}(t)$$

Then, strict concavity is equivalent to

$$-\frac{t^2}{\psi}\cdot\frac{1}{f\left(\overline{F}^{-1}\left(\frac{t}{\psi}\right)\right)} + \frac{\overline{T}(t)}{B}\cdot\left(\frac{\psi A}{\overline{T}(t)}\right)^2 < 0$$

First, recall that A, B are both positive. We first deal with $\frac{\psi A}{\overline{T}(t)}$. As above, let $v = \overline{F}^{-1}\left(\frac{t}{\psi}\right)$.

$$\frac{\psi A}{\overline{T}(t)} = -\psi\frac{\frac{dT}{dt}(t)}{\overline{T}(t)}M\left(\frac{t}{\psi}\right) + \frac{t}{\psi f(v)} \leq \frac{t}{\psi f(v)}$$

As $A > 0$, this implies

$$\Rightarrow \quad \left(\frac{\psi A}{\overline{T}(t)}\right)^2 < \frac{t^2}{\psi^2 f(v)^2}$$

Now, deal with $\frac{B}{\overline{T}(t)}$. Unlike with the term of A, since this is in the denominator, we aim to find a lower bound. Since T is regular, we have

$$1 + \frac{\frac{dT}{dt}(t)^2 + \overline{T}(t)\frac{d^2T}{dt^2}(t)}{\frac{dT}{dt}(t)^2} \geq 0$$

In particular, this implies that

$$\overline{T}(t)\frac{d^2T}{dt^2}(t) \geq -2\frac{dT}{dt}(t)^2 \quad \Rightarrow \quad \frac{\frac{d^2T}{dt^2}(t)}{\overline{T}(t)} \geq -2\left(\frac{\frac{dT}{dt}(t)}{\overline{T}(t)}\right)^2$$

Evaluated at $t(\psi)$, since $\frac{dT}{dt}(t)\big/\overline{T}(t) = \frac{v}{\psi W(\overline{F}(v))}$, we have

$$\frac{\frac{d^2T}{dt^2}(t)}{\overline{T}(t)} \geq -2\left(\frac{v}{\psi W\left(\overline{F}(v)\right)}\right)^2$$

We then have[15]

$$\begin{aligned}\frac{B}{\overline{T}(t)} =& \frac{1}{\psi f(v)} + 2v\frac{\frac{dT}{dt}(t)}{\overline{T}(t)} + \psi W\left(\overline{F}(v)\right)\frac{\frac{d^2T}{dt^2}(t)}{\overline{T}(t)} \\ =& \frac{1}{\psi f(v)} + 2\frac{v^2}{\psi W\left(\overline{F}(v)\right)} + \psi W\left(\overline{F}(v)\right)\frac{\frac{d^2T}{dt^2}(t)}{\overline{T}(t)} \geq \frac{1}{\psi f(v)}\end{aligned}$$

Returning to our initial condition:

$$-\frac{t^2}{\psi}\cdot\frac{1}{f(v)} + \frac{\overline{T}(t)}{B}\cdot\left(\frac{\psi A}{\overline{T}(t)}\right)^2 < -\frac{t^2}{\psi}\cdot\frac{1}{f(v)} + \psi f(v)\cdot\frac{t^2}{\psi^2 f(v)^2} = 0$$

This proves the claim. □

All that is left is to show that $A^* \subseteq A^{S.M}$. Let η^* denote the multiplier on the production constraint in the utilitarian allocation, and similarly $\eta^{S.M}$. We must show that, if $A^{S.M} \subseteq A^*$, if

$$c_g M(0) > \eta^*$$

then

$$c_g M(0) > \eta^{S.M}$$

This would show that $A^* \subseteq A^{S.M}$. Notice that this relies on, when $\psi_g = 0$, the monopolist being able to extract the full value from a genre. It is hence sufficient to show that $\eta^* > \eta^{S.M}$. If $A^{S.M} \subseteq A^*$, then we have some $g' \in A^{S.M}$ with

$$\psi_{g'}^{S.M} \geq \psi_{g'}^*$$

Now,

$$\eta^* = \int M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_{g'}^*}\right\}\right) dT_g(t)$$

[15]This argument also shows that since $B > 0$, the derivations for $\frac{\partial}{\partial\psi}t(\psi)$ work in all cases.

and

$$\begin{aligned}\eta^{S.M} =& M\left(\frac{t^*}{\psi_{g'}^{S.M}}\right)\overline{T}_g(t) = \int_{t^*}^{\infty} M\left(\frac{t^*}{\psi_{g'}^{S.M}}\right) dT_g(t^*) \\ <& \int_{t^*}^{\infty} M\left(\frac{t}{\psi_{g'}^{S.M}}\right) dT_g(t^*) < \int_{t^*}^{\infty} M\left(\frac{t}{\psi_{g'}^{*}}\right) dT_g(t^*) \\ <& \eta^*\end{aligned}$$

The first and second inequalities come from M being an increasing function. The last inequality comes from observation. This completes the proof. □

A.4.3 Recommendation System Proofs

Definition 11. A recommendation system $\mathcal{T}$ is called a threshold mechanism if $\mathcal{T} = \{(1, r_1), ..., (G, r_G)\}$ with $r_g(v, t) = \mathbb{1}\left\{v \geq p_g\right\}$ for some $p_g \in \mathbb{R}_+$. That is, $\mathcal{T}$ defines a single threshold p_g for each genre g, and recommends all content in a genre above this threshold to all agents.

I first show that these simple threshold mechanisms are optimal within the set of all mechanisms. This will be useful below: identifying an improvement in the wider range of mechanisms would violate the optimality of the mechanism in the smaller class of threshold mechanisms.

Lemma A.7. The recommendation system does not benefit from using a more general mechanism instead of a threshold mechanism.

Proof. Consider a more general mechanism $\mathcal{M}$, and some allocation of producers $(\psi_m)_m$ across these menu items. All active menu items must have the same anticipated demand. Let $\psi_g = \sum_{m:g\in m} \psi_m$ be the total mass of producers that produce content in genre g under this mechanism.

Consider the threshold mechanism $\mathcal{T}$ that, at these ψ_g, sets demand equal to the equilibrium demand of $\mathcal{M}$. This does not change producer incentives. Additionally, it means that the total mass of content consumed in genre g under $\mathcal{T}$ is the same as under $\mathcal{M}$. However, the quality of content must be weakly higher under $\mathcal{T}$ than under $\mathcal{M}$ by definition. Hence, the threshold mechanism improves upon the original mechanism $\mathcal{M}$. □

Although intuitive, this result is extremely powerful. If, at a candidate mechanism $\mathcal{T}$ there is an additional menu item m (even if not necessarily a threshold rule) that improves the recommendation system's profits, then $\mathcal{T}$ cannot be optimal.

I now turn to characterizing the optimal threshold mechanism. The problem is:

$$\max_{p_g, \psi_g} \sum_{x \in X} \psi_g \int W\left(\min\left\{\overline{F}(p_g), \frac{t}{\psi_g}\right\}\right) dT_g(t)$$

subject to the following constraints:

$$s_g + \int \min\left\{\overline{F}(p_g), \frac{t}{\psi_g}\right\} dT_g(t) - \overline{Q} = 0 \tag{λ_g}$$

$$\psi_g s_g = 0 \tag{γ_g}$$

$$1 - \sum_{x \in X} \psi_g = 0 \tag{η}$$

$$\psi_g \geq 0 \tag{η_g}$$

$$s_g \geq 0 \tag{ρ_g}$$

$$p_g \geq 0 \tag{ω_g}$$

Now everything is just indexed by the genre x, which reduces an entire degree of dimensionality (nice). We get the following first-order conditions:

$$\begin{aligned} &\int W\left(\min\left\{\overline{F}(p_g), \frac{t}{\psi_g}\right\}\right) dT_g(t) + \gamma_g s_g \\ &+ \int_0^{\psi_g \overline{F}(p_g)} \left[-\overline{F}^{-1}\left(\frac{t}{\psi_g}\right) \cdot \frac{t}{\psi_g} - \frac{t}{\psi_g^2} \cdot \lambda_g\right] dT_g(t) - \eta + \eta_g = 0 \end{aligned} \tag{ψ_g}$$

$$-\overline{T}_g(\psi_g \overline{F}(p_g)) \left[\psi_g p_g + \lambda_g\right] f(p_g) + \omega_g = 0 \tag{p_g}$$

$$\lambda_g + \psi_g \gamma_g + \rho_g = 0 \tag{s_g}$$

In order to derive meaningful first-order conditions for the optimal mechanism, I proceed in several cases.

Case 1: $\psi_g = 0$. If $\psi_g = 0$ at an optimal allocation, then as noted it is without loss to set $p_g = \infty$ (since this just relaxes the constraint on this genre).

Case 2: $\psi_g > 0$, $p_g > 0$. We have then that $\eta_g = 0, s_g = 0, \omega_g = 0$. Here, notice that from the first-order condition from p_g, we get that $\lambda_g = -\psi_g p_g$. With this, after some simplifications, we get the following conditions:

$$\int M\left(\min\left\{\overline{F}(p_g), \frac{t}{\psi_g}\right\}\right) dT_g(t) + \overline{Q} \cdot p_g = \eta$$
$$\int \left\{\overline{F}(p_g), \frac{t}{\psi_g}\right\} dT_g(t) = \overline{Q}$$

Case 3: $\psi_g > 0$, $p_g = 0$. In this case, while $\eta_g = 0$ and $s_g = 0$, we may have $\omega_g > 0$. Then, notice that we have $\lambda_g = -\psi_g p_g + \omega'_g$, where $\omega'_g \geq 0$ (note the negative sign in front of the $\lambda_g + \psi_g p_g$ in the first-order condition). Hence $\lambda_g \geq -\psi_g p_g$. Similar simplifications then give us

$$\int M\left(\min\left\{\overline{F}(p_g), \frac{t}{\psi_g}\right\}\right) dT_g(t) - \omega''_g = \eta$$
$$\int \left\{\overline{F}(p_g), \frac{t}{\psi_g}\right\} dT_g(t) = \overline{Q}$$

where again $\omega''_g \geq 0$. This yields another necessary first-order equation. This result is summarized in the following lemma.

Lemma A.8. If a set of penalties p_g and producer allocations ψ_g are optimal, then there exist $\overline{Q}$ and η such that for all x with $\psi_g > 0$:

$$\begin{aligned}
&\int \min\left\{\overline{F}(p_g), \frac{t}{\psi_g}\right\} dT_g(t) = \overline{Q} \\
&\int M\left(\min\left\{\overline{F}(p_g), \frac{t}{\psi_g}\right\}\right) dT_g(t) + \overline{Q} \cdot p_g = \eta && \text{if} \quad p_g > 0 \\
&\int M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\}\right) dT_g(t) \geq \eta && \text{if} \quad p_g = 0 \\
&\min p_g = 0 \\
&\sum \psi_g = 1
\end{aligned}$$

If $\psi_g = 0$, it is without loss to set $p_g = \infty$.

I first show that if demand is sufficiently low, then a genre is active.

Lemma A.9. Let $\overline{Q}$ be demand in the optimal recommendation system (as defined in Lemma A.8). Suppose that $\overline{Q} < c_g \overline{F}(0)$. Then, in the price-discriminating recommendation system, genre g is active ($\psi_g > 0$).

Proof. I show that if $\psi_g = 0$, the recommendation system would strictly benefit from shifting some mass to genre x, without changing $\overline{Q}$. That is, it is sufficient in both cases to show that

$$\eta < c_g W\left(\frac{\overline{Q}}{c_g}\right)$$

where η is defined as in Lemma A.8. By setting $p_g = \overline{F}^{-1}\left(\frac{\overline{Q}}{c_g}\right)$ or $P_g = \frac{\overline{Q}}{c_g}$, producers are indifferent between producing genre x or any other active genre. Hence, a marginal addition does not change producer incentives, but because $c_g W\left(\frac{\overline{Q}}{c_g}\right) > \eta$, it does increase the payoff of the recommendation system.

Proof of (i). I proceed similarly to the proof of $A_{CE} \subseteq A_{Mech}$. That is, consider any active genre with $p_{g'} = 0$. This means

$$\int \min\left\{\overline{F}(0), \frac{t}{\psi_{g'}}\right\} dT_{g'} = \overline{Q}$$

and

$$\eta \leq \int M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_{g'}}\right\}\right) dT_{g'}$$

Now, there exists an a such that $a\overline{F}(0) = \overline{Q}$. Since M is strictly convex with $M(0) = 0$, we have that

$$\eta < aM\left(\overline{F}(0)\right) = aW\left(\overline{F}(0)\right)$$

Now, since W is strictly concave with $W(0) = 0$, we have that for $\alpha < 1$, $W(\alpha A) > \alpha W(A)$. Now, observe that we have $a < c_g$, since by assumption $c_g\overline{F}(0) > \overline{Q}$. Hence, we have

$$\eta < aW\left(\overline{F}(0)\right) < c_g\left(\frac{a}{c_g}W\left(\overline{F}(0)\right)\right) < c_g W\left(\frac{\overline{Q}}{c_g}\right)$$

This proves the claim.

$\square$

Proof of Proposition 7(ii).

Proof that $A^0 \subseteq A^R$. This follows from Lemma A.9 after one observes that demand must be weakly lower in the recommendation system than in the competitive equilibrium with zero price.

Proof that $A^R \subseteq A^*$. Suppose that $A^* \subseteq A^R$. I show that $A^R \subseteq A^*$ so that this latter inclusion holds in general. In order for a genre g to be included in A^R, it is sufficient and necessary for $\overline{Q}$ to be lower than $c_g \overline{F}(0)$.

First, focus on the case when there exists some genre $g \in G$ with $p_g = 0$ where $\psi_g^R \leq \psi_g^*$. For this y, we have

$$\int \min\left\{\overline{F}(0), \frac{t}{\psi_g^*}\right\} dT_g(t) \leq \overline{Q} \leq c_g \overline{F}(0)$$

Since M is strictly convex with $M(0) = 0$, we then have that

$$\int M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g^*}\right\}\right) dT_g(t) < c_g M\left(\overline{F}(0)\right)$$

Now, consider the case when we have $\psi_{g'}^R > \psi_{g'}^*$ for all g' with $p_{g'} = 0$. This implies that, for some g with $p_g > 0$, we have $\psi_g < \psi_g^*$.

Notice that this implies that

$$\eta < \int M\left(\min\left\{\overline{F}(0), \frac{t}{\psi_g}\right\}\right) dT_g(t)$$

I now focus exclusively on genre g, and so I drop the subscripts on T and ψ (I maintain the subscript on p_g in order to highlight that it is from the specific subgenre). First, observe that if

$$\overline{Q} \leq \overline{F}(0)\overline{T}\left(\psi \overline{F}(p_g)\right)$$

then we can construct an improvement to utility without affecting demands, which would be a contradiction. I.e., add an additional menu item for genre g that targets only those types with $t > \psi\overline{F}(p_g)$ and always recommends acceptable content. Then, by the same argument as in Lemma A.9, this menu item would result in an improvement, which is a contradiction by Lemma A.7. Now, recall

$$\eta = \int M\left(\min\left\{\overline{F}(p_g), \frac{t}{\psi}\right\}\right) dT(t) + \overline{Q}p_g$$

Define now the function

$$\mathrm{H}(p) := \int M\left(\min\left\{\overline{F}(p), \frac{t}{\psi}\right\}\right) dT(t) + \overline{Q}p$$

I claim that we must have $\mathrm{H}(p)$ increasing on $[0, p_g]$. If this is true, then

$$\eta = \mathrm{H}(p_g) \geq \mathrm{H}(0) = \int M\left(\min\left\{\overline{F}(0), \frac{t}{\psi}\right\}\right) dT(t)$$

This would be a contradiction, since the right-hand side is larger than η in this case. A simple computation shows that

$$\mathrm{H}'(p) = \overline{Q} - \overline{F}(p)\overline{T}(\psi\overline{F}(p))$$

Suppose that for some $p \in [0, p_g]$, we have $\mathrm{H}'(p) < 0$. This would imply that

$$\overline{Q} < \overline{F}(p)\overline{T}(\psi\overline{F}(p)) < \overline{F}(p)\overline{T}(\psi\overline{F}(p_g)) < \overline{F}(0)\overline{T}(\psi\overline{F}(p_g))$$

This contradicts the observation above. Hence $\mathrm{H}'(p)$ is increasing on $[0, p_g]$, proving the claim. □

A.5 Proof of Proposition 1

In this section I prove Proposition 1 as well as its subsequent results in Section 6. I first briefly discuss the differences in timing across regimes.

Fixed Prices, Incomplete Information. Producers choose their genres, and then their values are realized.

Fixed Prices, Complete Information. Producers observe their and their opponents values, and then sort across genres.

Competitive Pricing, Incomplete Information. Producers choose their genres, values are realized (and observed by both firms), and then producers choose prices.

Competitive Pricing, Complete Information. First, producers observe their values. Then, the producer with the larger value commits to a price, the worse producer commits to a price, and finally producers sort across genres.

Proof of Proposition 1(i). I show that this result holds for each regime separately.

Fixed Pricing, Ex-Ante Realization of Quality. In this setting, clearly the only equilibrium is for the firm with the larger value to produce in the larger genre, and the firm with the smaller value to produce in the smaller genre.

Competitive Pricing, Ex-Post Realization of Quality. If firms produce in separate genres, then the firm which produces in the smaller genre will charge his value, earning expected profits of $\frac{3}{2}(1-\mu)$ on average. If he enters genre 1, then the firms will engage in Bertrand competition, with the firm with largest value earning profits equal to the difference between the values. Hence expected profits are equal to

$$\frac{1}{2}\mathbb{E}\left[|v_1 - v_2|\right] \cdot \mu = \frac{1}{6}\mu$$

This is larger than $\frac{3}{2}(1-\mu)$ if and only if

$$\mu \geq \frac{9}{10}$$

This aligns with the efficient allocation, as derived below.

Competitive Pricing, Ex-Ante Realization of Quality. Recall that the producer with the larger value is assumed to be able to commit to a genre and pricing choice before the producer with the smaller value. I show that there is an equilibrium where the producer with the larger value always producers in genre 1, and the producer with the smaller value always produces in genre 2. Let the larger value be denoted by $\overline{v}$, and the smaller value $\underline{v}$. In the proposed equilibrium, the producer with the better technology charges $\overline{v} - \frac{2\mu-1}{\mu}\underline{v}$.

If the better producer is able to charge this price and commands the demand of the larger market, as

$$\mu\left(\overline{v}-\frac{2\mu-1}{\mu}\underline{v}\right)\geq(1-\mu)\overline{v}$$

the better producer will not want to deviate to producing in the smaller genre.

To see that the worse producer will want to produce in the smaller genre, in order to command demand in the larger genre it would need to charge a price p such that

$$\underline{v}-p\geq\frac{2\mu-1}{\mu}\underline{v}\Rightarrow p\leq\frac{1-\mu}{\mu}\underline{v}$$

But then its profits would be

$$\mu p\leq(1-\mu)\underline{v}$$

which are its profits from producing alone in the smaller genre. This proves the claim.

□

Proof of Proposition 1(ii). I prove the more general result presented in Section 6.3, since this subsumes other results.

For (a), if $\mu > 2/3$, then the expected profits from entering genre 1 when both producers are in genre 1 is $\frac{1}{2}\cdot\mu > \frac{1}{3}$ which are expected profits from entering genre 2 alone.

For (b), expected profits when both enter genre 1 are given by

$$\mu\cdot\alpha\cdot\frac{1}{2}\left(1+\frac{2}{3}(b-1)\right)$$

Expected profits from being alone in genre 2 are

$$(1-\mu)\cdot\alpha\cdot\frac{1}{2}\left(1+b\right)$$

The first is strictly larger than the second when $\mu > \frac{3+3b}{4+5b}$.

For (c), expected welfare when both producers produce in genre 1 is

$$\mu\left(1+\frac{2}{3}(b-1)\right)$$

expected welfare when each produces in a different genre is $\frac{1}{2}(1+b)$. The former is smaller than the latter exactly when

$$\mu > \frac{3}{2} \cdot \frac{1+b}{1+2b}$$

This completes the proof. $\square$