The rise of streaming music and implications for music production

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Abstract

In this paper, we model the potential for streaming music, a non-durable product, to upend and displace durable music sales, thereby completing the unbundling of artists' music. As the popularity of streaming music increases producers will switch their focus to the non-durable channel. We identify conditions under which the changing industry will encourage musicians to release fewer songs, higher quality songs, leading to market deepening and increased listeners. We find that increases on the extensive margin are larger than the intensive margin from this strategy. This result could extend to information goods increasingly provided as a non-durable product. Beyond a model of consumer utility and producer profit, we analyze the most played songs of the large streaming music platform, Spotify, and compare those results to traditional album sales using Nielsen data.

1 Introduction

The music industry has undergone tremendous technical and structural changes in the last twenty years. Before widespread use of the internet, music was typically delivered in two ways: by radio in a passive non-durable setting, where the consumer had no direct control over content, and by purchasing physical media for permanent ownership of a song or album. Physical media has the benefit of being a durable good, which required a one-time payment. Internet distribution increased consumers' options, and provided both durable and eventually non-durable options. Distribution happened initially with illegal file sharing, and then through online sales of durable unbundled music (MP3s).

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More recently non-durable "streaming" music, delivered through a data connection has gained prominence. Streaming music has the potential to change the way in which music is made, bundled, and delivered, emphasizing individual songs over albums. In this paper we model the potential for that change and through the available data analyze the early transition

The realities of music long dictated that songs were optimally bundled for sale. The dominant form of physical media went through a product cycle of vinyl, cassettes, and compact discs, but all these formats shared some common features. Each format is durable and delivers a collection of songs known as an album (Connolly and Krueger, 2006). As internet usage increased, it allowed for digital delivery of music. Initially, this led to illegal distribution of music, as networks of users would share MP3 music files. More recently legal options have emerged. Elberse (2010) documents the effect of this digital distribution on the music industry, noting the potential for unbundling. She considers the availability of mixed bundles when alternative distribution methods became more prominent.

The current industry model used by most producers of music offers a mixed bundle, implying that creating an album and selling the album as well as the individual offerings provides a greater profit than simply releasing songs as pure components. The album or song sold in a durable mixed bundle brings a one-time payment to the rights-holder. This encourages artists to convince consumers to "own" their products. As streaming gains in prominence, there is the potential for a substantial impact on how music is produced and distributed. Streaming pays based on the number of "listens," or amount of times the song has been streamed.[1] This means that unlike the previous products, streaming encourages artists to emphasize use of their products.

We examine how streaming could change production in both a fully-served and partially-served market, and find conditions under which producers shift to a "hits strategy," where artists produce less music at a higher quality. Both streaming and MP3 purchases provides a unbundled product since users can listen to individual songs by an artist without having to purchase any other songs by the same artist. Unbundling of music began well before streaming music, however, its introduction is likely to accelerate the trend. The non-durable nature of streaming music means that total listens is more important than the number of songs available. This paper contributes to both the bundling literature and the non-durable goods literature, and is applicable to other products with durable bundled, durable unbundled, or non-durable unbundled options.

Our model predicts that music producers will prioritize quality as a typical user's catalog of streaming music increases. As number of streams of quality song increases, profitability will increase, particularly if the consumer's catalog is sufficiently large. Although this strategy increases profitability in both a partially and fully-served market due to market deepening, we find that the increases on the extensive margin are larger than the intensive margin, meaning the threshold for success is lower in the partially served market. The data shows that streaming music is already experiencing a significant in-

[1]For an overview of how Spotify determines payments see http://www.spotifyartists.com/spotify-explained/ Accessed 3/18/2015.

crease in demand and revenue. The number of subscribers, number of songs streamed, and royalties are all increasing in this environment. Our data on album sales in the United States in the same time frame shows a declining market for the album as a durable good. Currently, the relationship between popular songs on streaming services and albums sold shows a focus on album production. As the popularity of streaming increases, however, these two measures begin to diverge revealing the possibility of different strategies of production for the newer market.

2 Literature review

Coase (1972) examined the optimal pricing of a durable good for a monopolist. In this seminal paper he showed that limiting the durability of a good via licensing or contracting may lower a seller's cost, while potentially increasing profit. However, additional work by Bulow (1982), showed that renting or leasing may carry additional cost if the product can be damaged. Bulow finds that a monopolist generally does not do as well renting, as it also requires influencing consumers' expectations about future production. For many products, the method of obtainment determines durability. The option to obtain many information goods includes both buying (durable) and renting (non-durable). Historically, renting information goods required obtaining a physical product, such as CD, VHS, etc. Varian (2000) discusses the market for both rented and purchased movies.

Initially, movie studios focused on non-durable consumption of movies by encouraging rentals. However, purchases of durable movies were later embraced by offering video sales directly to consumers. This not only illustrates how renting can transform a durable good into a non-durable for a consumer, but also highlights the gains from multiple pricing techniques. The retail risk associated with renting physical goods differs from that of digital goods. As noted by Dana and Spier (2001), the cost of inventory in the face of uncertain demand increases a rental store's risk. However, the use of digital goods removes inventory concerns and also removes the need for brick and mortar stores. In the case of music and videos, the quantity of goods obtained online, as opposed to brick and mortar establishments, continues to increase (Zentner, 2008). As such, consumers' preferred method of buying many information goods has changed from physical to digital versions, and as long as the consumer owns the digital version, the products are still durable.

The practice of releasing "singles," or individual songs for promotion has been done in advance of album releases for many years. The single was intended to encourage purchase of the artist's bundled album, which was the only option for a consumer listening to music on demand. Consumers would then be required to buy the bundle in order to get the hit song. As Elberse (2010) shows, digital distribution encouraged labels to release the single individually at a substantially reduced price. She considers the availability of mixed bundles when alternative distribution methods became more prominent. Her data shows that the more concentrated the sales of singles within an album the lower the album sales, making the bundle less useful. In order to boost album sales, artists need to create similar demand for every song on an album. Assuming increased costs to produce songs of greater

utility, this makes a high demand album more costly to make. With declining sales, the bundled album loses its primary advantage of appealing to heterogeneous preferences, and the format becomes less logical.

Alternatives to purchasing also exist in the market for digital information goods. Varian (2000) provides scenarios where only providing consumers the option of purchasing information goods will not be profit maximizing for a firm. His discussion focuses on sharing of goods, but there are implications for both renting and streaming products. Sundararajan (2004) examines fixed fee and usage fee pricing for various services or information goods which allows producers to price discriminate. Both renting and usage-fee services share some similarities with subscription streaming. Specifically, all three methods provide the product as a non-durable good. However, each method is distinct. Traditional renting allows the consumer unrestricted usage for a set period of time, as consumers increase their usage during the rental period, the price per use decreases. While usage-fee service charges based on usage of the product, as consumers increase their usage, price per use remains constant. Subscription streaming shares properties with both of the previous approaches depending on the "type" of song. If the song is complimentary to a user's streaming catalog, then the amount of music consumed by the user is increased. Increased usage decreases the price per use for that song and additionally, the price per song for the user's entire catalog is reduced. If, however, the song is a substitute the song replaces other music, creating a similar effect to usage-fee service.

Streaming music services offer a product bundle (of many artists' music), a strategy where the profitability has been explored in depth. Stigler (1963), Adams and Yellen (1976), and Schmalensee (1984) developed early theory and examples on when bundling is profitable. More recent extensions include McAfee et al. (1989) providing conditions for when mixed bundling is profitable, Chu et al. (2011) including bundling pricing, and Chen and Riordan (2013) establishing general conditions for the profitability of bundling negatively dependent products. Bakos and Brynjolfsson (1999) explore the benefits of large scale bundling of information goods, and Danaher et al. (2014) examine bundling and pricing practices specifically related to digital music sales.

Recent music literature has focused on how the industry has changed in the digital age. Montoro-Pons and Cuadrado-García (2011) document the complementary nature of recorded music and live performances. Mortimer et al. (2012) then explain that concert revenue and the amount of time bands spend touring have increased in the period since file sharing began. The increased importance of concerts could act as a complementary good to streaming music. Not everything has changed, however, Waldfogel (2012) shows that quality in the music industry has not declined with general revenue decreases in the file sharing period. He uses various "best of" lists of the top albums in specific time periods to measure quality. The purpose of this paper is not to find a causal relationship between file sharing and album sales (see Liebowitz (2004); Oberholzer-Gee and Strumpf (2007) for a discussion on file sharing), but to note the change in the music industry that has occurred and explain potential future changes as demand for streaming music increases.

3 Streaming background

The digital sale of albums is a bundled product, while pure components are sold as individual songs. Digital distribution of the mixed bundle offers a discount over the physical media that existed prior to internet delivery. The digitally distributed songs and albums are durable goods, as purchasing the digital options allows for many listens, in fact content in digital form can have a longer life than physical media as excessive listening does not result in loss of fidelity or content. Streaming services differ from the mixed bundled products that Elberse (2010) considers, as the products streamed are not durable. Unlike digitally purchased products, a song streamed through a service is not saved once the subscription has expired. The experience is temporary, does not convey ownership, and cannot be duplicated without accessing the service again.

With legal streaming consumers access music through usually extensive digital libraries that contain much of the popular music past and present. The difference in the product from durable music goods such as CDs and purchases made from online stores such as iTunes is that the consumer does not store the music, having it "streamed" through their data connection.[2] Some streaming services provide a "freemium" model, allowing for an adverting supported free tier, and a premium subscription tier. We focus on the subscription tier in this paper, but we show how our analysis could extend to a free tier if we considered enduring advertising to be a price of listening.[3]

An album sold provides considerably more revenue per song than a single stream does as consumers are paying for a durable good that can be listened to many times. Songs have been bundled into an album to take advantage of heterogeneous willingnesses to pay for different songs and among consumers, as seen in the bundling literature of (Stigler, 1963; Adams and Yellen, 1976). When an album is the primary option this encourages the interested consumer to make a more substantial one-time payment. Once purchased, the number of times a consumer listens to the durable product is irrelevant to the artist. In contrast, streaming music incentivizes an artist to have the consumer listen to a song repeatedly. One song streamed ten million times provides the same revenue as ten songs streamed one million times, at what is likely a lower cost of production for the artist.

In recent years, streaming music services have gained in prominence and revenue share for the music industry, becoming an increasingly important method of distribution. The year 2015 was the first in which streaming music represented the largest source of revenue for the music industry in the United States, reaching 34.3% of revenue (compared to 34% from digital download, 28.8% from physical sales) from 7% in 2010. In an environment where both digital and physical sales decreased significantly, the large increases in streaming revenue resulted in a small increase for the industry from 2014 to 2015.[4]

[2]Some music services, such as Spotify, allow their customers to store music offline, much like an MP3. We consider this to be non-durable as the artist is paid by listens for that product, and the file is no longer accessible if the subscription ends.

[3]Spotify, the streaming service we focus on in the empirical section, receives 91 percent of revenue from their paying consumers. See http://www.billboard.com/articles/business/6561113/spotify-losses-accelerate-as-revenue-grows-to-122-billion Accessed: 9/10/2015.

[4]Statistics are from the RIAA, see http://www.riaa.com/wp-content/uploads/2016/03/RIAA-2015-

Industry experts seem to expect this trend to continue, potentially accelerating. It is not hard to imagine in this changing industry that musicians will pay increasing attention to producing music aimed at streaming distribution.

In this environment, a popular single can generate substantial and immediate revenue for the rights holder. A single by Wiz Khalifa, "See You Again" generated 4.2 million listens on its first day and 21.9 million listens worldwide its first week released on Spotify in April 2015.[5] Given the 2013 royalty payment estimates released by Spotify this single generated revenue between $131,000 and $184,000 in the first week on Spotify alone.[6] Spotify has agreed to pay 70 percent of revenues to rights holders in royalty payments, divided by percentage of streams for each song. Total revenue from other streaming services for popular singles such as this is likely substantial as well.

All of the growth in revenue comes from additional listeners to the service. The nature of streaming ensures that royalties are split, based on number of plays, from an amount of money determined by total revenue and not total number of songs played. More listens may increase revenue in the advertising platform, but as this is a small percentage of total income, increased revenue is coming almost entirely from subscriber increases.[7] A single musician can increase individual revenue by increasing the plays of their song due to the non-durable nature of the product, but the growth in industry revenue must come from additional subscribers.[8]

Spotify is the subject of streaming data for this paper. During the period studied, late 2013 through March 2015, Spotify was not the largest dedicated streaming service, second in total streaming activity to Pandora.[9] Pandora provides an internet radio service, taking revealed preferences of the consumer and playing music to suit tastes. YouTube, while not a dedicated streaming music service, also provides a substantial amount of the total streams. Other competitors such as Beats Music, Deezer, Google Play and others stream music, but with lower market share.[10] For this period, Spotify is the largest dedicated music service in the United States that is on-demand (the market used as example for this paper), where the music choice is left to the consumer completely. This service is chosen because it is closest in function to the consumer purchasing music through a physical or digital distribution format, and is presumed representative of the streaming industry as a whole.

Year-End-shipments-memo.pdf. Accessed: 4/07/2016

[5]See discussion here: https://insights.spotify.com/us/2015/04/15/paul-walker-tribute-sets-new-spotify-listening-records/ Accessed 4/17/2015.

[6]These estimates use Spotify's average per stream of between $0.006 and $0.0084, which were estimated in July 2013, and were anticipated to increase with subscribers by the song's April release.

[7]For a discussion of streaming subscribers, see http://www.billboard.com/articles/business/6875477/spotify-30-million-subscribers-apple-music-11-million-subscribers Accessed:4/07/2016.

[8]It is possible that songs can be licensed in bulk, not depending on a per stream payment. While this occurs in licensing movies to movies and television shows, there is no evidence of this model in streaming music, where counting streams is easy through the platform.

[9]Triton Digital measures streaming activity by month, http://www.tritondigital.com/press-releases/ Accessed: 4/17/2015.

[10]Apple Music entered the market after this period, and is expected to be a major force in the market.

4 A model of streaming music

In this section, we model music production decisions when consumers have an option to choose to listen to the songs from an album or a non-durable streaming service. Demand is first accounted for based on the quality of songs. We then consider profit to the artist, who has a monopoly on the distribution of their product, and consider their production decisions. To simplify our analysis, we focus on consumers' format decision and the artist's optimal production strategy. Consumers are divided into two separate markets which intended to mirror the industry.

The first model assumes a fully-served market, representing the consumers who are dedicated fans of an artist. These fans are going to consume new music produced and must only decide which purchasing option provides the most utility. The second model assumes a partially-served market; this market contains consumers who must first decide whether to pay for the music, and for those that decide to consume they must consider which format to use. This represents a market where the artist faces the potential for growth, or increased sales.

We assume that consumers are uniformly distributed on a unit distribution according to their source preference for music since both streaming and purchasing have advantages. Bran and Matula (2014) provide numerous benefits to both options. By owning a single or album by an artist, a consumer is given the freedom to use it in any capacity, on a variety of devices, and without an internet connection. In addition, ownership provides larger financial support for an artist. On the other hand, streaming is very convenient since it requires no data transfer between devices, storage space, or management.

The purchase decision involves a consumer's utility from song i on album j, and the price of available formats. Song V_{ij}'s quality (denoted by A, and taking three values: low, medium, and high) is represented by:

$$\mathrm{A}(V_{ij}) = \begin{bmatrix} A_H & \text{if the song has high value} \\ A_M & \text{if the song has medium value} \\ 0 & \text{if the song has low value} \end{bmatrix}$$

The value of low quality songs are normalized to zero for the consumer. The utility a consumer receives from a song depends on the format. A representative consumer x can receive utility from song i on album j in three ways: by purchasing a bundle of all album j songs, purchasing an MP3 of song i, or listening to song i through a streaming service. Therefore, a consumer's utility function from this music can be represented as:

$$U_{x,i,j} = \begin{bmatrix} \Sigma_{i=1}^{I} \left(A\left(V_{ij}\right) + x\tau\right) - P_W + Ly & \text{if purchasing bundle} \\ A\left(V_{ij}\right) + x\tau - P_{MP3} & \text{if purchasing single} \\ A\left(V_{ij}\right) + \left(1-x\right)\tau - \frac{P_S * F(A(V_{ij}))}{N + F(A(V_{ij}))} & \text{if purchasing subscription} \\ 0 & \text{if not purchasing} \end{bmatrix}$$

The consumer makes the decision monthly to purchase the music they intend to

listen to, or to subscribe to a streaming service.[11] We assume the consumer knows approximately how much music they will listen to in a month, and will therefore make a rational decision. The consumer does this knowing that once the streaming subscription is purchased there are no marginal costs for additional listening in that month, so the average price of listening to songs is the relative price. If the consumer wants to continue to use the service in the following month, they must pay the subscription again or return to purchasing music. Note that the price of a monthly streaming subscription could be replaced by the cost of listening to advertisements.[12]

The bundle has a price, $P_W = IP_a$, P_W denotes the price of a bundle, while P_a is the average price of each song in a bundle and I is the number of songs on the album, exogenously set by the producer. P_{MP3} is the price of purchasing a song individually (based on traditional industry pricing), P_S is the price of a streaming subscription (set by the streaming service), and the price of streaming an individual song is assumed to be the percentage of total streaming listens devoted to that song. L denotes the additional value derived from included extras obtained by purchasing a bundle, and y is a scale of appreciation a consumer has for a band's products beyond the value of listening to their music.[13] The number of listens song i receives is dependent on the quality. The consumer has a source preference, with the intensity measured by τ. We assume $\tau < P_a$ and $\tau < P_{MP3}$, since a rational consumer is unlikely to obtain a song based solely on the song's format. N is the total number of listens of all songs (excluding album j) by the consumer through a streaming service. The listens for a given quality are determined by:

$$\mathrm{F(A}(V_{ij})) = \begin{bmatrix} F_H & \text{if the song has high value } (A(V_{ij}) = A_H) \\ F_M & \text{if the song has medium value } (A(V_{ij}) = A_M) \\ 0 & \text{if the song has low value } (A(V_{ij}) = 0) \end{bmatrix}$$

We illustrate different production scenarios for bundles by using two discrete cases to derive results for the changing environment.[14] First, we assume that all songs on an album are of a medium value (the medium strategy), representing a scenario where the bundle may be purchased in large numbers due to the uniformity of song quality. Second, we assume the artist produces a bundle with one high quality song (the hits strategy), and the remainder low quality. Given the fact that the value to consumers of low quality songs is zero, this can be thought of as releasing a single hit.

[11] Similar to Chang and Walter (2015), our focus is on the method with which consumers obtain a product and the implications it has for producers, therefore we ignore substitution from other competitor's products and any income effects.

[12] This analysis require replacing $\frac{P_S * F(A(V_{ij}))}{N + F(A(V_{ij}))}$ with P_{AD}, where P_{AD} is the cost of watching an advertisement

[13] This measure could include band covers, limited edition material, liner notes, etc. for physical bundles or personal emails, thanks, videos, promotional material included with digital purchases. The value is zero if the consumer only cares for the music produced.

[14] Many other scenarios are possible, the stylized model is intended to illustrate the potential for change.

4.1 Value of bundle extras

We first consider the consumer's decision to purchase a bundle or individual MP3s in an unbundled form, without a streaming service option. We begin by examining the relevance of extras in the bundled form, which implies that $L > 0$. Assume that the number of songs to be sold as singles (with utility greater than zero) is D. In order for digital singles to strictly dominate bundled sales it must be that:

$$\Sigma_{i=1}^{I}\left(A\left(V_{ij}\right)+x\tau\right)-P_W<\Sigma_{i=1}^{D}\left(A(V_{ij})+x\tau-P_{MP3}\right)$$

Or that $\Sigma_{i=1}^{I}\left(A\left(V_{ij}\right)\right)-P_W>\Sigma_{i=1}^{D}\left(A(V_{ij})\right)-DP_{MP3}$, which implies that if $D=I$ and $P_W<IP_{MP3}$ then the bundle will be preferred. Intuitively, if every song is good enough to be sold as a single, then the relative price of a bundle versus MP3s will determine the format. However, if any song has low or no utility, then purchasing a bundle requires that $P_W<DP_{MP3}$, which becomes less likely as the number of high quality songs diminishes in a bundle. Since the strategy employed by the artist has implications even in the absence of a streaming option, we examine the effects of extras on album sales using differing strategies. We start by employing the medium strategy in a fully-served market. A consumer that prefers the bundled option relative to purchasing MP3s is represented by:

$$\Sigma_{i=1}^{I}\left(A_M+x\tau\right)-P_W+Ly>\Sigma_{i=1}^{I}\left(A_M+x\tau-P_{MP3}\right)$$

Solving for the level of appreciation of extras included in a bundle, we see that the bundle must satisfy $Ly>(P_W-IP_{MP3})$, or the consumer's level of appreciation for the added value of the bundle must exceed the price difference to sell albums. Similarly, considering an album with one high value song and the remainder low, a consumer prefers the bundled option if:

$$A_H+x\tau I-P_W+Ly>A_H+x\tau-P_{MP3}$$

Implying that the bundle must satisfy $y>\frac{1}{L}(P_W-x\tau(I-1)-P_{MP3})$. Since $P_{MP3}>x\tau$ for all x, it is clear that $P_W-IP_{MP3}<P_W-x\tau(I-1)-P_{MP3}$. As this property will always hold, we can conclude that the threshold is higher for a user to prefer purchasing an album from an artist that used the "hits" strategy relative to the "medium" strategy. For that reason, we state the following:

Proposition 1 *Given a sufficient level of utility for extras (L), artists can sustain some bundled sales in the presence of unbundling, but the hits strategy reduces the sales of bundles compared to the medium strategy. With the hits strategy, purchasing individual songs is strictly preferred to a bundle in the absence of extras.*

Our approach provides a theoretical reason for the empirical findings of Elberse (2010)

that demand for bundles of songs with similar appeal is less impacted by alternative formats. Albums composed of similar songs (medium strategy) fare better than albums with songs of differing appeal (hits strategy), due to the value of the songs included. The advantage of purchasing an MP3 single is that it allows users to avoid the tying of bad songs to good ones, an effect magnified as artists incorporate more lesser appeal songs in an album. The removal of this effect makes users indifferent to bundled albums and buying every song individually. This indifference and the inclusion of extras that have utility within the bundle will therefore tip the users preference to purchasing the bundle.

Our result indicates that the dedication of fans may lead to different strategies. An artist with a dedicated fan base may find bundles more profitable, whereas a new or struggling artist may aim for a hit to derive profit. Moreover, in the absence of extras a bundle's price under the hits strategy will certainly exceed the price of an individual MP3. Owning the remaining low value songs adds some utility, but the bundled premium will surpass any additional benefit.

As shown by Boluk (2015), the only music formats to increase in spending in the last 15 years are digital download and digital streaming, therefore we assume that when an artist identifies an optimal strategy they concern themselves less with the implications for bundled sales with extras.[15] Obviously, the dedication of fans plays an important role in the demand for music. Since our focus is the digital market, we proceed with the assumption that $L = 0$, to illustrate the potential for streaming to affect the digital market for music. We have shown that for the medium strategy, purchasing all singles is strictly preferred if $P_W > IP_{MP3}$ in the absence of extras. For ease of notation, we assume this is the case for the remainder of the paper, which allows for focus on the comparison between (durable) digital songs and (non-durable) streaming.[16]

4.2 Fully-served market

We examine a fully-served market, where all consumers purchase the music and must decide between formats. This is representative of a market of dedicated fans, as the music is always obtained in some form. In order to identify the form purchased, we locate the consumer indifferent between purchasing and streaming a representative song:

$$\Sigma_{i=1}^{I}\left(A\left(V_{ij}\right)+x\tau-P_{MP3}\right)=\Sigma_{i=1}^{I}\left(\left(1-x\right)\tau+F(A\left(V_{ij}\right))-\frac{P_{S}F(A\left(V_{ij}\right))}{N+\Sigma_{i=1}^{I}F(A\left(V_{ij}\right))}\right)$$

When evaluating the market for an artist using the medium strategy (M), the indifferent consumer, x, satisfies:

$$I\left(A_{M}+x\tau-P_{MP3}\right)=I\left(\left(1-x\right)\tau+A_{M}-\frac{P_{S}F_{M}}{N+IF_{M}}\right)$$

[15] The steady downward trajectory of bundled sales makes this assumption even more likely in the future.

[16] We could easily assume $P_{MP3} > P_W$ and artists release bundles, the results are the same under the medium strategy.

Solving this expression yields $x = \frac{1}{2\tau}\left(P_{MP3} + \tau - \frac{P_S F_M}{N + IF_M}\right)$. Since consumers closer to zero have a preference for streaming, this gives a quantity demanded (Q_D) for the streaming form (which is encapsulated by users in the interval $[0, x]$) in a fully-served market (denoted by $*$) as:

$$Q^*_{D^S}(A_M) = x = \frac{1}{2\tau}\left(P_{MP3} + \tau - \frac{P_S F_M}{N + IF_M}\right) \tag{1}$$

Similarly, consumers closer to one have a preference for purchasing the durable option, so all users in the interval $[x, 1]$ purchase the MP3s, thus $1 - x$ gives the quantity demanded for purchasing singles in a fully-served market:

$$Q^*_{D^{MP3}}(A_M) = (1 - x) = 1 - \frac{1}{2\tau}\left(P_{MP3} + \tau - \frac{P_S F_M}{N + IF_M}\right) \tag{2}$$

Using this approach we can evaluate the market when an artist uses the hits strategy (H). In this scenario the indifferent consumer, x, satisfies:

$$(A_H + x\tau - P_{MP3}) = \left((1 - x)\,\tau + A_H - \frac{P_S F_H}{N + F_H}\right)$$

The quantity demanded for streaming from an artist using the hits strategy in a fully-served market is:

$$Q^*_{D^S}(A_H) = x = \frac{1}{2\tau}\left(\tau + P_{MP3} - \frac{P_S F_H}{N + F_H}\right) \tag{3}$$

And the quantity demanded for the hit single in a fully-served market is:

$$Q^*_{D^{MP3}}(A_H) = 1 - x = 1 - \frac{1}{2\tau}\left(\tau + P_{MP3} - \frac{P_S F_H}{N + F_H}\right) \tag{4}$$

Production decisions are based on the profit to those creating music. We develop a profit function for each artist from durable sales and streaming revenue. In this profit function we assume costs are identical for producing the medium strategy album and the hit strategy, and exclude costs from the analysis.[17] The artist's profit is

$$\pi = P_{MP3}\Sigma_{i=1}^{I} Q_{D^{MP3}}\left(A(V_{ij})\right) + r\Sigma_{i=1}^{I} Q_{D^S}(A\left(V_{ij}\right)) \tag{5}$$

Where r is the royalty rate paid per stream. The royalties going to an individual artist are determined by their percentage of streams generated. Substituting in Equations 1 and 2 provides profit for the medium strategy in the fully-served market:

[17]There are many other possibilities. Producing an album full of medium quality songs could be argued as more expensive than the hit strategy or vice versa, we explore the implications of different costs in Section 5.

$$\pi^{M*} = IP_{MP3} + \frac{I\left(rF_M - P_{MP3}\right)}{2\tau}\left(P_{MP3} + \tau - \frac{P_S F_M}{N + IF_M}\right) \tag{6}$$

Similarly, we can solve for profits under the hits strategy. Note that no low quality songs are sold individually, so the hit song provides the only sales. Therefore, the profits for the hits strategy in the fully-served market are:

$$\pi^{H*} = P_{MP3} + \frac{\left(rF_H - P_{MP3}\right)}{2\tau}\left(P_{MP3} + \tau - \frac{P_S F_H}{N + F_H}\right) \tag{7}$$

4.3 Partially-served market

Not all consumers are dedicated fans or even heavy listeners. In this section we examine a market of consumers that do not necessarily purchase an artist's music in any form. This is representative of a growth market, since the base of listeners can always increase. In this partially-served market, improving quality can therefore add to demand. Using qualitative data on consumer research Sinclair and Green (2015) found that consumers that were formerly downloading music on file sharing services were now being convinced to stream music by the low cost and consistent quality. The consumer that is indifferent between purchasing the streaming of an album and not purchasing satisfies $\Sigma_{i=1}^{I}\left((1-x)\,\tau + A\left(V_{ij}\right) - \frac{P_S F(A(V_{ij}))}{N+\Sigma_{i=1}^{I} F(A(V_{ij}))}\right) = 0$. If an artist uses a medium strategy, this leads to the quantity demanded for streaming in a partially-served market (denoted by $**$) as

$$Q_{D^S}^{**}(A_M) = x = 1 + \frac{1}{\tau}\left(A_M - \frac{P_S F_M}{(N + IF_M)}\right) \tag{8}$$

A consumer indifferent between purchasing an individual song on an album or not solves $\Sigma_{i=1}^{I}(A(V_{ij} + x\tau - P_{MP3}) = 0$. Assuming the artist uses a medium strategy, this leads to the quantity demanded of each song in the partially-served market as

$$Q_{D^{MP3}}^{**}(A_M) = 1 - x = \frac{A_M + \tau - P_{MP3}}{\tau} \tag{9}$$

Using the same approach, we can evaluate the market when an artist uses the hits strategy. Quantity demanded for streaming in this partially-served market is

$$Q_{D^S}^{**}(A_H) = 1 + \frac{1}{\tau}\left(A_H - \frac{P_S F_H}{N + F_H}\right) \tag{10}$$

Quantity demanded for MP3s with a hits strategy in a partially-served market is

$$Q_{D^{MP3}}^{**}(A_H) = \frac{A_H + \tau - P_{MP3}}{\tau} \tag{11}$$

The profit function of each strategy can be calculated using Equation 5, which fol-

lows the same general logic of the fully served market. We begin by substituting the demand expressions for the partially-served market when a medium strategy is used. Using Equations 8 and 9 gives us the artist's profit using the medium strategy as

$$\pi^{M**} = \left(1 + \frac{A_M - P_{MP3}}{\tau}\right) IP_{MP3} + \left(1 + \frac{A_M}{\tau} - \frac{P_S F_M}{\tau\left(N + IF_M\right)}\right) IF_M r \tag{12}$$

Similarly, using Equations 10 and 11 gives the artist's profit with the hits strategy:

$$\pi^{H**} = \left(1 + \frac{A_H - P_{MP3}}{\tau}\right) P_{MP3} + \left(1 + \frac{A_H}{\tau} - \frac{P_S F_H}{\tau\left(N + F_H\right)}\right) F_H r \tag{13}$$

4.4 Market Analysis

In this section, we look at how the effects of a changing market can alter music consumption and impact the profitability of a production strategy.[18]. Table 1 provides the signs for important results from first order derivations of each strategy. We find that the quantity demanded for streaming a song increases in each market as the consumer's overall base of listening on a streaming service (N) increases. The increase in demand for similar songs decreases the relative price of each song when purchasing the streaming bundle. For the same reason, demand for streaming actually falls as the quality of an individual song (A) increases, all else equal, in the fully-served market. This increase in listens raises the relative price of the individual song. In the partially-served market, the increase in overall listening (more subscribers) counters the higher relative price, and quantity demanded increases. In each market, quantity demanded increases as the quality of a song increases in tandem with the consumer's listening base, as the combination serves to deepen the market, or increase the listens of the non-durable product. Consumers appreciate the quality more as there are complementary songs of more artists that they are also listening to.

The quantity demanded for MP3s necessarily moves in the opposite direction in the fully-served market as N increases, but is unaffected by an increase in N in the partially-served market as all growth is from consumers formerly not purchasing now streaming music, providing an increase at the extensive margin. This indicates the importance of an artist knowing their market. An established artist facing a fully-served market may be drawing demand away from their sales by placing their music on streaming services. Hiller (2016) finds substantial reductions in album sales from streaming music, particularly among the top selling albums in a given week. This may be a significant reason for artists like Taylor Swift long withholding her music from streaming services.[19] Still, with a promised increase in royalties she relented and allowed her music to be streamed on Apple Music, possibly because increased revenue from streaming supplements displaced

[18]We treat quality (A) as a continuous variable in this section. The function mapping quality into the number of listens is assume to be strictly increasing in quality, such that $\frac{\partial F(A)}{\partial A} = F_A(A) > 0$

[19]http://www.nytimes.com/2014/11/06/arts/music/sales-of-taylor-swifts-1989-intensify-streaming-debate.html Accessed: 9/10/2015.

sales, as in (Aguiar and Waldfogel, 2015).[20] Cannibalization from streaming music may exist, but as streaming increases in relative importance it becomes more difficult for an artist to ignore the format, even with these considerations.

In contrast, when facing a partially-served market the artist has little to lose from an increasing N, and the quantity demanded can add new consumers without depleting existing sales. Using European data, Kretschmer and Peukert (2014) find that streaming music stimulates album sales, but displaces individual song sales, potentially recognizing the difference between a fully and partially-served market. Bands not among the highest levels of popularity can face this scenario. Additionally, this model does not include the complementary concert industry. For artists facing a partially-served market, the increasing importance of the concert industry may provide additional incentive to produce using a strategy specific to the streaming market.

Profit increases in the partially-served market as each variable examined increases, with the exception of source preference (τ). The increase in N is increasing the listening base without decreasing MP3 sales, and the increase at the extensive margin leads to increased profit. Change in profit is not certain in the fully-served market. The increase in N increases the quantity demanded for streaming, but at the cost of MP3 sales. If $rIF_M - IP_{MP3} > 0$ (or $rF_H - P_{MP3} > 0$ for the hits strategy) then profit will increase with N. The revenue from streaming of songs must exceed album revenue in order for the producer to receive greater profit from increased streaming.[21] Profit is increasing in both markets as quality increases.

4.5 Production strategy

Given these profit implications the artist must decide which strategy to follow. Substituting Equations 6 and 7, the hits strategy is more profitable in the fully-served market, or $\pi^{H*} > \pi^{M*}$, if

$$P_{MP3} + \left(\frac{P_{MP3} + \tau - \frac{P_S F_H}{N+F_H}}{2\tau} \right) (rF_H - P_{MP3}) > IP_{MP3} + \frac{I\left(F_M r - P_{MP3}\right)}{2\tau} \left(P_{MP3} + \tau - \frac{P_S F_M}{N + IF_M} \right)$$

In order to solve this equation we make the assumption that $A_H = IA_M$, and by extension that $F_H = IF_M$ which allows us to identify the conditions under which artists benefit from using a hits strategy.[22] Specifically, the hits strategy is more profitable if:

[20] See http://time.com/3940500/apple-music-taylor-swift-release/ Accessed: 9/10/2015.

[21] We discuss the probable outcome that royalties (r) will increase with N in Section 5.

[22] $A_H = IA_M$ shows a large discrepancy between hits and middling songs in number of plays. However, in our data in Figure 1, the number one song is streamed on average five times more than the number 50 song and 9 times more than the 200th song, all of which are considered hits. A greater disparity is likely between a high and medium quality song in our model. Nevertheless, alternative substitutions could be used without loss of generality.

$$N^* > \frac{IF_M\left(\tau P_{MP3} + rF_M P_S - P_{MP3}^2\right)}{P_{MP3}\left(P_{MP3} - \tau\right)} \tag{14}$$

When N is sufficiently large, the hits strategy becomes a more profitable production strategy. Given the changing market, this could have profound implications for how music is produced. Instead of creating a bundle of songs, and releasing the bundle all at once as an album artists may release one hit, allow for demand to decline on the streaming services, and release another high quality song. This would imply that fewer songs would be produced and release of those songs spaced apart based on diminishing demand, but at a higher average quality.

Using a similar approach, we can examine when in the partially-served market $\pi^{H**} > \pi^{M**}$, substituting Equations 12 and 13. Assuming that $F_H = IF_M$, the hits strategy is more profitable if:

$$N^{**} > \frac{IF_M\left(rP_S F_M + \tau P_{MP3} - rIF_M^2 - P_{MP3}^2\right)}{rIF_M^2 + P_{MP3}^2 - \tau P_{MP3}} \tag{15}$$

Providing a similar result in describing what is necessary for the average user's number of listens to allow an artist to benefit from using a hits strategy. If we compare the thresholds needed in each market for the hits strategy to be profitable, we identify which threshold is smaller. Assuming $N^* > N^{**}$, we obtain:

$$\frac{r^2 I^2 F_M^4 P_S}{P_{MP3}\left(P_{MP3} - \tau\right)\left(rIF_M^2 + P_{MP3}^2 - \tau P_{MP3}\right)} > 0$$

Leading to the next proposition:

Proposition 2 *As the average user's base of listens in a streaming service increases, the hits strategy becomes more profitable in both the partially-served and fully-served markets. However, the hits strategy increases profit in the presence of a lower listening threshold in the partially-served market indicating that increases on the extensive margin are larger than the intensive margin.*

The opportunity for the hits strategy comes from a market deepening, where profits are increased from more listening in the fully-served market. Payments for the non-durable product increase from the additional use of the product. In the partially-served market the increase from the hits strategy is derived from market expansion, more consumers listen to the hits. When comparing the advantages derived from the hits strategy

increases on the extensive margin seem to dominate the intensive margin, further indicating that an artist with lower demand will find increased benefit from the hits strategy, whereas an already established artist requires a greater threshold.

The hits strategy works sooner in the partially-served market, where customers were not previously committed to the artist's music. These customers could be thought of as casual fans who currently consume most of their music through radio, or possibly illegal downloads. They are not purchasing MP3s or CDs, and may be attracted to streaming music. As these uncommitted consumers begin to use streaming services more, it will encourage artists to release hits to increase demand in that market. Profits are also increased by the hits strategy in the fully-served market once N is sufficiently large. Implying that as streaming becomes more popular, the hits strategy becomes more viable, even in a fully-served market.

4.6 Royalty implications with a fixed listening base

In this section, we conveniently let $N = bF_M$ and $\beta = \frac{1}{b+I}$ in order to simplify the comparison of profit from each strategy in both markets, and the effect of a change in royalties on the production strategies. Note that we are still assuming a hit yields the same number of listens as a bundle of medium quality songs (or that $IF_M = F_H$), this allows us to represent $\frac{P_S F_M}{bF_M + IF_M} = \beta P_S$. This assumption appears reasonable from the data presented in Section 6.

Comparing the profit of both strategies in the fully-served market, we can identify conditions under which a particular strategy will yield a higher profit. Since our focus is on the effects of streaming on the digital marketplace, we observe the circumstances under which the non-durable royalties from streaming make a hits strategy more profitable. If an artist's profit from a hits strategy exceeds profit from a medium strategy, the royalties paid to artists for digital streams satisfy:

$$r^* > \frac{(P_{MP3} - \tau) P_{MP3}}{\beta I F_M P_S} \tag{16}$$

Similarly, we can compare profit in the partially-served market. As before, we can compare the artist's profit under both strategies. From this we can conclude that if an artist's profit from a hits strategy exceeds profit from a medium strategy, then the royalty rate paid to artists for digital streams satisfies:

$$r^{**} > \frac{P_{MP3} (P_{MP3} - \tau)}{(\beta P_S - F_M) I F_M} \tag{17}$$

We summarize these results with the following proposition.

Proposition 3 *With a sufficiently high royalty rate, artists' profits increase with a hits strategy in both a fully-served and partially-served market, which further incentivizes a change in music production.*

Our findings have shown that in the presence of sufficient royalties and demand for streaming music, an artist can increase their profits by producing less, higher quality music. As consumers' listening habits evolve and shift toward streaming music, an artist's profit increases with the hits strategy in two ways, through a deepening of the non-durable market as well as additional consumers on the extensive margin. Similarly, the royalty rate paid by digital streaming companies also influences an artist's production method. With sufficiently large royalty payments, artists benefit from a hits strategy. And although our focus is on the music production, it's noteworthy that a hits strategy increases the number of streaming users, thus benefiting streaming companies.

This implies that if a streaming company has a goal of expanding the user base and encourage artists to produce "hits", the best strategy is a low subscription price with a high royalty rate. Essentially, they pander to both sides of the market. Of course, this is a risky strategy as losses are likely in the short run but in the long-run this may lead to a shift in preference for distribution of music, which could eventually lead to higher subscription prices.[23]

5 Alternative assumptions

There are still three alternatives we could apply to our assumptions that may change our model. The first assumption is that costs of production are the same for the medium and hits strategies. In reality costs can vary substantially, a hit could cost more than an album full of medium quality songs or vice versa. Still, the specifics of the cost structure should not qualitatively change our results, just the threshold at which the relative profitability of strategies starts to shift. If the cost of hits is substantially more than the cost of several middle quality songs, then the threshold becomes higher and delays the hits strategy.

The second assumption we use in the model is that royalties (r) will not increase as N increases. For a single paying consumer this is certainly true. However, as the

[23]Indeed, Spotify is not profitable during this period, with directors saying "We believe our model supports profitability at scale." See http://www.theguardian.com/technology/2015/may/11/spotify-financial-results-streaming-music-profitable Accessed: 9/30/2015.

overall number of consumers increases the royalty rate paid to artists for their percentage of plays will rise, all else equal. Revenues have been rising in the streaming industry. Spotify revenues grew 45 percent in 2014, and given the commitment to pay 70 percent of revenues as royalties, total royalties also grew by 45 percent.[24] If the percentage of streams devoted to each artist remains relatively constant with these increases, profits from streaming will increase for all artists.

Other streaming services are reported to have similar royalty structures, and would pay increasing royalties as revenue increased. In the partially-served market much of the benefit for the artists is attracting consumers who were not paying for music before, so profits are always increasing with the increased consumers as long as producers can maintain their share of music. However, this also makes the condition $rA_H - P_{MP3} > 0$ more likely to hold,[25].

Additionally, in our model we assume that all else is held constant with a single changing variable. Given the predictions of the model it would be fair to conclude that the composition of songs competing for listeners will change as streaming becomes more prominent. The effects of this competition would not be clear. A first prediction is that song quality would increase, presumably increasing competition. But as the listening base for consumers increases, each becomes more likely to subscribe to a streaming service. Given that there is no marginal cost for listening to an additional song once a consumer has subscribed, the number of songs listened to increases on the extensive margin. This creates an uncertain net effect from the increasing quality, with higher quality songs vying for the consumer's attention but increases in the number of potential consumers for a song provided by additional subscribers.

6 Data and existing evidence

Streaming music is still relatively immature as an industry, but some signs of a shifting industry can be seen from existing data. Streaming data comes from the activity of the top songs on Spotify in the United States. Beginning on April 28th, 2013, Spotify released the 50 most streamed songs by week. That list was extended to the top 200 most streamed songs in November of 2014. We have scraped each top list from the Spotify website from the beginning of the listings through March 1 of 2015, providing 97 weeks of Spotify streaming data, when the Spotify top 200 ceased to be published. Each

[24]See http://www.billboard.com/articles/business/6561113/spotify-losses-accelerate-as-revenue-grows-to-122-billion Accessed: 9/10/2015.

[25]This a sufficient condition for product differentiation (user listens) to increase (decrease) profit in the partially-served market

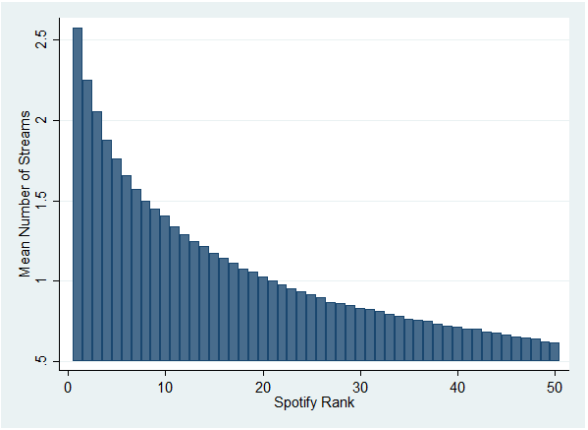
entry contains the artist name, title and rank of the song, and number of streams in the given week. The entire dataset is used in descriptive statistics, but in order to maintain consistency for comparison with album sales, the streaming charts with the top 200 are trimmed to the top 50.

The album sales data for this study is based on the Billboard 200, the U.S. industry standard for album sales. The Billboard 200 is a ranking of the 200 bestselling music albums from any genre. The chart in this period is based solely on sales (physical and digital combined) of albums in the United States. This sample is restricted, as is the Spotify streaming chart, to the top 200 albums in a given week. We obtained access to the weekly sales data for the Billboard 200 albums from Nielsen SoundScan, which is the official basis for the Billboard charts rankings. In December of 2014 the Billboard 200 began to incorporate streaming activity into the chart. Comparison after that point would change significantly as the streaming in the Spotify chart would be included in the Billboard chart.

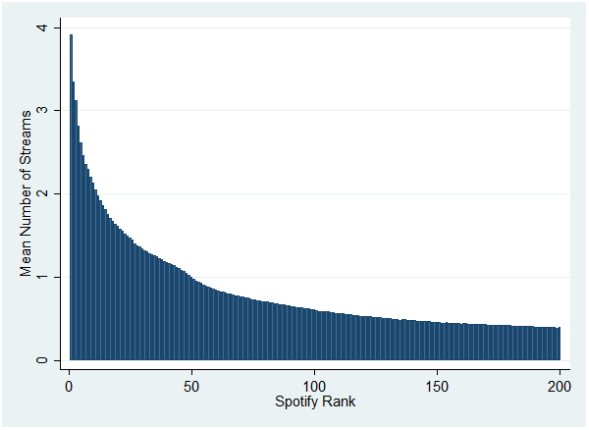
Figures 1a and 1b provide summary statistics on consumer streaming activity by rank on Spotify. Figure 2 compares the total streams by week in both the top 50 and top 200 rankings. Figures referencing the top 200 charts cover the window in which we have the entire top 200 dataset. Two observations are immediately evident. First, that there is a great disparity in the number of plays of songs at the top and bottom of the chart. Considering that these songs are all considered hits on the top 200, we may expect an even greater inequality past the top 200. Songs that peak at the top of the chart will likely receive many additional streams as they fall down the rankings. However, songs that peak at a lower rank can expect to receive a small fraction of the total streams of a hit. This difference emphasizes the need for hits in the streaming model. As payment occurs based on number of plays, the number one song on the charts in a week provides the same revenue to the producer as a nine song album of all songs ranked at 200.

Second, the total streams seem to indicate that Spotify is providing more streaming music. This is in line with an increase in streaming music overall. In August of 2015, year-to-date streams were up 100 percent over the same period in 2014, while singles purchases fell dramatically.[26] Revenues for streaming are increasing for these services, and with them royalty payments. N is also likely increasing with the streaming spike as the paying consumers generating the revenue replace alternative forms of music consumption with streaming. These changes are all leading to the conditions we have identified for a profitable hits strategy.

[26]See http://www.billboard.com/articles/columns/chart-beat/6685832/digital-song-sales-seven-year-low-streaming-rises Accessed: 9/10/2015.



(a) Top 50 streams by rank (in millions)



(b) Top 200 streams by rank (in millions) - for weeks available

Figure 1: Average streams by rank

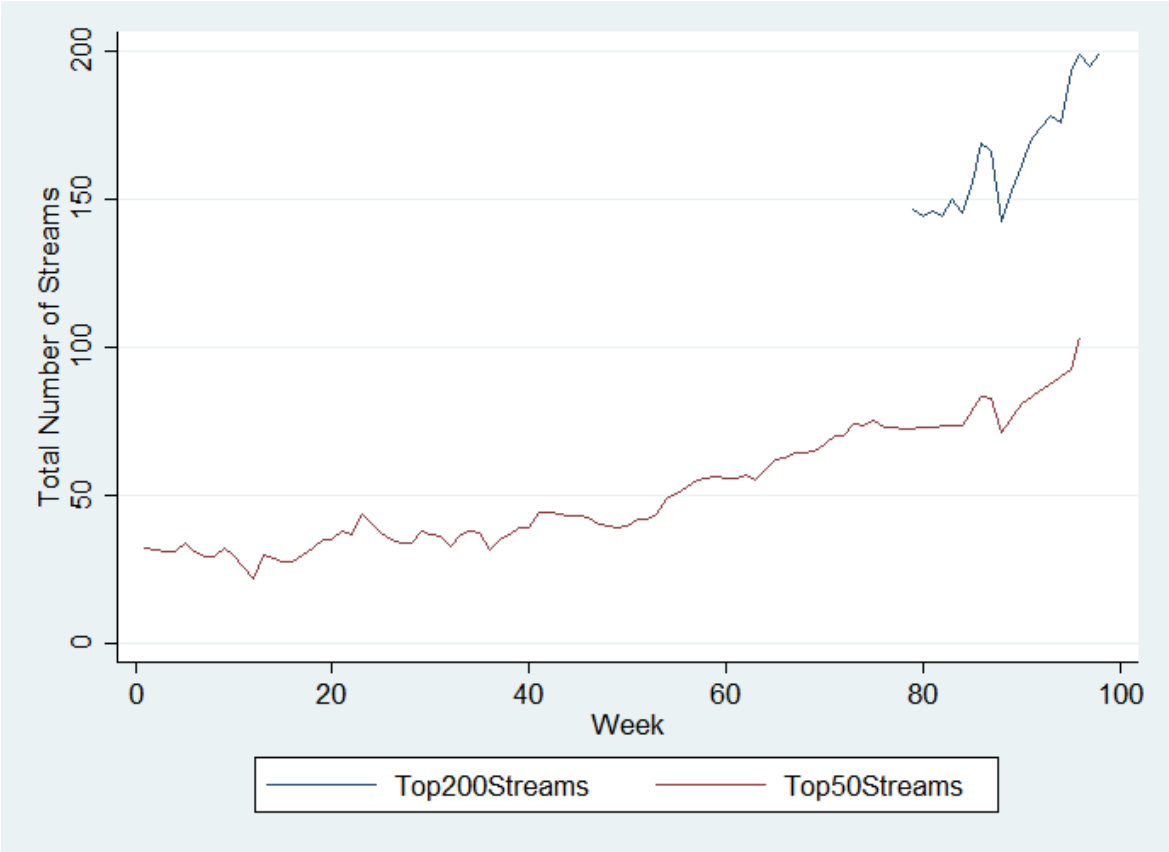
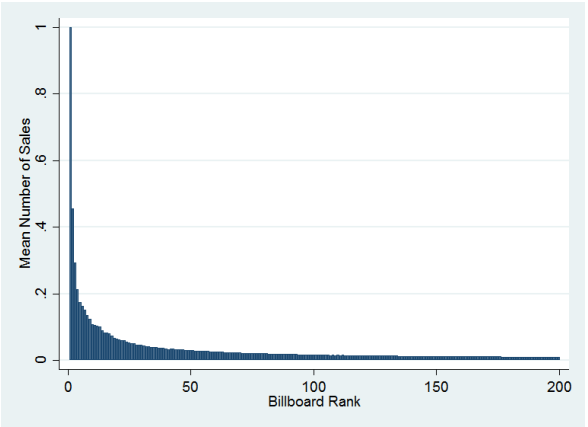


Figure 2: Total streams by weeks (in millions)

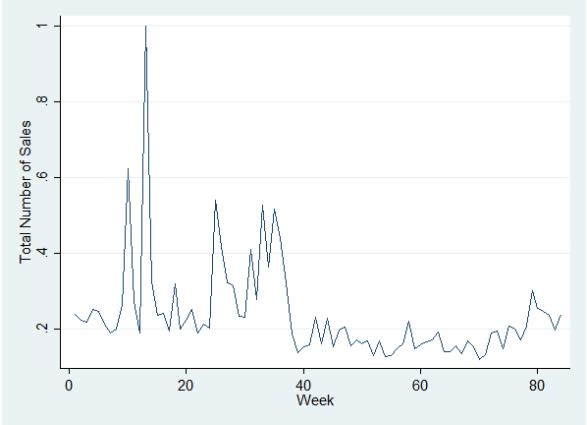
Figures 3a and 3b show the first 84 weeks of the sample for album sales among the Billboard top 200.[27] These numbers include physical and digital album sales, representing the durable option of production. The peak sales spike around the Christmas season of

[27] Any results beyond this week begin to incorporate streaming data directly into calculation.

2013. The results are relative to that peak, in order to protect proprietary data, but two things are clear from the chart. First, the inequality among sales from high ranking to lower ranking albums is even greater by week in the Billboard data. Second, unlike the Spotify data album sales are flat, at best, and more likely declining.[28]



(a) Average sales by rank relative to rank 1



(b) Total number of sales by weeks - relative to peak

Figure 3: Summary statistics of the Billboard 200 - proprietary data restricted

The tremendous disparity in sales for the top few albums versus the rest of those released seems to indicate how small the fully-served market is today. The albums at the top of the charts can still sell in considerable numbers. These few artists facing a fully-served market likely risk substantial losses from the expansion of the streaming market, as there are few consumers to add on the extensive margin and any market deepening is unlikely to counter the format change. However, the average sales in a week for an album in the top 200 are 9,514 for this period. Considering many albums never even make the top 200, this indicates that most artists are facing the partially-served market, with little to lose from the expansion. Their prospects from the growth of streaming music improve from the consumers to be gained.

Table 2 shows the increased likelihood of an album in the Billboard top 200 being in the top 50 (or top 10) given placement of songs in the Spotify top 50.[29] Marginal effects are presented, and the coefficients represent the percentage difference associated with a unit change of the variable compared to the mean Billboard album. This is not intended to show causal effects, but rather the regressions give correlations between the

[28]Beyond this sample, all long term trends indicate declining album sales. See, for example: http://www.billboard.com/articles/business/6236365/albumsaleshitanewlow2014 Accessed: 9/14/2015.

[29]The number of observations do not neatly meet the total expected from the Billboard 200 over the entire sample. This is because observations had to be removed from the Billboard data if they were compilation albums, soundtracks, or anything that made it impossible to match the album to appropriate songs on the Spotify charts.

two formats and measures of popularity. This is intended to measure the relationship of the formats, and potential divergence as streaming increases in popularity.

Column 1 gives a simple relationship between an album placing a song in the Spotify Top 50, $Spotify50$, and placing an album in the top 50 rankings of the Billboard chart, showing that there is a significant positive relationship. Column 2 adds the relationship of an album with more than one song ($SongsStreaming50$) in the Spotify top 50. Column 3 gives results showing that a one week lead on Spotify is correlated with a higher probability of being in the top 50, but weeks further in the past do not show significant results. Columns 4-6 provide similar results, but with an album ranking in the top 10 of the Billboard instead of the top 50.

Table 3 provides regressions from the same exercise, but using album sales and rankings within the top 200 as the dependent variable, rather than an indicator for reaching the top 50. Each column uses a least squares regression and contains album fixed effects, a positive coefficient in columns 1-3 represent increasing sales, while a negative coefficient in columns 4-6 represent an improved rank within the top 200. The coefficients show the same positive relationship between the two measures of popularity over the entire sample, which makes sense if production strategies focus on durable sales, with streaming music as a secondary source of income.

Clearly there is a positive relationship in this sample between the two rankings, however, Figure 4 provides more nuance to this result. The figure is based on column 1 of Table 2, with a simple relationship between the top 50 albums in the Billboard charts and songs in the Spotify top 50. The regression differs in the fact that the coefficient is measured by week rather than throughout the sample. The relationship begins with the strong positive correlation that is expected if these markets are treated the same.[30] However, as Spotify increases in popularity this correlation diminishes, and becomes negative toward the end of the sample.

The diminishing relationship over the sample between the two measures indicates an early beginning in the separation of the markets. Having a top selling album is clearly not necessary for having a hit, and indeed this may be early evidence of the two strategies diverging. As seen in the summary statistics, the popularity of Spotify increased dramatically in this period, while album sales were flat or declining.[31] The album sales of the top 50 likely represent artists facing a fully-served market, where attempts to produce for streaming music may still decrease profit. Many other artists can take advantage of a partially-served market, and use the increasingly popular Spotify platform to enhance

[30]The weekly coefficients are significant at least the 10 percent level in 65 of 84 weeks.

[31]Spotify entered the United States in July of 2011, the period summarized represents April of 2013 through December of 2014.

profits over what could be earned in the stagnant market for albums. While still early in the shift toward streaming music and despite currently remaining quite similar to the market for albums, the preliminary data indicate that some artists are beginning to focus on the expanding market.

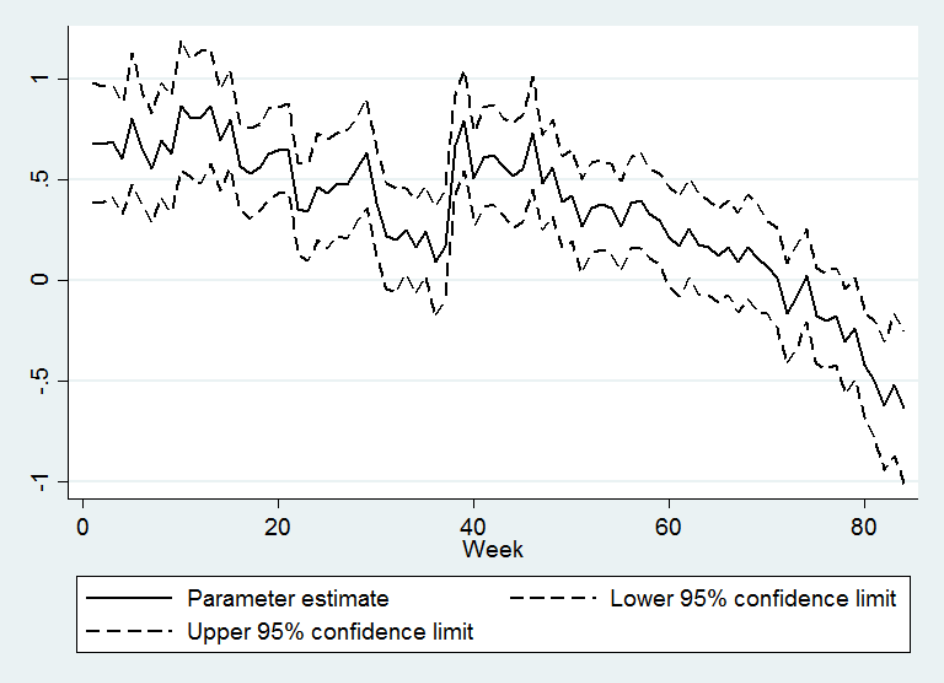


Figure 4: Probit estimates of correlation by week

In a final descriptive exercise found in Table 4, we explore the probability of an album reaching the Billboard Top 50 (in columns 1 and 2) and the Spotify Top 50 (in columns 3 and 4) given past success in album sales. This regression establishes each album or Spotify song as a single observation for the entire period, measuring whether the title in the top 200 reached the top 50 of each in the data. This means fewer observations, particularly for the Spotify regressions where we can only observe those titles for which we have the entire top 200. The variable *Albumsintop*50 provides the number of albums for the artist that have reached the Billboard top 50 since 2004. Artists with more loyal fans, or a larger fully served market, have likely had more success in albums since 2004. The first two columns show a distinct relationship between current album sales and prior album sales, as well as current Spotify placement. In contrast, past album success seems to have a negative relationship with the Spotify top 50, while current album success has the same positive relationship, providing a potential contrast in markets and strategies.

7 Conclusion

Streaming music is gaining in importance for the music industry. With this change in delivery to a non-durable product, makers of music will begin to change how they create and deliver music. As the popularity of streaming music increases the profitability of using a hits strategy, creating fewer singles of higher qualities and releasing them independently becomes more common. This may be delayed in fully-served markets, where artists already have a very established demand that allows sales of large numbers of bundled albums, but will happen at a sufficient listening base due to a market deepening. Transitioning to the hits strategy should happen quicker in partially-served markets, where producers gain earlier from consumer gains.

Album extras are excluded from the majority of our model, and may sustain some album sales in the face of substantial streaming if the value is sufficiently high. Niche demand for products like vinyl records may help stem the loss from album sales, but although vinyl sales have grown substantially in recent years, they still constitute a small fraction of overall album sales.[32] Still, the trends indicate that album sales are declining and streaming music is gaining in popularity, leading to the conditions necessary for the production changes predicted in our model.

The existing evidence shows that the streaming and album markets are still related, but that relationship is declining. The discrepancy in sales for the top tier of artists versus all others shows a small fully-served market, and a substantial partially-served market. Coupled with the decline in durable albums and increase in streaming, the hits strategy becomes more attractive and many artists seem to be moving toward producing for streaming. Future work could extend the relationship between the markets for albums and streaming, analyzing how they may diverge as streaming increases in popularity.

The conclusions of the model depend on the mounting popularity of the non-durable option of streaming. With a sufficiently low price and sufficiently high base of listening, the paid streaming model becomes an attractive option for consumers. No longer forced to pay for individual durable bundles, a subscription allows access to a much larger, diverse bundle. Because the payment to producers is based on listens in this non-durable setting, artists are likely to adopt the hits strategy in the near future.

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Table 1: Important first order derivatives using either strategy

Ind. Variable	$\partial Q^{*}_{D^S}(A)$	$\partial Q^{*}_{D^{MP3}}(A)$	$\partial Q^{**}_{D^S}(A)$	$\partial Q^{**}_{D^{MP3}}(A)$	$\partial \pi^{*}$	$\partial \pi^{**}$
$/\partial \tau$	$\downarrow$	$\uparrow$	$\downarrow$	?	$?/\uparrow^{1}$	$?/\downarrow^{1}$
$/\partial N$	$\uparrow$	$\downarrow$	$\uparrow$	0	$?/\downarrow^{1}$	$\uparrow$
$/\partial A$	$\downarrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$
$/\partial N \partial A$	$\uparrow$	$\downarrow$	$\uparrow$	0	?	$\uparrow$

[1] If $A > P_{MP3} > rF(A)$

Table 2: Probability of top album

	(1) Top 50	(2) Top 50	(3) Top 50	(4) Top 10	(5) Top 10	(6) Top 10
Spotify50	0.36***	0.26***	0.13***	0.42***	0.18***	0.32***
	(0.021)	(0.028)	(0.043)	(0.042)	(0.054)	(0.072)
SongsStreaming50		0.071***			0.16***	
		(0.013)			(0.022)	
Spotify50Previousweek			0.14***			0.31***
			(0.052)			(0.087)
Spotify50Twoweeks			0.071			-0.0068
			(0.051)			(0.086)
Spotify50Threeweeks			0.024			-0.071
			(0.051)			(0.089)
Spotify50Fourweeks			0.069*			-0.18**
			(0.041)			(0.077)
N	14230	14230	13553	14230	14230	13553

Standard errors in parentheses. Coefficients represent the marginal difference in probability of placing in the Billboard top 50 or 10 associated with a one unit change in the dependent variable. Estimated with a random effects Probit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Relationship of Spotify with weekly album sales

	(1) Sales	(2) Sales	(3) Sales	(4) Ranking	(5) Ranking	(6) Ranking
Spotify50	10241.7***	-2622.1***	9676.4***	-37.6***	-27.5***	-20.3***
	(700.5)	(843.7)	(1326.4)	(1.93)	(2.39)	(3.62)
SongsStreaming50		9483.8***			-7.42***	
		(367.2)			(1.04)	
Spotify50Lastweek			4947.2***			-11.1**
			(1617.9)			(4.40)
Spotify50Twoweeks			-2261.5			0.69
			(1596.6)			(4.32)
Spotify50Threeweeks			-856.5			-2.57
			(1599.5)			(4.32)
Spotify50Fourweeks			-2356.5*			-11.7***
			(1294.6)			(3.52)
Constant	6267.0***	6090.5***	6382.8***	106.0***	106.2***	107.3***
	(170.0)	(165.4)	(185.9)	(0.47)	(0.47)	(0.51)
N	13851	13851	13182	14230	14230	13553
R^2	0.018	0.072	0.020	0.032	0.036	0.036

Standard errors in parentheses. Estimated with Least Squares. The dependent variable is the weekly album sales in Columns 1-3 and the the Billboard rank for Columns 4-6.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Relationship of each format with previous success

	(1) Bboard50	(2) Bboard50	(3) Spotify50	(4) Spotify50
Albumsintop50	0.072***	0.064***	-0.0066	-0.024*
	(0.0060)	(0.0062)	(0.013)	(0.014)
Spotify50		0.18***		
		(0.033)		
Bboard50				0.081**
				(0.034)
N	2856	2856	565	565

Standard errors in parentheses. Coefficients represent the marginal difference in probability of placing in the Billboard or Spotify top 50 with a one unit change in the dependent variable. Estimated with a Probit regression.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix 1: Derivations

$\frac{\partial\left(Q^*_{DS}\right)}{\partial\tau} = \frac{F(A)(P_S - P_{MP3}) - NP_{MP3}}{2\tau^2(N+F(A))} < 0$

$\frac{\partial\left(Q^*_{DS}\right)}{\partial N} = \frac{F(A)P_S}{2\tau(N+F(A))^2} > 0$

$\frac{\partial\left(Q^*_{DS}\right)}{\partial A} = \frac{-P_S F_A(A)(N-F(A))}{2\tau(N+F(A))^2} < 0$

$\frac{\partial\left(Q^*_{DS}\right)}{\partial A\partial N} = \frac{F_A(A)P_S(N-3F(A))}{2\tau(N+F(A))^3} > 0$

$\frac{\partial\left(Q^*_{DMP3}\right)}{\partial\tau} = \frac{(P_{MP3}-P_S)F(A)+NP_{MP3}}{2\tau^2(N+A_H)} > 0$

$\frac{\partial\left(Q^*_{DMP3}\right)}{\partial N} = \frac{-P_S F(A)}{2\tau(F(A)+N)^2} < 0$

$\frac{\partial\left(Q^*_{DMP3}\right)}{\partial A} = \frac{NP_S F_A}{2\tau(F(A)+N)^2} > 0$

$\frac{\partial\left(Q^*_{DMP3}\right)}{\partial A\partial N} = \frac{P_S(F(A)-N)F_A(A)}{2\tau(F(A)+N)^3} < 0$

$\frac{\partial\left(Q^{**}_{DS}\right)}{\partial\tau} = \frac{(P_S - A_H)F(A) - NA_H}{\tau^2(F(A)+N)} < 0$

$\frac{\partial\left(Q^{**}_{DS}\right)}{\partial N} = \frac{P_S F(A)}{\tau(F(A)+N)^2} > 0$

$\frac{\partial\left(Q^{**}_{DS}\right)}{\partial A} = \frac{(N+F(A))^2 - F_A(A)P_S N}{\tau(F(A)+N)^2} > 0$

$\frac{\partial\left(Q^{**}_{DS}\right)}{\partial A\partial N} = \frac{(N-F(A))F_A(A)P_S}{\tau(F(A)+N)^3} > 0$

$\frac{\partial\left(Q^{**}_{DMP3}\right)}{\partial\tau} = \frac{(P_{MP3}-A)}{\tau^2} \quad < or >$

$\frac{\partial\left(Q^{**}_{DMP3}\right)}{\partial N} = \frac{\partial\left(\frac{A+\tau-P_{MP3}}{\tau}\right)}{\partial N} = 0$

$\frac{\partial\left(Q^{**}_{DMP3}\right)}{\partial A} = \frac{\partial\left(\frac{A+\tau-P_{MP3}}{\tau}\right)}{\partial A} = \frac{1}{\tau} > 0$

$\frac{\partial\left(Q^{**}_{DMP3}\right)}{\partial A\partial N} = \frac{\partial\left(\frac{1}{\tau}\right)}{\partial N} = 0$

$\frac{\partial(\pi^*)}{\partial\tau} = \frac{(P_{MP3} - F(A)r)(F(A)P_{MP3} - F(A)P_S + NP_{MP3})}{(F(A)+N)2\tau^2} \quad < or >$

Note: if $rF(A) > P_{MP3} \quad \Rightarrow \frac{\partial(\pi^*)}{\partial\tau} < 0$

$\frac{\partial(\pi^*)}{\partial N} = \frac{(rF(A) - P_{MP3})P_S F(A)}{2\tau(F(A)+N)^2} \quad < or >$

Note: if $rF > P_{MP3} \quad \Rightarrow \frac{\partial(\pi^*)}{\partial\tau} > 0$

$\frac{\partial(\pi^*)}{\partial A} = \frac{rF_A(A)}{2\tau}\left(P_{MP3} + \tau - \frac{P_S F(A)}{N+F(A)}\right) - \frac{(rF(A) - P_{MP3})NP_S F_A(A)}{2\tau(F(A)+N)^2} > 0$

$\frac{\partial(\pi^*)}{\partial A\partial N} = \frac{F_A(A)P_S((F(A)-N)P_{MP3} + 2F(A)Nr)}{2\tau(F(A)+N)^3} \quad < or >$

$\frac{\partial(\pi^{**})}{\partial\tau} = -\frac{(AF(A) + AN - F(A)P_S)rF(A) + P_{MP3}(A - P_{MP3})(F(A)+N)}{\tau^2(F(A)+N)} \quad < or >$

Note: if $A > P_{MP3} \quad \Rightarrow \frac{\partial(\pi^*)}{\partial\tau} < 0$

$\frac{\partial(\pi^{**})}{\partial N} = \frac{rP_S(F(A))^2}{\tau(F(A)+N)^2} > 0$

$\frac{\partial(\pi^{**})}{\partial A} = \frac{P_{MP3} + 2rF(A)}{\tau} + r + (F_A(A) - F(A))\, r\left(\frac{NP_S F_A(A)}{(F(A)+N)^2}\right) > 0$

$\frac{\partial(\pi^{**})}{\partial A\partial N} = \frac{rF_A(A)P_S(N-F(A))(F(A)-F_A(A))}{(F(A)+N)^3} > 0$