One-Hit Wonder or Superstardom? The Role of Technology Format on Billboard's Hot 100 Performance*

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Abstract

Changes in the technology format of popular music distribution are nothing new. Vinyl records and cassette tapes disappeared in the 1990s, CDs faded out in the 2000s, and digital downloads began their decline in the 2010s to make way for streaming subscriptions and on-demand radio. We use data from Billboard's Hot 100, a weekly ranking of the most popular songs in the United States, to investigate the impact of technology format changes on the popularity characteristics of these songs. We find that the transition from CD to digital impacts popularity characteristics significantly. The digital technology format reduces the cost of releasing a single, which allows established artists to crowd out the Hot 100 by virtue of their reputation. Faster feedback mechanisms and social learning lead to the emergence of ?one-week wonders? i.e., songs charting on the Hot 100 for only a week before disappearing.

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1 Introduction

On June 8, 2015, famed technology giant, Apple Inc., announced plans to launch a new music service that would provide on-demand streaming, a 24/7 radio station, and an interactive forum for artists to connect with fans (The Associated Press, 2015). Two weeks later on June 23, 2015, Google retaliated and offered its streaming service with human-curated playlists for free via ad-support (Welch, 2015). Music streaming services are nothing new: services such as Spotify or Deezer have been operating in the United States as early as 2011 and 2013, respectively. But with an estimated 41 million people worldwide who pay for music streaming services in 2014 (up from 28 million in 2013) – coupled with an 8 percent overall decline in digital download sales – new firms, each with their promised distinct advantage, are eager to enter the competition for music subscription services (International Federation of Photographic Industry, 2015).

The popular music industry is no stranger to new distribution channels or new technology platforms. Since radio broadcasting of music began in the early 1920s, the industry has experienced the introduction and the gradual disappearance of technologies such as the vinyl record or the cassette tape. For most of the 2000s, music critics and commentators lamented the decline in physical album sales, only to see a rise in digital formats like legal digital downloads or online audio streaming (Christman 2013). The story is starting to repeat itself once again as the sales from permanent digital downloads decline and the attention shifts towards subscription-based music streaming services. In the words of Placido Domingo, chairman of the International Federation of the Phonographic Industry, "The technology changes: the music remains" (International Federation of Photographic Industry 2014).

This paper explores how a change in the technology format of released singles affects their popularity characteristics. The two main popularity characteristics we focus on are chart survival (i.e., how long a song survives on the charts) and Top 10 likelihood (i.e., the chance for a song to reach Top 10). We compare popularity characteristic of songs released in different technology formats in three transitions: vinyl to cassette, cassette to CD, and CD to digital. To measure popularity, we use historical data from Billboard's Hot 100, a weekly ranking of the most popular songs in the United States across all genres, ranked by radio airplay audience impressions, sales data, and streaming activity (Billboard 2015). We find that when the technology format brings on concurrent changes in music consumption and distribution, popularity characteristics are significantly affected. The switch to digital from CDs lowers the cost of releasing a single, allowing established artists to flood the Hot 100. Digital technologies increase the avenues – and the frequency – by which a song is evaluated. The digital vetting process swiftly separates the duds and creates a new phenomenon of

"one-week wonders," i.e., songs which chart for only one week. The end result is that digital songs are significantly more likely to fall off the chart in the first week compared to CD songs, but the effect moderates over time as the digital songs are scrutinized and only the good songs remain.

The remainder of this paper is structured as follows. Section 2 presents a brief literature review and details the contribution of this paper. Section 3 gives a timeline of criteria changes in the Billboard Hot 100; section 4 describes the data. Section 5 explains the estimation strategy. Section 6 and 7 presents the regression results on the impact of technology format on chart survival and popularity characteristics. Section 8 investigates the mechanism of how technology format affects popularity characteristics.

2 Literature Review and Contributions

2.1 Literature Review

Music, as an experience good, only has its true value revealed after its consumption (Nelson, 1970) but sampling music can require a significant amount of time due to the large amount of available recorded music (Bhattacharjee et al., 2006). Music is often considered as a fashion-oriented product where customer tastes and preferences can change rapidly and be influenced by other consumers who have purchased it (Bhattacharjee et al., 2007). The bandwagon effect, where demand increases because other people demand it (Leibenstein, 1950), emphasizes the importance of popular music charts as well as the importance of the initial debut rank (Strobl & Tucker, 2000). The superstar effect, where relatively small numbers of people dominate the activity in which they engage (Rosen, 1981), tends to occur in popular music as consumers minimize their search and sampling costs of wading through a plethora of new music releases by choosing the most popular artist (Adler, 1985).

The major labels, with the financial resources to access large customer bases, exert significant control in recording, distributing, and promoting of music albums (Bhattacharjee et al., 2007). For the U.S. market in 2013, three major labels (Universal Music Group, Sony Music Entertainment, and Warner Music Group) controlled 89.58 percent of total album sales, 86.82 percent of digital albums sales and 85.92 percent of digital singles sales Nielsen (2013). The increased presence of independent labels in the digital albums and the digital singles category suggests that independent labels tend to operate in niche segments due to their lack of financial resources (Spellman, 2005). Albums from major labels tend to last longer on the charts due to better promotion and wider audience exposure (Strobl & Tucker, 2000). Timing and seasonality also play a role in the determination of chart survival as

industry statistics show that a large number of albums are released during the Christmas holiday period (Montgomery & Moe, 2002).

Digital technologies have changed the way consumers experience and sample music. The Internet significantly lowered consumer costs to acquire knowledge on artists and to interact with other individuals through forums and reviews. Consumers discover what they like and dislike, and the information is spread through word-of-mouth and other media, affecting the consumption decisions of potential customers (Walls, 2005). The Internet has led to an explosion of outlets providing critical assessment of new music, with the number of reviews produced per year doubling since 1995 (Waldfogel, 2015). Sharing technologies may allow consumers to be more discerning on their purchases from music products by superstars, leading to a dilution in the superstar effect and the emergence of more new artists on the charts (Gopal et al., 2006). The narrowing of the advantage held by the major labels is suggestive evidence that independent labels have used digital technologies to popularize their music (Bhattacharjee et al., 2007). Digital technologies reduce the cost of labels bringing music products to market, increasing the number of new music products since 2000 (Telang & Waldfogel, 2014; Aguiar & Waldfogel, 2016). Production is now far less expensive and an artist can create a recording with a few hundred dollars worth of software rather than hundred of thousands of dollars of studio time (Waldfogel, 2015). There has been substantial growth in the number of albums released annually since 2000: the number of new albums released is 36,000 in 2000, 106,000 in 2008, and 75,000 in 2011 (Oberholzer-Gee & Strumpf, 2010; Waldfogel, 2015). Products with low *ex ante* appeal account for a growing share of sales due to the growth in the number of products and the unpredictability of commercial appeal (Aguiar & Waldfogel, 2016).

Rapid information sharing, however, has a significant negative impact on the survival of lower debut ranked albums but no significant impact for top debut ranked albums (Bhattacharjee et al., 2007). The availability of music – via illegal or legal avenues – affects album sales heterogeneously. File sharing harms ex ante popular artists by reducing album sales but benefits ex ante unknown artists by increasing exposure (Blackburn, 2006). Similarly, albums that have a very successful debut face more displacement from YouTube videos, while the effect on lower debuting albums may be moderated by a promotional effect (Hiller, 2016). There is no evidence of a reduction in the quality of music released since file sharing took off with the advent of Napster in 1999 (Waldfogel, 2011).

2.2 Contributions

This paper presents two complementary empirical tests to examine whether the technology format of a released single may alter the pattern in which music becomes – and remains – popular. To examine whether technology format changes the way singles retain popularity, we compare the survival rates of singles on Billboard's Hot 100 released in vinyl, cassette, CD, and digital. To examine whether technology format changes the way singles become popular, we compare the likelihood for songs to reach Top 10 in the different technology formats. Throughout both tests we pay particular attention to the interrelationship between technology formats and independent labels. That is, we are interested in whether technology formats can help or hinder the ability of independent labels to release a successful song. We retain the standard set of controls commonly found in the literature (e.g., debut rank, superstar status, and holiday debut) but we also add year and Billboard criteria fixed effects. The goal of this approach is to control for variation in the survival patterns and other unobservable factors that may have changed concurrently with the technology format changes. For example, in 1991, when Billboard switched from a tally combining ranked airplay and sales reports submitted by radio stations and retailers to one based on electronically-monitored airplay and piece counts of single sales by Nielsen, the popularity patterns of all songs – regardless of technology format – were affected.

This paper expands on Bhattacharjee et al. (2007) in three distinct ways. We begin by switching the focus from investigating album popularity to investigating individual track popularity. Edgar Bronfman, the chairman of Warner Music, noted the declining importance of albums when he commented, "The music industry is growing. The record industry is not growing" (Economist, 2007). The benefits of focusing on individual tracks is twofold. First, we are better able to capture the effects of new technologies on the music industry because the majority of the innovations in music distribution and consumption revolved around singles. Second, the focus on individual tracks also allows us to investigate the effects of new technologies on smaller independent labels due to the higher concentration of independent labels in the digital tracks market (Nielsen, 2013). Next, Bhattacharjee et al. (2007) end their analysis in 2003, when new digital technologies were about to take off. We extend the analysis to include observations beyond 2003 and up to 2015. Billboard did not include sales of paid digital downloads on the Hot 100 until 2005 (Billboard, 2005), of streaming and on-demand music until 2007 (Mayfield, 2007) and of YouTube songs until 2013 (Billboard, 2013). Global digital revenues from the music industry did not match physical format sales until 2014 (International Federation of Photographic Industry, 2015). The extension of the data allows us to not only track the cumulative effect of technology on music popularity, but to track how the effect of technology might change over time.

We are — to our knowledge -– the first paper to investigate how the release of singles in different technology formats impacts music popularity. Previous literature often takes file sharing as a given and then examines the effects of copying on the music industry. What the previous literature misses is that in order for a file to be shared, it must first be in a format that facilitates sharing. We differentiate between songs that are released as vinyl, cassette, CD or digital to look deeper into the mechanisms of how songs in different formats might have different characteristics on the charts.

3 Background and History

3.1 History of Billboard's Hot 100 Criteria Changes

In this section, we describe how the criteria for a song to appear on the Hot 100 changed over time. The ranking of a song on the Hot 100 is – for the purposes of this paper – synonymous with the popularity characteristics of a song. Understanding when and how Billboard changed its Hot 100 criteria is vital for correct model specifications: we do not want to misattribute a change in popularity to a change in technology format if the actual cause was the change in criteria. We address the possible effects of the criteria changes in section 5.

Since 1913, Billboard magazine tracked and chronicled the popularity of music recordings in the United States. Initially, Billboard stored the characteristics of popular songs on a variety of different charts, each with a slightly different emphasis: "Best Sellers in Stores," "Most Played by Jockeys," and "Most Played in Juke Boxes." On August 4, 1958, Billboard created the Hot 100, which integrated the three components of disc jockey plays, jukebox activity and record sales into a single weekly chart of a track's popularity (Whitburn, 2003). The Hot 100, in an effort to become the best-respected source of information in the commercial music field, made the reliance on a single set of numbers possible by being accurate, timely, and complete (Anand & Peterson, 2000). Today, the mission of the Hot 100 has stayed the same. Radio airplay continues to account for a third of the Hot 100's data mix, with digital downloads and streaming becoming the modern-era version of record sales and jukebox activity (Trust, 2015).

Over the course of the chart's history, Billboard updated the Hot 100 criteria to reflect changes in the music industry and to incorporate advances in information collection. The first major change occurred on May 11, 1968 when the top half of the Hot 100 chart no longer utilized airplay information because a number of Top 40 radio stations changed their airplay tabulation methods (Carroll, 2015). Top 40 stations had been dropping songs from their

Top 40 list despite sales in the market, in order to make room for stronger new products or because the station management decided the sound of the record was not what they desired for their audience (Billboard, 1968). The second major change occurred on June 9, 1973 which marked the first time Billboard used a computer to rank each week's selection, narrowing the time interval from the moment the market place sample is taken and the chart is printed Zhito (1973). The 1973 criteria update also returned to an emphasis on airplay and sales of singles by one-stop distributors, the primary singles source for jukebox operators. Due to an increased public preference for albums, the number of dealers handling singles had been dwindling. The inclusion of one-stop distributors allows the Hot 100 to factor in the relative strength of singles in jukeboxes. The 1973 changes were considered by the editor to be so dramatic that Billboard wrote, "No valid basis of comparison exists between the chart positions as they appear this week with previous weeks. In short, a different yardstick is being used now to measure singles strength" Zhito (1973).

The third major change began on November 30, 1991 when the Hot 100 transformed from a tally combining ranked airplay and sales reports submitted by radio stations and retailers, to one based on electronically-monitored airplay by Nielsen Broadcast Data Systems and piece counts of singles scales according to Nielsen SoundScan (Trust, 2009). Computer-monitored airplay data was collected for 122 large-market Top 40 stations in 85 markets. The data of single sales came from 123 chain and independent stores reporting to SoundScan, which include 8,000 rack locations and 3,400 retail locations nationwide (Billboard, 1991). A minor change occurring around the same time on December 7, 1991 was the introduction of the "20-20 rule" on the Hot 100. The "20-20 rule" says that any single that charted for more than 20 weeks and has fallen out of the Top 20 will be removed from the Hot 100. The move was designed to speed up the chart and was further amended twice, first on January 25, 1992 and then on August 7, 1993. Both of the amendments relaxed the "20-20 rule" and only removed songs off the Hot 100 if they had charted for more than 20 weeks and if they had fallen out of the Top 40 or Top 50, respectively.

The fourth major change occurred on December 5, 1998 when the Hot 100 broadened the radio panel from mainstream Top 40, rhythmic Top 40, adult Top 40, adult contemporary and modern rock formats to including R&B, adult R&B, mainstream rock, triple-A rock, and country (Mayfield, 1998). Increasing segmentation of radio stations, which had been occurring over the past two decades, prompted the inclusion of new genres. Meanwhile, an increasing number of airplay-only tracks -– i.e., tracks that have bypassed retail -– became big radio hits, forcing Billboard to adjust the retail component of the chart from 40 percent to 25 percent (Mayfield, 1998). The goal, as always, was to make sure the Hot 100 took into account the current industry practices to reveal the most popular songs.

The final set of major changes was a response to the digitalization of the music industry. The Hot 100 had almost become identical to its radio airplay component due to the decline of retail singles in the late 1990s (Billboard, 2005). Billboard, in an effort to bring back a voice to the music consumer, added the sales of paid downloads to the Hot 100 on February 12, 2005. Two years later, on August 11, 2007, streamed and on-demand music became a part of the Hot 100's chart formula (Mayfield, 2007). The inclusion of streaming and on-demand music was made to account for the vigorous growth that digital distribution has experienced (Mayfield, 2007). Data limitations initially prevented streaming data from sources other than Yahoo and AOL to be incorporated, but by March 24, 2012, the list of on-demand sources expanded to including every on-demand play request and plays from unlimited listener-controlled radio channels on MOG, Muve Music, Rdio, Rhapsody, Slacker and Spotify (Billboard, 2012). A year later on February 21, 2013, Billboard included demand from all official videos and authorized audio on YouTube in the Hot 100 to, once again, reflect the divergent platforms for music consumption in the modern world (Billboard, 2013).

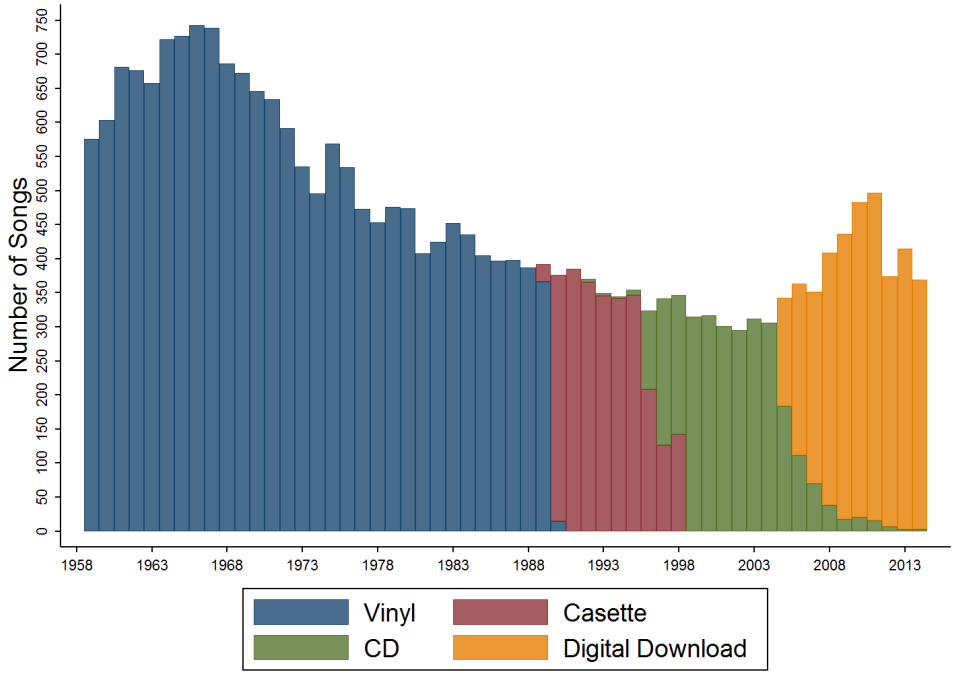
4 Data

Data for the Billboard Hot 100 ranks the ordinal popularity of a hundred songs per week from August 4, 1958 to March 28, 2015. A total of 26,592 tracks by 6,962 unique artists appeared on the Hot 100 during this period. Data for each observation contains the song title, the recording artist, any featuring artists, the song length, the label, and the technology format. The label is classified as major if it belongs to, or is distributed by, any one of the three major labels, namely, Universal Music Group, Sony Music Entertainment, or Warner Music Group. The technology format of the song can be one of four different formats: vinyl (65.26 percent), cassette (9.95 percent), CD (10.78 percent), or digital (14.00 percent). The technology format of each track is available from Discogs, a user-built database with information on more than 6 million recordings and 4 million artists (Discogs, 2015). Each observation contains the date the track first debuted, and the date the track exited, and the respective ranking of each week the song remained on the chart. Tracks are eligible to debut and to exit at any rank from the highest rank of 1 to the lowest rank of 100. The peak rank is the highest rank a song obtained during its chart appearance.

Table 1 describes the summary statistics of the data. Chart survival is the number of weeks a track remains on the Hot 100. A track may, on occasion, drop off for some weeks and then reenter the chart. We follow each song continuously until its final drop-off. Top 10 and Top 40 are indicator variables which equal 1 if the track peaked in the Top 10 or the Top 40, respectively. Independent Label is an indicator variable which equals 1 if the

track is released by an independent label. New Artist is an indicator variable which equals 1 if the song is by an artist who is appearing on the Hot 100 for the first time. Featured Artist is an indicator variable which equals 1 if the track featured more than one artist. Peak Rank is the highest rank achieved by the song. Debut Rank is the initial rank of song during its first week on the chart. Holiday Debut is an indicator variable which equals 1 if the track debuted in the month of December. Song Length denotes the length of the track in number of minutes. Table 2 breaks down the same variables by technology format. Vinyl was the longest lasting format at 42 years from 1958 to 1990. CD is the second longest lasting format at 22 years from 1992 to 2014. Digital is currently at 11 years from 2005 to 2015, while cassettes lasted only 9 years from 1989 to 1998. Figure 1 shows the number of unique singles per year on the Hot 100 by technology format.

Figure 1 Number of Songs per Year by Technology Format



Notes: Data include all 26,592 singles by 6,962 artists that appeared on the Billboard Hot 100 from August 4, 1958 until March 28, 2015. Songs were released in one of four different formats: vinyl (65.26 percent), cassette (9.95 percent), CD (10.78 percent), and digital download (14.00 percent).

5 Empirical Strategy

This paper measures two main outcomes: *Chart Survival* is the length of time in weeks that a song remains on the charts before dropping off, and *Top 10* is whether the song makes Top 10, if ever. Both the chart survival process and the Top 10 process are stochastic processes that govern whether the event, i.e., falling off the charts or reaching Top 10, occurs (Bhattacharjee et al., 2007). We model the *Top 10* process with a logit. We model *Chart Survival* by following a form of hazard model known as the Cox model, or the proportional hazard model. For a point in time, t:

$$h(t) = h_0(t) \exp\left(X_1\beta_1^{PH} + X_2\beta_2^{PH} + \cdots + X_p\beta_p^{PH}\right) \tag{1}$$

where the X_i are a set of explanatory variables which shift the hazard function proportionally, $\beta_i^P H$ are the parameters to be estimated, and $h_0(t)$ is the baseline hazard (Bhattacharjee et al., 2007). In the Cox specification, no assumption is incorporated about the distribution of $h(t)$.

In order to model each technology format transition separately, we split the dataset into three eras, one for each technology transition period. The first era, from 1989 to 1990, captures the change in technology format from vinyl to cassette. The second era, from 1992 to 1998, captures the change in technology from cassette to CD. The third era, from 2005 to 2014, captures the change in technology from CD to digital. The beginning of each era marks the first year the new format appeared on the chart. The end of each era marks the last year the old format appeared on the chart. For example, in the cassette-CD transition, 1992 is the first year CD appears on the chart while 1998 is the last year cassette appears on the chart.

The key variable of interest is the change in technology format. We allow for the possibility that the technology format may have a differential effect over time. That is, the effect of a new technology on *Chart Survival* may be different for new debut songs versus longstanding veteran songs. The secondary variable of interest is the independent label indicator, which measures whether being on an independent label changes *Chart Survival* or *Top 10*. We check to see if the effect of being on an independent label changes when different technology formats are prevalent.

One of the key challenges in estimation is the fact that the Hot 100 changed its criteria many times over the chart's history. The goal is to make sure that the effect on *Chart Survival* or *Top 10* that we capture from the change in technology format is not due to a concurrent change in the way Billboard decided the Hot 100 criteria. We first minimize the effect of the changing criteria by tightening up the way we split the dataset into the relevant

eras, if possible. For the vinyl-cassette transition, we did not make any changes because the Hot 100 criteria did not change during 1989 to 1990. We use the entire period from January 1, 1989 to December 31, 1990 for the vinyl-cassette transition. For the the cassette-CD transition, we end the era slightly earlier on December 4, 1998 instead of December 31, 1998 because the Hot 100 revamped its criteria on December 5, 1998 (see section 3). We use the truncated period from January 1, 1992 to December 4, 1998 for the cassette-vinyl transition.

For the CD-digital transition, we start the era the week of February 12, 2005, which is the first week the Hot 100 included sales of digital download songs. From February 12, 2005 to March 28, 2015 (the last week in our dataset), Billboard changes the Hot 100 criteria three times: on August 11, 2007 to account for Yahoo and AOL streaming, on March 24, 2012 to expand the list of streaming sources, and on February 21, 2013 to include YouTube (see section 3). We address the criteria changes either by focusing on periods where the criteria is consistent, or by including Billboard criteria-fixed effect dummies. Criteria-fixed effects are indicator variables for each period where the Hot 100 used the same criteria and data sources. Finally, we include year-fixed effects to ensure that any changes are due to the difference in technology format and not because songs changed characteristics due to external market factors.

6 Baseline Estimates for the Effect of Technology Format on Chart Survival

To systematically examine the effect of a change in technology format on chart survival, baseline survival model regressions estimate equation 2 for each technology transition era separately

$$log(h_{i,t}) = \alpha_t + \beta_1 NewTech_i + \beta_2 NewTech_i \cdot t + W'_{S,i}\theta_S + \delta_y + \lambda_c \tag{2}$$

where the $h_{i,t}$ is probability of song i dropping off the Billboard Hot 100 at week t given that song i survives until week $t-1$. The main variable of interest, $NewTech_i$, records whether song i is released in the new media format of the era. For example, when we estimate equation 2 in the vinyl-cassette transition era, $NewTech_i$ is an indicator variable for whether song i is released in the cassette format. The control group are songs released only in the old media format. The coefficient β_1 identifies the effects of new technology on chart-exiting hazards for the first week song i appears on the Hot 100. The time-varying coefficient β_2 on $NewTech_i \cdot t$ captures whether the effect of the new technology format on chart-exiting hazards changes over time.

The vector of song attributes, W_S', include the Song Length (recorded in minutes), the Debut Rank (the initial rank when the song first appears on the chart), and indicator variables for Independent Label (whether the song was released from an independent label), New Artist (whether the artist appeared on the Hot 100 before), Featured Artist (whether the song contains features from another recording artist), and Holiday Debut (whether the song was released during December). Year-fixed effects, δ_y, control for unobservable variation in the length of chart survival overtime that may have caused chart survival to change across all technology formats in year y. Criteria-fixed effects, λ_c, control for differences in measurement during eras where Billboard revamped its popularity scoring system.

6.1 Vinyl-Cassette Transition

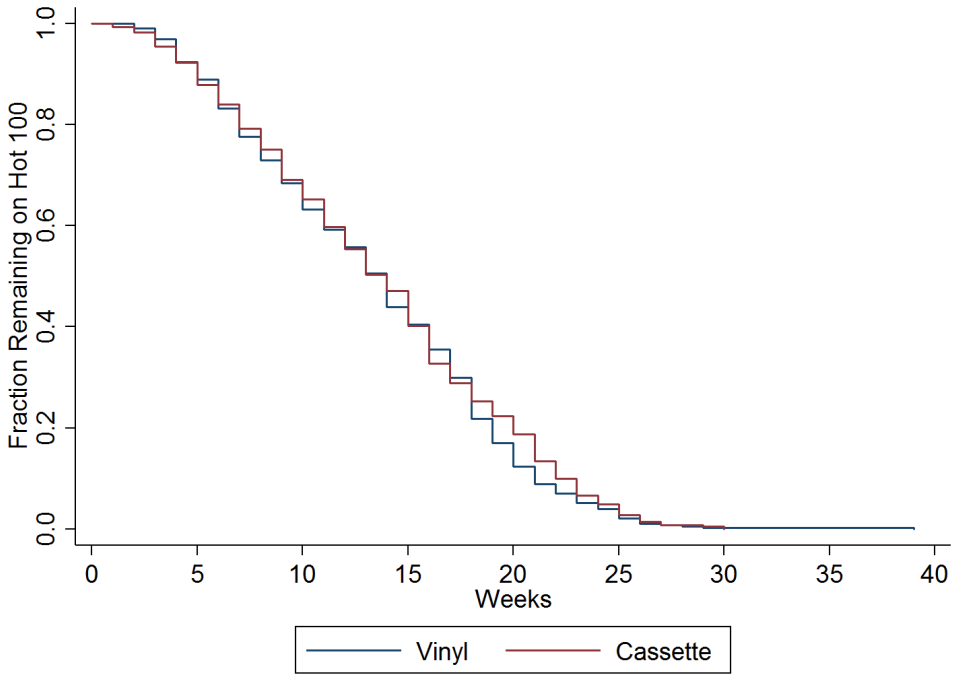
To estimate the effect of the cassette technology format on chart survival, we estimate Equation 2 using the Billboard Hot 100 dataset from January 1, 1989 to December 31, 1990. The control group are songs released only in vinyl. $NewTech_i$ is an indicator variable for whether song i is released in the cassette format. Figure 2 shows the Kaplan-Meier survival curves for songs released in vinyl and for songs released in cassette. The graphical evidence suggests that songs released in vinyl and songs released in cassette are not significantly different in terms of chart survival.

Table 3 compares – across vinyl and cassette – the vector of song attributes, W_S': Independent Label, New Artist, Featured Artist, Debut Rank, Holiday Debut, and Song Length. Apart from Holiday Debut, songs released in cassette are not significantly different from songs released in vinyl in terms of song attributes observable in the dataset.

Table 4 quantifies the effect of the cassette format on chart survival. We do not include criteria-fixed effects in any of the specifications because Billboard did not change the Hot 100 criteria in the vinyl-cassette transition period from January 1, 1989 to December 31, 1990. Column 1 shows the estimates of Equation 2 without the control variables, W_S'. Column 2 adds the control variables and column 3 adds year-fixed effects. All the specifications agree that the survival rate of songs released in cassette are not significantly different from the survival rate of songs released in vinyl.

The most surprising result in Table 4 is the coefficient on *New Artist*. Songs released by new artists charting the Hot 100 for the first time are 16.97 percent ($e^{-0.186} - 1 = -0.1697$) less likely to fall off the chart compared to songs released by veteran artists who appeared on the Hot 100 in the past. The "breakout hit effect" occurs because new artists need a catchy song to chart the Hot 100 because they cannot generate demand from their nonexistent reputation. Veteran artists, on the other hand, can rely on their reputation to generate

Figure 2 Kaplan-Meier Survival Curves: Vinyl vs. Cassette



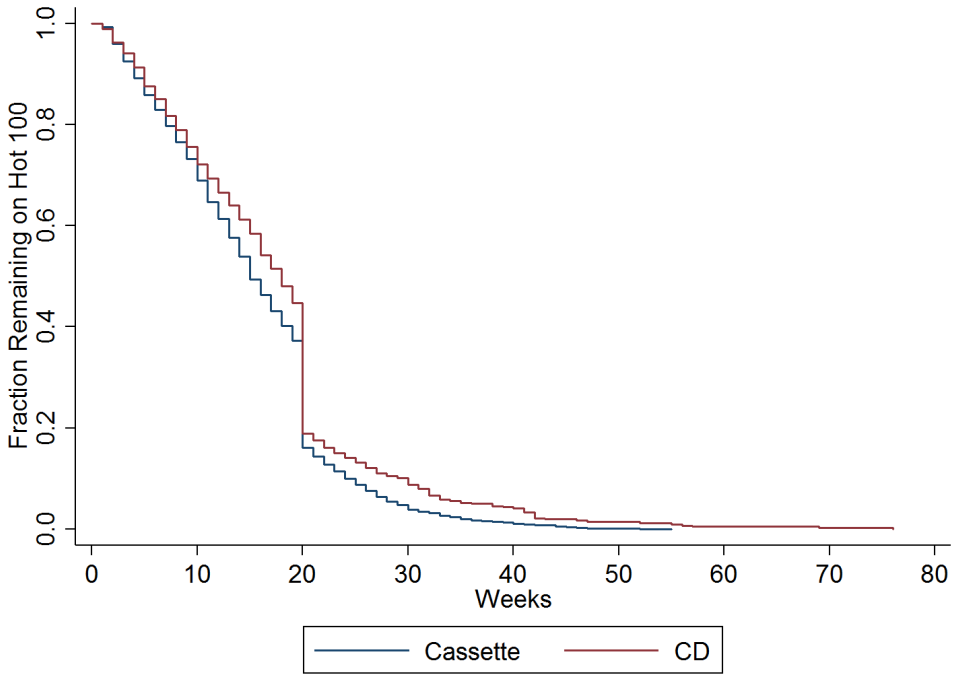
Notes: Effect of technology format on chart survival. Data are from the Billboard Hot 100 dataset from January 1, 1989 to December 31, 1990. Kaplan-Meier curves are plotted for two groups of songs: those released in vinyl and those released in cassette. Kaplan-Meier curves plot the fraction of songs remaining on the Hot 100 after t weeks.

initial interest in a single. Thus, the breakout song of a new artist, which must rely on song popularity alone, tends to survive longer than songs released by veteran artists, which chart based on a combination of artist reputation and song popularity.

6.2 Cassette-CD Transition

To estimate the effect of the CD technology format on chart survival, we estimate Equation 2 using the Billboard Hot 100 dataset from January 1, 1992 to December 4, 1998. We end the period on December 4, 1998 instead of December 31, 1998 because Billboard changes the Hot 100 criteria on December 5, 1998. The control group are songs released only in cassette. $NewTech_i$ is an indicator variable for whether song i is released in the CD format. Figure 3 shows the Kaplan-Meier survival curves for songs released in cassette and for songs released in CD. The graphical evidence suggests that songs released in cassette and songs released in CD are not significantly different in terms of chart survival.

Figure 3 Kaplan-Meier Survival Curves: Cassette vs. CD



Notes: Effect of technology format on chart survival. Data are from the Billboard Hot 100 dataset from January 1, 1992 to December 4, 1998. Kaplan-Meier curves are plotted for two groups of songs: those released in cassette and those released in CD. Kaplan-Meier curves plot the fraction of songs remaining on the Hot 100 after t weeks. The vertical drop for both technology formats in the fraction remaining on the Hot 100 at 20 weeks is the result of the "20-20" rule, newly introduced on December 7, 1991, which states that any song that charted for more than 20 weeks and has fallen out of the Top 20 will be removed from the Hot 100.

Table 5 compares – across cassette and CD – the vector of song attributes, W_S': Independent Label, New Artist, Featured Artist, Debut Rank, Holiday Debut, and Song Length. There are significant differences in observable song attributes between songs released in cassette and song released in CD. Song released in CD are more likely to be from an independent label, more likely to feature another artist, and more likely to debut higher on the chart.

Table 6 quantifies the effect of the CD format on chart survival. We do not include criteria-fixed effects in any of the specifications because we truncated our data period to avoid the Hot 100 change on December 5, 1998. Column 1 shows the estimates of Equation 2 without the control variables, W_S'. Column 2 adds the control variables and column 3 adds year-fixed effects. Despite the differences in observable song characteristics between cassette and CD, none of the specifications show that the survival rate of songs released in CD differed significantly from the survival rate of songs released in cassette.

Similar to the vinyl-cassette transition, we find evidence for the breakout effect: songs

released by new artists are 21.26 percent less likely to fall off the Hot 100 compared to songs released by veteran artists (Table 6, column 3). We also find that songs from independent label are 13.20 percent more likely to fall off the chart compared to songs from major labels (Table 6, column 3).

6.3 CD-Digital Transition

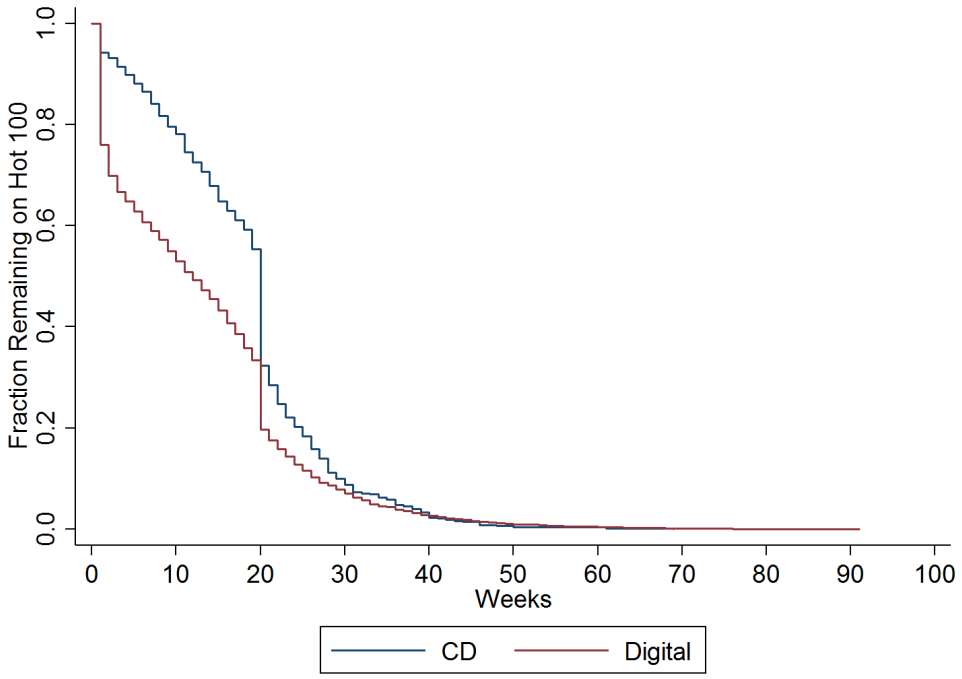
To estimate the effect of the digital technology format on chart survival, we estimate Equation 2 using the Billboard Hot 100 dataset from February 12, 2005 to March 28, 2015. We start the period on February 12, 2005, the first week Billboard includes the sales of digital download songs to the Hot 100 criteria. The control group are songs released only in CD. $NewTech_i$ is an indicator variable for whether song i is released in the digital format. Figure 4 shows the Kaplan-Meier survival curves for songs released in CD and for songs released in digital. The graphical evidence suggests that songs released in CD and songs released in digital are quite different in terms of chart survival. In particular, the fraction of songs remaining on the Hot 100 after one week are drastically different for songs released in digital format compared to songs in CD format.

Table 7 compares – across CD and digital – the vector of song attributes, W_S': Independent Label, New Artist, Featured Artist, Debut Rank, Holiday Debut, and Song Length. There are significant differences in observable song attributes between songs released in CD and song released in digital. Song released in digital are less likely to be from an independent label, less likely to be by a new artist, less likely to feature another artist, more likely to debut higher on the chart and more likely to be shorter in length.

Table 8 quantifies the effect of the digital format on chart survival. Criteria-fixed effects control for changes in Billboard criteria that occurred on August 11, 2007 and March 24, 2012. Column 1 shows the estimates of Equation 2 without the control variables, W_S'. Column 2 adds the control variables, column 3 adds year-fixed effects and column 4 adds criteria-fixed effects. Across all specifications, the positive coefficient on *Digital* means that songs released in digital are significantly more likely to exit the chart in the first week compared to songs released in CD. For example, when we use all our controls and fixed effects, songs released in digital are 144.98 percent ($e^{0.896} - 1 = 1.4498$) more likely to fall off the chart compared to songs released in CD (Table 8, column 4).

The negative and significant coefficient on *Digital* * t means that the effect of the song in digital format on chart survival changes over time: for each additional week a digital song remains on the chart, the chance of falling off decreases by 3.55 percent compared to the song's CD counterpart (Table 8, column 4). The summation of the coefficients on

Figure 4 Kaplan-Meier Survival Curves: CD vs. Digital



Notes: Effect of technology format on chart survival. Data are from the Billboard Hot 100 dataset from February 12, 2005 to March 28, 2015. Kaplan-Meier curves are plotted for two groups of songs: those released in CD and those released in digital. Kaplan-Meier curves plot the fraction of songs remaining on the Hot 100 after t weeks. The vertical drop for both technology formats in the fraction remaining on the Hot 100 at 20 weeks is the result of the revamped "20-50" rule, amended on August 7, 1993, which states that any song that charted for more than 20 weeks and has fallen out of the Top 50 will be removed from the Hot 100.

Digital, i.e., β_1, and *Digital* * t, i.e., $\beta_2 * t$, describe the total effect of digital format on chart survival at week t. The term $\beta_1 + \beta_2 * t$ is negative when t is at least 24.82 (Table 8, column 4). Therefore, if a digital song manages to stay on the charts for at least 24.82 weeks, the likelihood of chart survival for a digital song is actually greater than the CD control group.

Similar to the vinyl-cassette transition and the cassette-CD transition, we find evidence for the breakout effect: songs released by new artists are 11.04 percent less likely to fall off the Hot 100 compared to songs released by veteran artists (Table 8, column 4). We explore reasons why the digital era reduces the breakout effect in section 8.

7 Baseline Estimates for the Effect of Technology Format on Popularity

We now investigate whether the technology format affects the likelihood of a song to reach Top 10 on the Billboard Hot 100. To formally test the effect of a change in technology format on chart popularity, we estimate the following logit model:

$$log\left(\frac{Pr(Top10_i = 1)}{1 - Pr(Top10_i = 1)}\right) = \alpha_0 + \beta_1 NewTech_i + W'_{S,i}\theta_S + \delta_y + \lambda_c \tag{3}$$

where the $Pr(Top10_i = 1)$ is probability of song i reaches Top 10 on the Billboard Hot 100. The main variable of interest, $NewTech_i$, records whether song i is released in the new media format of the era. For example, when we estimate equation 3 in the CD-digital transition era, $NewTech_i$ is an indicator variable for whether song i is released in the digital format. The control group are songs released only in the old media format. The coefficient β_1 identifies the effects of new technology on the probability song i reaches Top 10.

The vector of song attributes, W'_S, include the Song Length (recorded in minutes), the Debut Rank (the initial rank when the song first appears on the chart), and indicator variables for Independent Label (whether the song was released from an independent label), New Artist (whether the artist appeared on the Hot 100 before), Featured Artist (whether the song contains features from another recording artist), and Holiday Debut (whether the song was released during December). Year-fixed effects, δ_y, control for unobservable variation in the length of chart survival overtime that may have caused chart survival to change across all technology formats in year y. Criteria-fixed effects, λ_c, control for differences in measurement during eras where Billboard revamped its popularity scoring system.

7.1 Vinyl-Cassette Transition

To estimate the effect of the cassette technology format on popularity, we estimate Equation 3 using the Billboard Hot 100 dataset from January 1, 1989 to December 31, 1990. The control group are songs released only in vinyl. $NewTech_i$ is an indicator variable for whether song i is released in the cassette format.

Table 9 reports the logit model estimates for the vinyl-cassette transition. The only covariate to affect the likelihood of a song reaching Top 10 with statistical significance is *Debut Rank*. The cassette format does not appear to impact the likelihood of a song reaching Top 10.

7.2 Cassette-CD Transition

To estimate the effect of the CD technology format on popularity, we estimate Equation 3 using the Billboard Hot 100 dataset from January 1, 1992 to December 4, 1998. We end the period on December 4, 1998 instead of December 31, 1998 because Billboard changes the Hot 100 criteria on December 5, 1998. The control group are songs released only in cassette. $NewTech_i$ is an indicator variable for whether song i is released in the CD format.

Table 10 reports the logit model estimates for the cassette-CD transition. The CD format does not have a statistically significant impact on the likelihood of a song achieving Top 10 when we include the vector of control variables and the year-fixed effects (column 3). The positive and significant coefficient on *New Artist* supports the breakout effect: the first song released by a new artist is more likely to reach Top 10 compared to songs released by veteran artists. The estimated average marginal effects on *New Artist* suggest that, everything else equal, we would expect a 5.4 percent increase in the proportion of songs reaching Top 10 if we change the status of the artist from veteran to new (column 3).

7.3 CD-Digital Transition

To estimate the effect of the digital technology format on popularity, we estimate Equation 3 using the Billboard Hot 100 dataset from February 12, 2005 to March 28, 2015. We start the period on February 12, 2005, the first week Billboard includes the sales of digital download songs to the Hot 100 criteria. The control group are songs released only in CD. $NewTech_i$ is an indicator variable for whether song i is released in the digital format.

Table 11 reports the logit model estimates for the CD-digital transition. The digital format negatively impacts the likelihood of a song to reach Top 10, and the effect is statistically significant in all specifications (column 1-4). Using the preferred specification with all control variables, year-fixed effects, and criteria-fixed effects, the estimated average marginal effects on *Digital* suggest that, everything else equal, we would expect a 14.1 percent decrease in the proportion of songs reaching Top 10 if we change the format of the song from CD to digital.

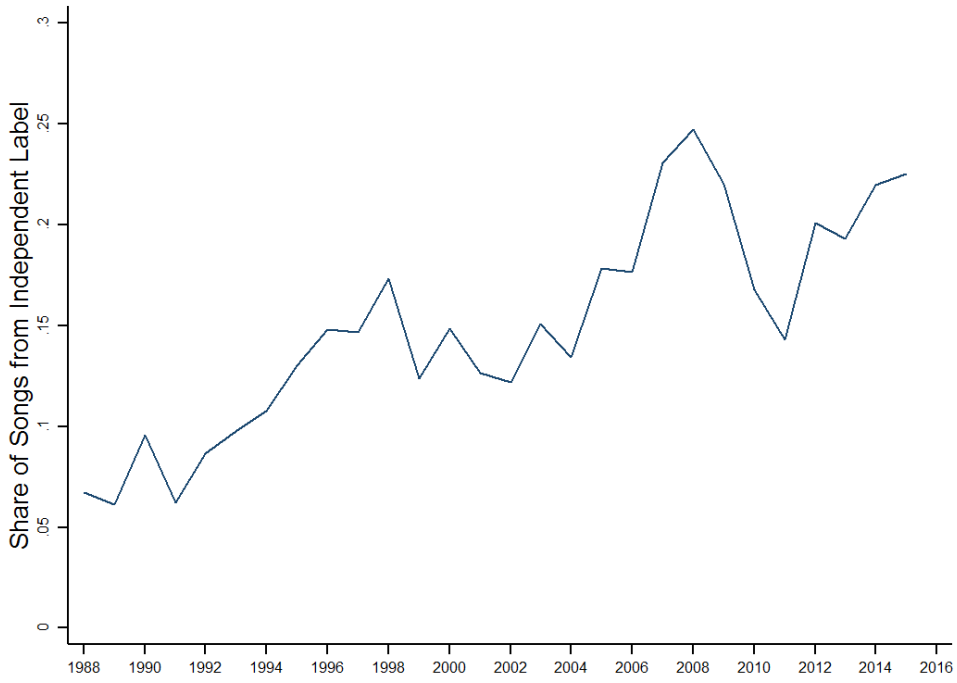
The positive and significant coefficient on *New Artist* in all specifications shows the continuation of the breakout effect into the CD-digital transition (Table 11, column 2-4). The estimated average marginal effects on *New Artist* suggest that, everything else equal, we would expect a 6.2 percent increase in the proportion of songs reaching Top 10 if we change the status of the artist from veteran to new (column 4).

Although *Independent Label* has no impact on a song's chart survival in the CD-digital transition (Table 8, column 2-4), *Independent Label* significantly reduces the likelihood of a

song to reach Top 10 across all specifications (Table 11, column 2-4). The average marginal effects on *Independent Label* suggest a 4.4 percent decrease in the proportion of songs reaching Top 10 if we change the label of a song from major to independent (Table 11, column 4).

Figure 5 shows the share of songs from independent labels over time. The average share of independent labels is 7.85 percent in the vinyl-cassette transition, 12.71 percent in the cassette-CD transition, and 20.01 percent in the CD-digital transition. The graphical evidence combined with the regression results suggest that, while independent labels are increasingly able to chart – and survive – on the Hot 100, the spots on the Top 10 remain more elusive.

Figure 5 Share of Songs from Independent Labels, 1988-2015



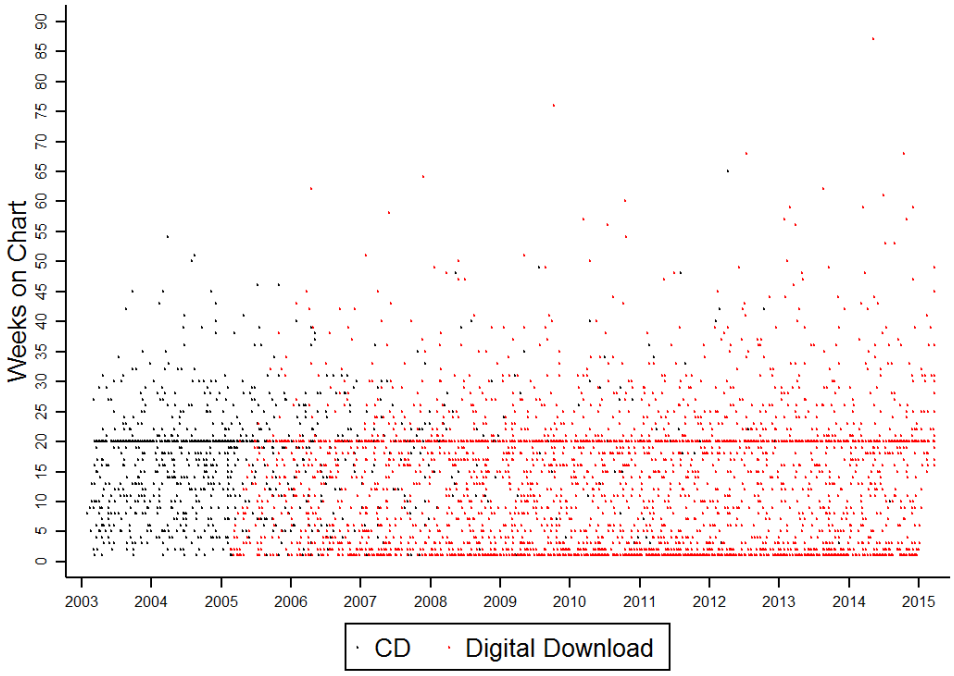
Notes: Data from Billboard's Hot 100 from January 1, 1988 to March 28, 2015. Share of songs from independent label are calculated – for each year – by dividing the number of independent label songs with the total number of songs (major and independent).

8 Mechanisms and Implications

The key result from the analysis is the heterogeneous effect of the digital technology format on released singles. The digital format is initially a curse: songs released in the digital format are much more likely to drop off the chart in the first week. But for songs that manage to

survive 24 weeks, the digital format is a boon, allowing songs to remain popular for even longer periods of time compared to previous formats.

Figure 6 Total Number of Weeks on Chart by Technology Format, 2003-2015



Notes: Raw scatter plots show how many weeks a song stayed on the Hot 100 from 2003 to 2015 by technology format. Each dot represents a unique single. The clustering of songs at week 20 is the result of the revamped "20-50" rule from August 7, 1993, which states that any song that charted for more than 20 weeks and has fallen out of the Top 50 will be removed from the Hot 100. The clustering of digital songs surviving for exactly one week show the prevalence of "one-week wonders" in the CD-digital transition.

The raw data scatter plot (Figure 6) lends insight to the mechanism behind the heterogeneous effect of the digital format. The introduction of digital downloads in 2005 dramatically increased the number of songs which appeared on the Hot 100 for only one week. For songs released in the CD format, 1.85 percent of songs (53 out of 2868) lasted only one week on the charts. For songs released the digital download format, a staggering 24.07 percent of songs (896 out of 3723) lasted only one week. The clustering of points at the week 1 line is something novel to the introduction of digital download formats which did not occur during any of the other technology formats eras. Naturally, songs that drop off after one week were unlikely to reach the Top 10, which helps explain why songs released in the digital format were also less likely to hit Top 10. These "one-week wonders" are emphatically not "one-hit wonders." While we see the emergence of one-week wonders during the digital age, the effect of the digital format technology is the opposite for the more resilient songs. Some

digital songs found new levels of success, including the record setting 87 weeks from Imagine Dragon's "Radioactive" (Trust, 2014).

We account for the sudden emergence of one-week wonders in a threefold manner. First, new digital avenues of distribution dramatically lowers the cost of releasing a single. With physical formats such as vinyls, cassettes, or CDs, artists had to decide whether – and how many – of a particular single they should manufacture and distribute. In previous eras, the majority of the songs on an artist's album were not available for individual purchase as singles. Digital formats simplified the decision: once an album is already recorded, there is no additional cost in providing the option to access each song individually either via digital download to buy (e.g., iTunes) or via streaming to sample (e.g., Spotify). The supply of easily accessible music increases.

Second, the increase in the supply of easily accessible music strengthens the bandwagon effect as consumers face the paradox of choice: judging by individual song is costly; judging by artist reputation a shortcut. Digital technologies offer consumers access to artists – professional or amateur – from around the entire world. The multitude of choices leads consumers to give a stronger weight to artist reputation, as a heuristic for finding music they prefer. Consumers do not know whether they like a particular song unless they actually hear it, but the chances of liking a particular song by your favorite artist is higher than a particular song selected at random. Established artists benefit from the advances in digital discovery because consumers can now select a particular song to be played instantly – through means such as YouTube or on-demand streaming – and consumers are more likely to select songs by a reputable artist.

Finally, digital feedback mechanisms create a vetting process: although a single can debut on the Hot 100 by artist reputation alone, the song must maintain interest or it will fall off in the next week immediately. The demand of songs in digital format – e.g., whether consumers sample the song once and turn it off, or whether consumers play the song repeatedly – can now be tracked instantaneously instead of daily or weekly. Twitter and other online forums allows consumers to share their opinions, good or bad, about a particular song to everyone else. Advances in digital feedback quickly sort out the potential hits from the passing fads, creating a harsh world for a song to survive. The passing fads, boosted onto the Hot 100 by artist reputation without enough momentum to survive, turn into one-week wonders as the next batch of songs pique consumer interest. If, however, a song manages to pass all tests, then the ease of accessing the digital format along with the positive reviews allows the song to remain on the charts for longer than previous technology formats. Digital distribution facilitates the discovery of popular songs by placing new releases and trending songs front and center (e.g., iTunes Store), or by directly suggesting songs you may enjoy based on your

past preferences and what is currently popular (e.g., Spotify or YouTube).

Our empirical evidence lends credence to our narrative. Established artists account for 777 out of the 924 one-week wonders (84.09 percent) in the CD-digital transition. For an established artist with a recorded album, digital distribution dramatically lowers the marginal cost of releasing another single, allowing established artists to crowd out spots on the Hot 100. The lowered cost of releasing a single means that, regardless of quality, an established artist can release a song and count on their fans to demand it, at least for a while. Digital feedback mechanisms quickly removes the songs without potential. For example, 17 songs from Taylor Swift's platinum album, "Speak Now," charted the Hot 100, but only 7 of them charted for more than one week.

In addition, our empirical evidence allows us to infer the strengthening of the bandwagon effect in the CD-digital transition. The coefficient on *New Artist* – i.e., the breakout effect – compares songs by new artists (no reputation) with songs by established artists (prior reputation). If the increased supply of new music in the CD-digital transition causes the consumer to tire of evaluating individual songs and to select songs based on reputation then, all else equal, we would expect songs with a prior artist reputation to perform better. In other words, if the bandwagon effect strengthens, we would expect the magnitude of the breakout effect to diminish, which is exactly what we find in the CD-digital transition: the coefficient on *New Artist* is -0.251 in the vinyl-cassette transition, -0.238 in the cassette-CD transition, but only -0.116 in the CD-digital transition (Table 4, column 3; Table 10, column 3; Table 8, column 4). One threat to the identification of the bandwagon effect is if the quality of songs by new artists decrease across the different technology transition eras, in which case the decline in the *New Artist* coefficient would capture the decline in song quality. Although the inherent quality of the song is difficult to measure and beyond the scope of our dataset, papers such as Waldfogel (2011) suggest that there is no evidence in the reduction of quality music since 1999. Therefore, it is reasonable to assume that song quality changes – if any – would not account for the entire decline in the breakout effect, and that the increased bandwagon effect must be playing a role.

The social implications of the digital technology is that established artists are in a better position to take advantage of lowered distribution costs and to use their fan base to generate a presence on the Hot 100. The "foot-in-the-door" strategy of established artists succeeds even if the released singles turn out to be one-week wonders. In a world where the supply of music continually increases, the mere existence of an audience examining and evaluating your work is superior to being ignored and forgotten. Unknown artists benefit from a lowered cost of release too, but they do not have the luxury of relying on their fan base to make the initial jump onto the charts. Unknown artists have trouble getting an audience to scrutinize their

music, let alone popularizing it. The final result is that proportion of songs by new artists on the Hot 100 declined from 25.6 percent under CD to 18.2 percent under digital (Table 7). A position on the Hot 100 increases the number of potential consumers discovering the music of the artist, which, in turn, increases sales. Or as independent artist Mackenzie Scott puts it, "I never expected to make money off of streaming or off of album sales, necessarily. The only world I've ever known is the one where people pirate music. Or the one where only the 1 percent of musicians actually make a lot of money doing this" (Schonfeld, 7/23/15).

9 Conclusion

Technological progress changed – and will continue to change – the way music becomes and remains popular. We study popularity characteristics of songs on Billboard's Hot 100 in order to investigate how technology impacts popularity, and consequently, how technology shapes the relationship between music consumers and music artists. We focus on three transition periods where music labels change the distribution format of the popular songs: vinyl to cassette, cassette to CD, and CD to digital.

Our empirical results show no discernible differences in the popularity characteristics of songs in neither the transition period from vinyl to cassette nor the transition period from cassette to CD. In the transition period from CD to digital, however, we find that songs released in the digital format are initially 144.98 percent more likely to fall off the Hot 100 compared to songs released in CD, but the effect moderates over time. We document the emergence of one-week wonders, i.e., songs charting on the Hot 100 for only a week before disappearing. We account for the phenomenon with reference to the new digital era: digital technologies lower the cost of releasing new music while concurrently creating an efficient vetting mechanism to separate the hits from the duds.

We highlight the breakout effect, where the first song by a new artist is both more likely to survive on the Hot 100 and to reach the Top 10 compared to a song by an existing artist. We infer the strengthening of the bandwagon effect in the digital era through the weakening of the breakout effect in the CD-digital transition. In other words, the digital technologies create an influx of new songs, causing consumers to bandwagon on artist reputation because evaluating each song individually is costly. Consequently, songs with a prior artist reputation perform better in the CD-digital era than either the vinyl-cassette era or the cassette-CD era. In an industry where success begets further success, our analysis suggests that established artists crowd out the coveted spots from new artists on the Hot 100.

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Table 1: Summary Statistics

	Mean	Standard Deviation	Minimum	Maximum
Chart Survival (In Weeks)	11.176	7.719	1	87
Top 10	0.176	0.381	0	1
Top 40	0.458	0.498	0	1
Independent Label	0.211	0.408	0	1
New Artist	0.265	0.441	0	1
Featured Artist	0.114	0.317	0	1
Peak Rank	46.164	30.675	1	100
Debut Rank	81.898	17.149	1	100
Holiday Debut	0.084	0.278	0	1
Song Length (In Minutes)	3.419	0.836	1.033	9.500
Observations	26,592			

Notes: Summary statistics for the 26,592 songs from 6,962 artists that appeared on the Billboard's Hot 100 from its inception on August 4, 1958 until March 28, 2015. Top 10, Top 40, Independent Label, New Artist, Featured Artist, and Holiday Debut are all indicator variables for the given characteristics.

Table 2: Summary Statistics by Technology Format

	Vinyl 1958-1990	Cassette 1989-1998	CD 1992-2014	Digital Download 2003-2015
Chart Survival (In Weeks)	9.467	14.719	16.954	12.172
	(5.655)	(7.790)	(9.030)	(11.018)
Top 10	0.179	0.194	0.212	0.121
	(0.383)	(0.395)	(0.409)	(0.327)
Top 40	0.460	0.466	0.537	0.384
	(0.498)	(0.499)	(0.499)	(0.486)
Independent Label	0.241	0.107	0.156	0.190
	(0.427)	(0.309)	(0.363)	(0.393)
New Artist	0.266	0.345	0.289	0.182
	(0.442)	(0.475)	(0.454)	(0.386)
Featured Artist	0.067	0.082	0.237	0.258
	(0.250)	(0.275)	(0.425)	(0.437)
Peak Rank	46.178	44.474	41.149	51.165
	(30.973)	(29.930)	(29.712)	(29.775)
Debut Rank	84.720	79.674	74.916	75.705
	(12.661)	(18.937)	(20.979)	(25.363)
Holiday Debut	0.081	0.075	0.101	0.093
	(0.273)	(0.264)	(0.302)	(0.290)
Song Length (In Minutes)	3.125	4.143	3.996	3.827
	(0.761)	(0.658)	(0.623)	(0.697)
Observations	17,355	2,646	2,868	3,723

Notes: Summary statistics, by technology format, for the 26,592 songs from 6,962 artists that appeared on the Billboard's Hot 100 from its inception on August 4, 1958 until March 28, 2015. The year range below each technology format represents the number of years the technology format was active. Number of observations are the number of songs released in each format. Top 10, Top 40, Independent Label, New Artist, Featured Artist, and Holiday Debut are all indicator variables for the given characteristics.

Table 3: Comparison of Means – Vinyl vs. Cassette, 1989-1990

	Vinyl	Cassette	Difference
Independent Label	0.063	0.093	-0.030
			(0.019)
New Artist	0.250	0.304	-0.054
			(0.032)
Featured Artist	0.053	0.057	-0.004
			(0.016)
Debut Rank	83.124	82.124	1.000
			(1.013)
Holiday Debut	0.095	0.049	0.046*
			(0.019)
Song Length (In Minutes)	4.086	4.128	-0.042
			(0.041)

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Comparison of means of the control variables, W_S', between 388 songs released in cassette and 380 songs released in vinyl from January 1, 1989 to December 31, 1990.

Table 4: Vinyl-Cassette Transition, 1989-1990 – Hazard Model Estimates

	(1)	(2)	(3)
Cassette	0.020	0.051	0.119
	(0.171)	(0.172)	(0.225)
Cassette * t	-0.007	-0.006	-0.006
	(0.011)	(0.012)	(0.012)
Independent Label		-0.184	-0.186
		(0.140)	(0.140)
New Artist		-0.250**	-0.251**
		(0.085)	(0.085)
Featured Artist		-0.006	0.002
		(0.162)	(0.162)
Debut Rank		0.017***	0.017***
		(0.003)	(0.003)
Holiday Debut		-0.054	-0.044
		(0.141)	(0.142)
Song Length (In Minutes)		-0.118	-0.119
		(0.067)	(0.067)
Controls	No	Yes	Yes
Year-Fixed Effects	No	No	Yes
Observations	10,405	10,405	10,405

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Hazard model estimates for chart survival using the restricted dataset from January 1, 1989 to December 31, 1990. Observations are song-week pairs. *Cassette* compares the initial survival rate of 388 unique songs released in cassette with 380 unique songs released in vinyl.

Table 5: Comparison of Means – Cassette vs. CD, 1992-1998

	Cassette	CD	Difference
Independent Label	0.119	0.164	-0.045**
			(0.017)
New Artist	0.355	0.355	-0.000
			(0.024)
Featured Artist	0.092	0.183	-0.091***
			(0.016)
Debut Rank	78.565	63.838	14.727***
			(1.136)
Holiday Debut	0.079	0.068	0.011
			(0.014)
Song Length (In Minutes)	4.151	4.164	-0.013
			(0.035)

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Comparison of means of the control variables, W'_S, between 487 songs released in CD and 1,870 songs released in cassette from January 1, 1992 to December 4, 1998.

Table 6: Cassette-CD Transition, 1992-1998 – Hazard Model Estimates

	(1)	(2)	(3)
CD	-0.066	0.096	-0.064
	(0.104)	(0.105)	(0.112)
CD * t	-0.009	-0.004	-0.004
	(0.006)	(0.006)	(0.006)
Independent Label		0.144*	0.124*
		(0.063)	(0.063)
New Artist		-0.222***	-0.238***
		(0.045)	(0.045)
Featured Artist		0.140*	0.108
		(0.067)	(0.067)
Debut Rank		0.013***	0.014***
		(0.001)	(0.001)
Holiday Debut		0.057	0.041
		(0.077)	(0.078)
Song Length (In Minutes)		-0.044	-0.029
		(0.033)	(0.033)
Controls	No	Yes	Yes
Year-Fixed Effects	No	No	Yes
Observations	37,083	37,083	37,083

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Hazard model estimates for chart survival using the restricted dataset from January 1, 1992 to December 4, 1998. Observations are song-week pairs. *CD* compares the initial survival rate of 487 unique songs released in CD with 1,870 unique songs released in cassette.

Table 7: Comparison of Means – CD vs. Digital, 2005-2015

	CD	Digital	Difference
Independent Label	0.240	0.190	0.049*
			(0.019)
New Artist	0.256	0.182	0.074***
			(0.019)
Featured Artist	0.373	0.258	0.115***
			(0.021)
Debut Rank	79.102	75.705	3.398**
			(1.213)
Holiday Debut	0.100	0.093	0.007
			(0.014)
Song Length (In Minutes)	3.907	3.827	0.079*
			(0.033)

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Comparison of means of the control variables, W_S', between 3,723 songs released in digital and 480 songs released in CD from February 12, 2005 to March 28, 2015.

Table 8: CD-Digital Transition, 2005-2015 – Hazard Model Estimates

	(1)	(2)	(3)	(4)
Digital	0.907***	0.897***	0.889***	0.896***
	(0.090)	(0.090)	(0.096)	(0.096)
Digital * t	-0.038***	-0.037***	-0.036***	-0.036***
	(0.004)	(0.004)	(0.004)	(0.004)
Independent Label		-0.008	0.000	0.001
		(0.039)	(0.039)	(0.039)
New Artist		-0.128**	-0.117**	-0.116**
		(0.040)	(0.040)	(0.040)
Featured Artist		-0.007	-0.004	-0.008
		(0.035)	(0.036)	(0.036)
Debut Rank		0.002***	0.002***	0.002***
		(0.001)	(0.001)	(0.001)
Holiday Debut		0.082	0.068	0.081
		(0.053)	(0.053)	(0.053)
Song Length (In Minutes)		-0.053*	-0.049	-0.046
		(0.025)	(0.026)	(0.026)
Controls	No	Yes	Yes	Yes
Year-Fixed Effects	No	No	Yes	Yes
Criteria-Fixed Effects	No	No	No	Yes
Observations	57,705	57,705	57,705	57,705

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Hazard model estimates for chart survival using the restricted dataset from February 12, 2005 to March 28, 2015. Observations are song-week pairs. *Digital* compares the initial survival rate of 3,723 unique songs released in digital with 480 unique songs released in CD. Criteria-fixed effects control for Hot 100 criteria changes on August 11, 2007, March 24, 2012, and February 21, 2013.

Table 9: Vinyl-Cassette Transition, 1989-1990 – Logit Model Estimates

	(1)		(2)		(3)	
	Coeff.	Marg. Eff.	Coeff.	Marg. Eff.	Coeff.	Marg. Eff.
Cassette	-0.168	-0.035	-0.330	-0.051	-0.512	-0.079
	(0.159)	(0.033)	(0.186)	(0.029)	(0.431)	(0.066)
Independent Label			-0.630	-0.097	-0.638	-0.098
			(0.392)	(0.060)	(0.393)	(0.060)
New Artist			0.163	0.025	0.164	0.025
			(0.215)	(0.033)	(0.216)	(0.033)
Featured Artist			0.025	0.004	0.014	0.002
			(0.392)	(0.060)	(0.392)	(0.060)
Debut Rank			-0.085***	-0.013***	-0.085***	-0.013***
			(0.008)	(0.001)	(0.008)	(0.001)
Holiday Debut			0.221	0.034	0.194	0.030
			(0.344)	(0.053)	(0.349)	(0.054)
Song Length (In Minutes)			0.286	0.044	0.286	0.044
			(0.158)	(0.024)	(0.157)	(0.024)
Controls	No		Yes		Yes	
Year-Fixed Effects	No		No		Yes	
Baseline Predicted Probability	0.293		0.293		0.293	
Observations	768		768		768	

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Logit model estimates for popularity using the restricted dataset from January 1, 1989 to December 31, 1990. Observations are unique songs. *Cassette* compares the likelihood to reach Top 10 of 388 unique songs released in cassette with 380 unique songs released in vinyl. "Coeff." is the logit model coefficients. "Marg. Eff." is the average marginal effects. Baseline predicted probability is the unconditional probability to reach Top 10, i.e., out of the 768 songs in the sample, 29.3 percent peaked at rank 10 or above.

Table 10: Cassette-CD Transition, 1992-1998 – Logit Model Estimates

	(1)		(2)		(3)	
	Coeff.	Marg. Eff.	Coeff.	Marg. Eff.	Coeff.	Marg. Eff.
CD	0.281*	0.040*	-0.707***	-0.076***	0.161	0.017
	(0.129)	(0.018)	(0.167)	(0.018)	(0.221)	(0.023)
Independent Label			-0.457*	-0.049*	-0.349	-0.036
			(0.221)	(0.024)	(0.228)	(0.023)
New Artist			0.386**	0.041**	0.531***	0.054***
			(0.140)	(0.015)	(0.143)	(0.015)
Featured Artist			0.114	0.012	0.418*	0.043*
			(0.197)	(0.021)	(0.205)	(0.021)
Debut Rank			-0.051***	-0.005***	-0.061***	-0.006***
			(0.003)	(0.000)	(0.003)	(0.000)
Holiday Debut			0.080	0.009	0.160	0.016
			(0.231)	(0.025)	(0.239)	(0.025)
Song Length (In Minutes)			0.081	0.009	-0.011	-0.001
			(0.092)	(0.010)	(0.094)	(0.010)
Controls	No		Yes		Yes	
Year-Fixed Effects	No		No		Yes	
Baseline Predicted Probability	0.170		0.170		0.170	
Observations	2,357		2,357		2,357	

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Logit model estimates for popularity using the restricted dataset from January 1, 1992 to December 4, 1998. Observations are unique songs. *CD* compares the the likelihood to reach Top 10 of 487 unique songs released in CD with 1,870 unique songs released in cassette. "Coeff." is the logit model coefficients. "Marg. Eff." is the average marginal effects. Baseline predicted probability is the unconditional probability to reach Top 10, i.e., out of the 2,357 songs in the sample, 17.0 percent peaked at rank 10 or above.

Table 11: CD-Digital Transition, 2005-2015 – Logit Model Estimates

	(1)		(2)		(3)		(4)	
	Coeff.	Marg. Eff.	Coeff.	Marg. Eff.	Coeff.	Marg. Eff.	Coeff.	Marg. Eff.
Digital	-1.220***	-0.145***	-1.415***	-0.153***	-1.312***	-0.141***	-1.317***	-0.141***
	(0.110)	(0.013)	(0.119)	(0.013)	(0.147)	(0.015)	(0.147)	(0.015)
Independent Label			-0.359**	-0.039**	-0.389**	-0.042**	-0.408**	-0.044**
			(0.128)	(0.014)	(0.129)	(0.014)	(0.130)	(0.014)
New Artist			0.597***	0.065***	0.569***	0.061***	0.584***	0.062***
			(0.117)	(0.013)	(0.118)	(0.013)	(0.118)	(0.013)
Featured Artist			0.342***	0.037***	0.369***	0.040***	0.350***	0.037***
			(0.101)	(0.011)	(0.103)	(0.011)	(0.103)	(0.011)
Debut Rank			-0.028***	-0.003***	-0.029***	-0.003***	-0.029***	-0.003***
			(0.002)	(0.000)	(0.002)	(0.000)	(0.002)	(0.000)
Holiday Debut			-0.282	-0.031	-0.275	-0.030	-0.276	-0.029
			(0.171)	(0.019)	(0.172)	(0.018)	(0.173)	(0.018)
Song Length (In Minutes)			0.072	0.008	0.066	0.007	0.069	0.007
			(0.069)	(0.008)	(0.070)	(0.008)	(0.070)	(0.008)
Controls	No		Yes		Yes		Yes	
Year-Fixed Effects	No		No		Yes		Yes	
Criteria-Fixed Effects	No		No		No		Yes	
Baseline Predicted Probability	0.144		0.144		0.144		0.144	
Observations	4,203		4,203		4,203		4,203	

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Logit model estimates for popularity using the restricted dataset from February 12, 2005 to March 28, 2015. Observations are unique songs. *Digital* compares the the likelihood to reach Top 10 of 3,723 unique songs released in digital with 480 unique songs released in CD. Criteria-fixed effects control for Hot 100 criteria changes on August 11, 2007, March 24, 2012, and February 21, 2013. "Coeff." is the logit model coefficients. "Marg. Eff." is the average marginal effects. Baseline predicted probability is the unconditional probability to reach Top 10, i.e., out of the 4,203 songs in the sample, 14.4 percent peaked at rank 10 or above.