Social Media, Music Consumption, and Cross-Platform Spillover Effects*

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Abstract

Platforms play an important role in allowing users to consume digital content such as music or videos. At the same time, platforms may play a vital role in popularizing content that consumers may view or listen to through *other* platforms or channels. In this paper, we study the spillover effects of music consumption on TikTok on consumption on other platforms or channels. Specifically, we focus on Universal Music Group's (Universal's) withdrawal of its licenses from TikTok in early 2024 and study the impact of consumption of music by Universal's artists on Spotify. Our results demonstrate a short-term drop in streams on Spotify. To understand why the drop occurs, we examine discovery via Shazam—a music discovery app—and find discovery of Universal songs on Shazam drops after the exit, suggesting a reduction in discovery is the primary driver of the effect. Because discovery might matter most for newer songs and songs used more in TikTok videos, we evaluate the heterogeneity along these two dimensions and find further support for the discovery mechanism. Our results point to the role of platforms in popularizing digital content and show important spillover effects may occur between different platforms.

Keywords: music streaming, platforms, spillover effects, TikTok, social media

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1 Introduction

Social media, in addition to connecting users online, allow users to consume digital content that originates from other creators or platforms. This ability has led to an ongoing discussion about the type of spillover effects to expect from the availability of third-party content on social media platforms. Specifically, the concern is that making content available on social media hurt content creators because users may reduce their consumption of content through other, more profitable avenues. Alternatively, the availability on social media may benefit content creators, for example, if social media allow users to find content they would otherwise not have been exposed to.

Understanding whether social media substitute or complement consumption on other platforms is particularly important in the music industry. Music streaming on digital platforms accounts for around 67% of the industry's revenues as platforms like Spotify, Pandora, and Apple Music generate a significant amount of subscription revenues from streaming music to their subscribers (IFPI, 2024).[1] At the same time, social media users on TikTok use music, often just snippets of songs, as background sounds to their videos. Unlike Spotify, TikTok does not compensate artists for each individual stream, but only per video in which their content is being used (Xposuremusic, 2024); thus, it is often accused of paying artists less than platforms such as Spotify,[2] and has been described as "building its business off the back of artists without paying those artists what they deserve" (Worldwide, 2022). In January 2024, negotiations about compensation for music rights between Universal Music Group (Universal), one of the world's largest music labels, and TikTok broke down, leading Universal to withdraw from TikTok the licenses for songs by its artists, starting from February 1, 2024. As a result, music by Universal artists, including the likes of Eminem, Rihanna, and the Weeknd, was no longer available for use in TikTok videos. Existing videos using such songs were muted.

[1] Forbes (2024) reports an even higher estimate of 89%.

[2] `https://www.tiktok.com/@musicbyazuma/video/7325181676865244458?lang=en`

In this paper, we empirically study how Universal withdrawing music rights from TikTok affected content consumption on Spotify, the world's largest music streaming platform (Statista, 2024). Universal withdrawing its songs from TikTok provides a quasi-experimental setting because consumers were no longer exposed to Universal songs for reasons unrelated to their preferences, enabling us to causally identify the effect of availability of content on TikTok on consumption on other platforms.

We further study the possible role of content discovery in driving any cross-platform spillover effects. First, we analyze the effect on behavior on Shazam, an app that facilitates music discovery. Second, we examine songs that should be disproportionately impacted by the withdrawal if discovery plays an important role—newer songs and songs used in more TikTok videos.

We rely on granular data of worldwide streams of individual songs on Spotify for a period of four weeks prior to and five weeks following the withdrawal of Universal's music rights. Our treatment group is songs by Universal artists that were available on TikTok, and our control group is songs available on TikTok by artists signed with the two other dominant labels, Sony Music Group (Sony) and Warner Music Group (Warner). We use a synthetic difference-in-differences (DiD) analysis to identify the causal effect of Universal withdrawing music rights from TikTok on consumption on Spotify.

Our objective is to measure the effect of Universal withdrawing its songs from TikTok on the streams that these songs had on Spotify and their discovery on Shazam. While Universal has many other songs that are not present on TikTok we are not interested in the performance of these songs as, by definition, they were not treated. As a result, we focus in our analysis on the average treatment effect on the treated (ATT).

We find negative short-run spillover effects: streams of Universal songs on Spotify dropped by 552.9 on average, that is by 2.2%, relative to the control group of Sony and Warner songs that were on TikTok. We cannot rule out the possibility that TikTok users may have replaced Universal songs with music by Sony and Warner, which in turn could have led to

spillover effects on our control group. In this case, our estimation might overestimate the effect on Universal songs. Therefore, as a robustness check, we use as an alternative control group songs by Sony or Warner artists that were not used in TikTok videos in the four weeks prior to and during the weeks of our study. This control group still allows us to account for trends in music consumption while eliminating the possibility of substitution effects, because they are not used to substitute for Universal songs in TikTok videos. The effects we find on streams on Spotify, using this alternate control group, are similar to the previous set of results.

Our results suggest withdrawing songs from TikTok leads to a drop in streams on Spotify. We propose that this reduction may be an outcome of reduced music discovery. Social media platforms such as TikTok act as a marketing channel for music and increase the reach of music. As a result, consumers become aware of songs they were previously unaware of and subsequently listen to these songs on streaming platforms such as Spotify. Anecdotal evidence indeed supports that TikTok has become a channel for discovery (Times, 2024; Whateley, 2024) and suggests that 'users seek out songs on music-streaming services after hearing them on TikTok' (Worldwide, 2021). To test whether Universal's withdrawal from TikTok reduces music discovery, we examine its effect on content discovery via Shazam, a music-discovery app that can determine the title and artist of a song from only a snippet of the music. One important use of Shazam is for users to identify songs that are playing in another app on their device, such as on TikTok.

Our data record the number of times individual songs were identified using Shazam. Results from a synthetic DiD analysis suggest that as a result of Universal withdrawing music rights from TikTok, music discovery on Shazam decreased. On average, discovery of Universal songs on Shazam dropped by 11.6 (11.5%) relative to the control group. This effect is robust to using as a control group the set of Sony and Warner songs not present on TikTok.

This drop in songs identified using Shazam suggests the reduction in streams we observe

may be an outcome of reduced music discovery. We explore heterogeneous effects across songs to provide more insights into the role of music discovery.

First, we suggest that songs that have been released more recently will suffer more because discovery is particularly important in driving streams for more recent songs that are likely to be less well known. Indeed, we find that songs that have been released in the two months preceding the observation period suffer a 27.3% decrease in Spotify streams, relative to the control group, whereas songs released prior to that time suffer only a 2.2% decrease relative to the control group. The effect on Shazam discovery follows a similar pattern. Relative to the control, recently released Universal songs suffer a 25.0% decrease in discovery via Shazam versus an 8.5% decrease for songs not released in recent months. Our results are also robust to defining recently released songs as those released within the past one or three months.

Second, if discovery on TikTok is indeed an important driver of streams on Spotify, we should see a disproportionately higher impact on Universal songs that previously were present in a particularly large number of TikTok videos. Such songs are more likely to have received substantial exposure on TikTok; therefore, for these songs, presence on TikTok is more likely to facilitate discovery among consumers. For each song, we count the number of videos on TikTok that used this song in the week preceding Universal's withdrawing of its licenses. We then identify the 30% of songs with the largest number of TikTok videos as popular songs and the 30% of songs with the lowest number of TikTok videos as not popular during that period. We document that songs that are popular on TikTok suffer significantly more than songs that are not popular on TikTok. For songs popular on TikTok, the number of Spotify streams dropped by 2.5% while the number of instances a song was identified using Shazam decreased by 10.7%, on average. The respective effects on not popular songs were not significant. This result is robust to using different measures of TikTok popularity.

Our findings relate to three prior streams of literature.

The first stream of research focuses on the relationship between platforms or aggregators and content providers. Calzada and Gil (2020) and Athey et al. (2021) find the shutdown

of Google News in Spain significantly decreased the number of daily visits to Spanish news outlets. By contrast, Chiou and Tucker (2017) show The Associated Press removing its content from Google News led to users being less likely to investigate related content in depth. In the context of travel aggregators and airlines, Akca and Rao (2020) demonstrate aggregators lose most when they are not comprehensive. We contribute to this research in two ways. First, a key characteristic of prior research is that a user visiting an aggregator can directly click through to the full offering provided by a publisher such as a news site or airline. By contrast, in our setting, click-through is not possible, making the link between consumption on TikTok and Spotify less direct. Nonetheless, our results point to a positive spillover effect. Second, our results provide robust evidence supporting that such spillover effects are a result of discovery of new content on social media.

Two papers closely related to ours are Winkler et al. (2024) and Cheng et al. (2024), who similarly study the effect of Universal's exit from TikTok on music consumption. While the latter uses the same data source, the former uses a more restricted data source limited to US and Germany, and cannot distinguish between videos present on TikTok and those that are not, a crucial component required to identify the ATT. More importantly, our paper differs in two major aspects from the above mentioned papers. First, we are able to shed light on the mechanism as to why presence on TikTok is linked to spillovers on Spotify: we provide comprehensive empirical evidence regarding the role of discovery of music, based both on our analysis of discovery through Shazam and based on our heterogeneity analyses. Together, these support that a reduction in song discovery on TikTok causes the drop in Spotify streams. These insights matter because they help us generalize above and beyond the specific empirical setting we study. Second, our econometric specification differs. Unlike Winkler et al. (2024) and Cheng et al. (2024), who use log-transformed dependent variables, we focus on estimating changes in the levels of Spotify streams and discovery on Shazam. Estimating differences in levels also allows us to circumvent challenges associated with the use of log-transformed dependent variables in DiD settings (McConnell, 2024) and might

explain why we find different patterns than these two studies.[3]

The second stream of prior research our results relate to discusses substitution and complementarities in music streaming and the use of streaming platforms. Aguiar (2017) demonstrates free streaming stimulates purchasing and piracy activity. Aguilar and Waldfogel (2015) show Spotify use displaces permanent downloads. Datta et al. (2018) demonstrate the adoption of Spotify increases music consumption. We add to this literature by highlighting the tension between streaming platforms and a social media platform and emphasize the role of social media in the discovery of new music.

The third stream of research our results relate to centers on the importance of product discovery on crowded digital marketplaces. Greminger (2022*b*), Greminger (2022*a*), and Zhang et al. (2023) demonstrate the importance of product discovery in online retailing and online travel bookings. Deng et al. (2023) demonstrate the launch of a free version of an app increases demand for the paid version of the same app and provide evidence suggesting one contributing factor is enhanced product discovery. Closer to our empirical context, Kretschmer and Peukert (2020) suggest restricting access to online videos decreases recorded music sales in physical and digital download channels. Our results complement these insights in that they demonstrate that even on digital streaming platforms, discovery can be a challenge and social media can help users explore new musical content.

Our results have implications for content creators, digital platforms, and public policymakers. For content creators, our results suggest the presence of content, such as music, on social media platforms can play an important role in facilitating discovery and driving popularity of this content across other platforms. At the same time, though we are unable to measure the effect of Universal's license withdrawal on TikTok, our findings suggest—at least in the short run—a platform such as TikTok may have some market power in negotiations with content creators, or their labels, because of the positive spillover effects on consumption elsewhere. For digital platforms such as Spotify, our results suggest consump-

[3]See Online Appendix B for a discussion of the implications of log transforming the dependent variable in our context.

tion on this platform is in at least some way contingent on content discovery elsewhere. This finding leads us to believe Spotify could benefit from broadening features that facilitate content discovery for users within their own platform. Last, our results have implications for public policymakers. The spillover between platforms we document suggests regulatory action regarding social media platforms may have knock-on effects on consumption of content through other avenues, in turn suggesting regulators may need to account for such complex relationships in their assessment of policies.

2 Empirical Setting and Data

2.1 Empirical Setting

Music labels play a pivotal role in the promotion and distribution of music and the development of artists. The three largest music labels worldwide are Universal Music Group, Sony Music Group, and Warner Music Group. Together, they account for nearly 70% of the global market share (SoundPlate, 2021). In addition to the labels under their own respective names, they own a multitude of smaller labels. For example, Universal owns the label Def Jam. Although large record labels dominate the market, a large number of small, independent labels also exist.

Music is predominantly consumed through digital platforms. Much of this consumption happens through streaming services (IFPI, 2024) with Spotify being the dominant streaming service with an almost 32% market share worldwide (Statista, 2024). It is present in more than 180 markets with 626 million users[4] and offers both free ad-supported and paid subscriptions.

Users also get exposed to music on social media platforms such as TikTok. As of 2024, TikTok has 1.04 billion monthly active users worldwide.[5] TikTok allows users to create,

[4] https://newsroom.spotify.com/company-info/

[5] https://backlinko.com/tiktok-users

share, and watch a large number of short videos, many of which use music as background sound. When creating their videos on TikTok, content creators can select songs, or snippets of songs, as background sounds from TikTok's music library. Users viewing a TikTok video may not necessarily know the specific song that is playing as background. To identify a song on TikTok, users can use music-discovery apps such as Shazam. With nearly 300 million monthly users, Shazam is one of the most popular music-discovery apps (AppleNewsroom, 2022). Shazam identifies a song and its artist from just a snippet of music that is playing in another app on the user's device, such as TikTok. Shazam can also identify music that is played outside the device.

Streaming services such as Spotify compensate content creators, for example, labels and artists, by paying them per stream. By contrast, TikTok compensates content creators by paying them per video in which a song is used, independently of the number of times the video is viewed (Xposuremusic, 2024). Platforms such as Spotify and TikTok typically negotiate music rights with labels to give their users access to music of artists represented by the respective label. However, negotiations regarding the compensation for music rights between Universal and TikTok broke down in January 2024.

On January 30, 2024, Universal released an open letter to the artist and songwriter community (UMG 2024). This letter articulated the importance of TikTok, as well as the importance of music to TikTok, and called for a renegotiation of the terms laid out in its contract due to expire on January 31, 2024. Because of this failure to reach an agreement, TikTok had to remove all content by Universal artists on February 1, 2024 (NPR, 2024). On February 27, 2024, TikTok had to further remove songs written by any songwriter signed on to Universal (Reuters, 2024). In all instances, songs by artists, respectively, songwriters, signed on to Universal directly or to labels owned by Universal were no longer available to use as background music to TikTok videos, and existing videos using those songs were muted.

Crucial to our empirical design, the timing of the announcement of this exit coincided with

the contract termination date and not with any demand- or artist-driven factors, allowing us to treat the timing of Universal withdrawing songs from TikTok as exogenous to any other demand-related factors. In addition, other labels, including Sony, Warner, and independent labels, did not change their policy with respect to TikTok.

2.2 Defining Treated and Control Groups

To examine how Universal's withdrawal from TikTok affected consumption of Universal songs, we focus on the ATT. In our setting, the ATT is more informative than the ATE for two reasons.

First, Universal's withdrawal from TikTok can only affect songs used in TikTok videos. Songs not used in TikTok videos are, by definition, not affected. Hence, to examine the role social media platforms such as TikTok play in music consumption, the relevant sample is music that is used on such platforms. Including in our treatment group songs that were not available on TikTok would mean that the average treatment effect we estimate would shift with the share of Universal's portfolio that was or was not affected by the treatment. More broadly, ATT is more appropriate than ATE if the goal is to examine the effect of a treatment that would only be given to units similar to those currently receiving it (Greifer and Stuart, 2021). Second, record labels, platforms, and artists worry about understanding the impact of social media platforms on the consumption of the music that is indeed featured on these platforms rather than about an average effect across songs, independently of whether they are available on such a platform.

Because we focus on the ATT, our treated group consists of songs by artists signed with Universal, or with labels owned by Universal, that were used in a TikTok video in a specific time window. We discuss details on this time window in section 2.3.

We use two alternative control groups. First, we use songs by artists managed by Sony and Warner, or by labels owned by them, that similarly were present on TikTok in at least a single video on TikTok in the relevant period. This approach has the advantage that these

songs are similar to the treated Universal songs in their pre-treatment TikTok presence. It is, however, possible that removal of Universal songs from TikTok might give such songs more exposure on TikTok, implying we cannot exclude the possibility of a spillover effect on this control group. Second, we use as an alternative control group songs by artists managed by Sony and Warner, or labels owned by them, that were not present on TikTok in the relevant period but that were present on TikTok prior to that period. Because no single TikTok video used these songs during the relevant period, they were by definition not used to substitute for Universal songs that were removed from TikTok and Universal's exit from TikTok does not affect them.

2.3 Data

Our primary data source is Soundcharts, an analytics platform that gathers worldwide music data. It provides two main datasets crucial to our research question. First, it maintains a list of songs that are used on TikTok and a list of songs not used on TikTok. This dataset is used to create the set of songs in our sample. Second, through an API, it allows us to extract detailed song-specific information, including streams on Spotify and the song's label. The steps below highlight these datasets and their construction in more detail.

We first identify songs that were used in TikTok videos and are therefore directly relevant to measuring the effect of Universal's withdrawal on songs present on TikTok. Because we ask how Universal's withdrawal from TikTok affected consumption of Universal songs, we want to identify songs that were used in TikTok videos prior to Universal's withdrawal. To do so, we extracted from Soundcharts the list of songs that were used in TikTok videos in the past 90 days. Soundcharts does not allow a user to customize this period. Because we extracted the data on February 23, 2024, we obtain the list of all songs that were used in TikTok videos between November 24, 2023, and February 23, 2024. Ideally, we would want the list of such songs ending January 31, 2024 (the effective day of the exit), but Soundcharts does not allow us to customize this period. We therefore ensure any new songs that were

introduced to TikTok after the exit (and therefore might be contaminated by the exit) are excluded from the sample.[6] This set of songs forms the basis of our treatment group (in case of Universal songs) as well as of our first control group (in case of Sony and Warner songs).

Second, we identify songs that were not used in TikTok videos during our observation window, but were used on TikTok at some point prior to that time, enabling us to construct a second control group not impacted by the exit. To do so, we collected songs that did not have a video on TikTok between December 3, 2023, and March 3, 2024, but were present on TikTok prior to December 3, 2023.[7] Because these songs were not present on TikTok during our observation window, Universal's exit from TikTok does not affect them.

We then extracted, from Soundcharts' API, song-level data on the number of daily streams on Spotify, the number of times a song was identified using Shazam, and the number of TikTok videos in which a song was used between December 25, 2023, and March 5, 2024.[8] This period constitutes our observation window—four weeks prior to Universal's exit from TikTok and five weeks following the exit. These song-level data also contains the record label associated with each song.[9] Figure 1 visually summarizes the timeline of Universal's withdrawal from TikTok and our sample construction.

To measure the impact of Universal's withdrawal from TikTok on consumption of Universal songs, we need to be able to unambiguously link songs to music labels. Although many songs are directly under the label of Universal, Sony, or Warner, others are under smaller labels, some of which are owned by these larger labels. We rely on the official websites of Universal, Sony, and Warner to map individual labels to these firms.[10] Importantly, for songs

[6]This process results in excluding 372 songs that were introduced to TikTok post-exit from our sample.

[7]Soundcharts provides a list of songs that had at least one TikTok video in the past, but zero TikTok videos in the last 90 days. This list of songs is updated daily and is only available as a snapshot as of the day of data collection. We extracted this list on March 3, 2024.

[8]The data for TikTok videos are missing in the API from December 25, 2023, to January 1, 2024. Hence, we have data on the number of TikTok videos from January 2, 2024, to March 5, 2024.

[9]For songs for which the data do not capture the record label, we used ChatGPT to identify the record label of a song. Overall, about 15% of the songs in our analysis sample have been labeled by ChatGPT. To validate the classification of ChatGPT, we asked an independent RA to classify a randomly selected sample of 743 songs. We found 82.2% agreement with the classification of ChatGPT.

[10]`https://www.warnerrecordedmusic.com/labels-and-distribution/`, `https://www.sonymusic.com/labels/`, `https://www.universalmusic.com/labels/`, `https://www.universalmusic.com/labels/`

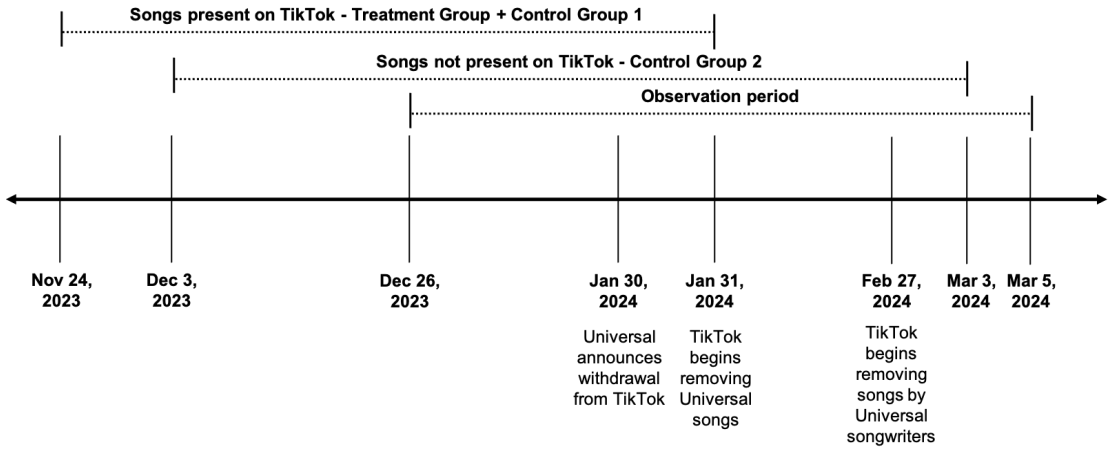


Figure 1: Timeline of sample construction and observation

that are not unambiguously linked to either Universal, Sony, or Warner, we do not know for certain that they are *not* linked to Universal. Thus, to be able to cleanly identify the effect on Universal songs, relative to a control group, we focus our analysis on songs we can clearly link to Universal, Sony, or Warner.

For our analysis we aggregate the data on a weekly level. In some instances, Soundchart did not collect the Spotify streams and the number of times a song was identified on Shazam for a song on a day. We focus on songs for which we have at least three non-missing observations for Spotify streams for each week. For this set of songs, we compute for each week the average number of daily Spotify streams based on the non-missing data points for that week. Because our estimation requires a balanced panel, we drop any songs for which this is not the case.[11] We follow the same process to aggregate the number of times a song was identified on Shazam on a weekly level.

We next check whether Universal songs had indeed been removed from TikTok. We would expect this process to be completed after a few days. Indeed, we find TikTok removed Universal songs starting January 31, 2024, and that a large portion had been removed by February 6, 2024. However, 26% of Universal songs in our data continued to be present on TikTok after this date, the vast majority of which were removed by February 27. This

`global/`. Accessed April 2024.

[11] This approach translates to removing 5.8% of the songs to create a balanced panel.

later removal is likely due to a subsequent withdrawal on February 27, 2024, where songs by Universal songwriters, even if they contributed to only a small portion of the song, had to be removed (Rackham, 2024). To cleanly measure the effect of Universal's exit from TikTok, we drop from the data Universal songs that TikTok had not yet removed by February 6, 2024. Removing these songs allows us to capture the average treatment effect on the treated. We later show that our results are robust to including these songs in our analysis.[12] In total, this approach yields 60,688 songs, of which 21,526 are mapped to Universal, 24,271 are mapped to Sony, and 14,891 are mapped to Warner.

Figure 2 shows that after TikTok removed Universal songs, the average number of TikTok videos per Universal song in our sample dropped significantly and reached zero two weeks later. We consider January 31, 2024, to be the date of treatment, because our data suggest TikTok started removing Universal songs from its platform starting January 31, 2024. To verify that the number of TikTok videos do not disproportionately belong to just a few songs, we plot in Figure 3 the proportion of Universal songs that had at least one video on TikTok. Again, this number clearly dropped significantly in the first week after the ban and reached zero at the end of the second week. Together, Figure 2 and Figure 3 confirm that, indeed, the sudden withdrawal of Universal music from TikTok resulted in Universal songs no longer being available and validate our empirical design is appropriate.

[12]In addition, to reduce noise in our data, we identify and drop from our sample 53 songs that were in high demand during the Christmas period but not otherwise. Specifically, we identify songs that recorded the maximum number of daily streams during the observation window on Spotify on December 25, 2023, and with more than 1 million Spotify streams on December 25, 2023.

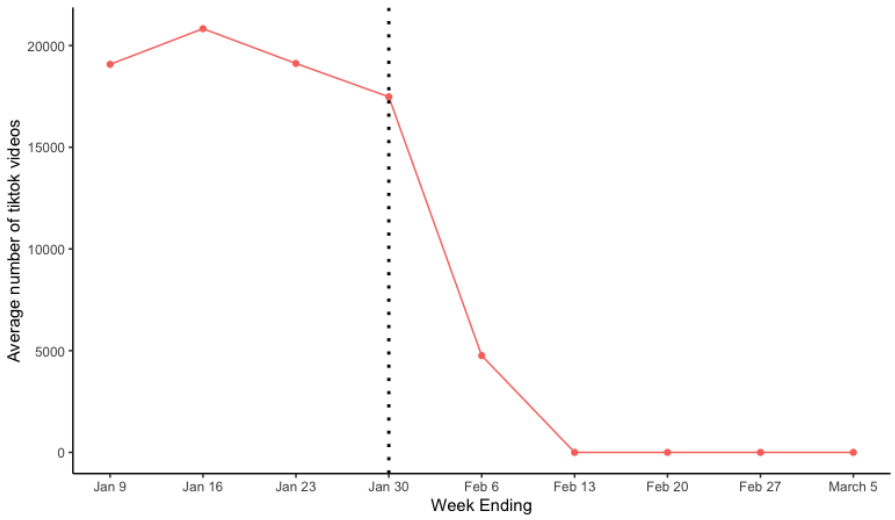


Figure 2: Average number of Universal's TikTok videos

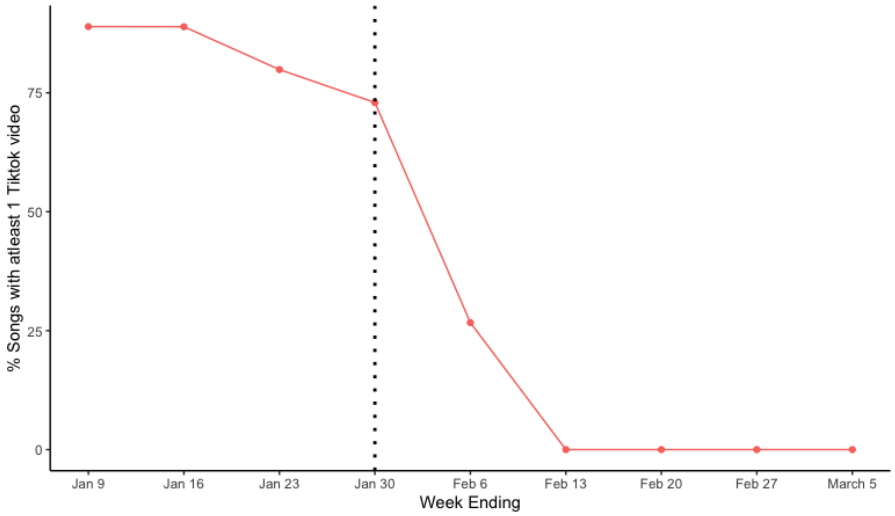


Figure 3: Proportion of Universal's songs with at least one TikTok video

Table 1 reports the summary statistics for the data. Panel A shows the number of average daily streams on Spotify. For songs present on TikTok, the average daily streams of Universal songs is 25,426, though the standard deviation of 105,332.4 is large. Daily streams for Sony and Warner songs are somewhat lower. Sony and Warner songs not present on TikTok during the past 90 days (but present at some point in the past) are still played frequently on Spotify.

Panel B shows the average daily number of times songs have been discovered using Shazam follows a similar pattern. The fact that discovery on Shazam is of a much smaller magnitude than Spotify streams is likely a result of multiple factors. For example, a user likely discovers a song only once but listens to it many times, and though both platforms are extremely popular, Spotify has more users than Shazam.

	N	Mean	Median	SD	Min	Max
A: Average daily Spotify streams						
Present on TikTok						
Universal	21,526	25,425.98	2,723.55	105,332.37	0	4,217,147
Sony	23,537	21,401.30	2,067.57	83,097.19	0	27,68,677
Warner	14,296	22,664.23	2,019.36	95,611.39	0	2,751,231
Not present on TikTok						
Sony	734	53,095.62	7,153.77	136,606.71	0	1,864,347
Warner	595	38,151.69	3,673.95	11,2943.97	0	1,273,420
B: Average daily discovery via Shazam						
Present on TikTok						
Universal	16,953	101.70	10.14	532.90	0	21,417.51
Sony	17,749	99.01	9.79	510.92	0	23,912.64
Warner	9,925	99.63	8.86	817.60	0	51,259.32
Not present on TikTok						
Sony	542	195.36	32.09	582.94	0	8,371.35
Warner	429	152.54	22.52	414.54	0	3,646.11

Notes: "Present on TikTok" refers to Universal, Sony, and Warner songs used in TikTok videos from November 24, 2023, to February 1, 2024. "Not present on TikTok" refers to Universal, Sony, and Warner songs not used in TikTok videos from December 4, 2023, to March 3, 2024.

Table 1: Summary Statistics

3 Estimation and Results

3.1 Estimation

Our observation period ranges from December 26, 2023, to March 5, 2024. We rely on the synthetic DiD (SDiD) approach (Arkhangelsky et al., 2021) because in the data the pre-treatment trends for the control and the treatment group are not parallel. The SDiD approach combines elements of the DiD model with elements of the synthetic control (SC) model and has been shown to be either comparable to or dominating both the regular DiD

method and the SC method. The SDiD approach is uniquely designed to address failures in parallel trends by "parallelizing" pre-trends. In SDiD, observations are weighted to align pre-trends in outcomes between treated and control units, thus parallelizing pre-trends. Observations are also weighted such that pre-treatment time periods that are more similar to post-treatment time periods for the control group are weighted more highly. The weighted observations are then used in a two-way fixed effects (TWFE) model to estimate treatment effects.

The SDiD model requires a balanced panel with homogenous treatment timing. Our data satisfy this requirement. Specifically, we estimate the following:

$$\underset{\beta,\alpha,\gamma}{\operatorname{argmin}} \left\{ \Sigma_i \Sigma_t (Y_{it} - \beta Treat_i \times After_t - \alpha_i - \gamma_t)^2 \hat{\omega}_i^{sdid} \hat{\lambda}_t^{sdid} \right\}, \tag{1}$$

where the outcome of interest Y_{it} is average daily streams on Spotify for song i in week t. Specifically, we are interested in differences in levels of Spotify streams as a result of a song's presence on or removal from TikTok.[13] We include song fixed effects α_i that account for song characteristics such as artist, genre, persistent popularity, and any time-invariant differences across songs. We also include week fixed effects, γ_t to control for cross-song shocks that affect music consumption. $\hat{\omega}_i^{sdid}$ are song weights that parallelize pre-trends and $\hat{\lambda}_t^{sdid}$ are time weights. $Treat_i \times After_t$ indicates whether song i is a Universal song post Universal's exit from TikTok at time t. The coefficient β from equation (1) is the SDiD treatment effect of removing Universal songs from TikTok on average daily Spotify streams, relative to the control group of songs by Sony and Warner artists. We report cluster-robust standard errors clustered at the song level to account for temporal autocorrelation within songs.

[13] See Online Appendix B for a discussion of challenges associated with using log-transformed dependent variables in DiD settings which estimate the ratio of growth rates.

3.2 Effect on Spotify Streams

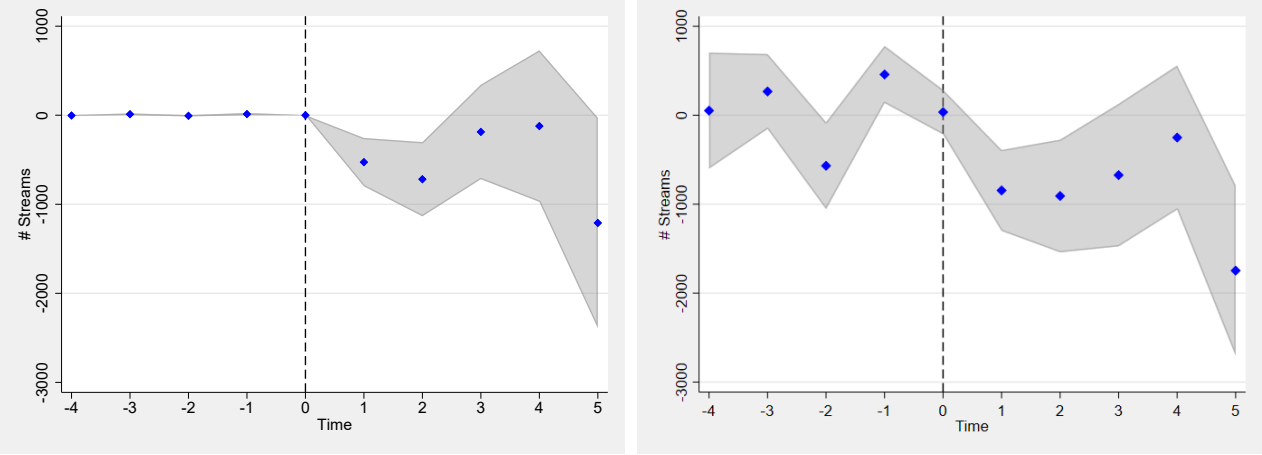
We present our results in Figure 4 and Table 2. First, Figure 4 shows the event-study plots of the SDiD treatment effects using our control groups. In Figure 4(a), we use Sony and Warner songs that were present on TikTok as control group. In Figure 4(b), we use Sony and Warner songs that were not present on TikTok as control group. The grey area represents the 95% confidence intervals, and the vertical dashed line represents the last day before Universal's withdrawal from TikTok. In Figure 4(a), all pre-treatment estimates contain zero in their confidence intervals, providing evidence for the parallel-trends assumption. In Figure 5(b), all pre-treatment estimates except the two pre-treatment periods contain zero in their confidence intervals. For both estimations, the test for parallel trends fails to reject the null hypothesis of parallel trends in the pre-treatment period, further supporting the assumption of parallel trends (Angrist and Krueger, 1999). The figures clearly show that, after the withdrawal of Universal songs from TikTok, the treatment-effect estimates are negative and inch toward 0 in later periods.[14]

We next quantify the magnitude of the decline in Table 2 using the same two control groups (Columns (1) and (2), respectively). Table 2, Column (1), shows that as a result of Universal's withdrawal from TikTok, Spotify streams of Universal songs decreases by 552.9 relative to the control group of Sony and Warner songs that were present on TikTok ($p < 0.01$). At the mean, this amount translates into a 2.2% decrease in daily streams, relative to the control group, calculated as the ratio between the point estimate and the pre-treatment mean of Universal songs. Column (2) demonstrates our results are robust to using the alternative control group of Sony and Warner songs that were not present on TikTok during the observation period. The average number of Spotify streams of a Universal song decreases by 884.6 relative to the control group of Sony and Warner songs not present on TikTok ($p < 0.01$).

Our result that Universal's withdrawal from TikTok led to a decrease in music consump-

[14]See Online Appendix A for a description of the method we used to construct this plot.

Figure 4: SDiD treatment effects on Spotify streams



(a) (b)

Notes: SDiD ATTs of Universal's withdrawal from TikTok on Spotify streams over time. Time 0 indicates the week before withdrawal. Other times are relative to the week before withdrawal. Figure (a) uses Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as control. Figure (b) uses Sony and Warner songs that were not used in TikTok videos from December 4, 2023, to March 3, 2024 as control.

tion of Universal songs on Spotify suggests that spillover effects from social media platforms such as TikTok on music consumption on other digital platforms are significant.

3.3 Effect on Discovery via Shazam

We explore why the unavailability of Universal songs on TikTok may have decreased streams of these songs on Spotify. We propose that removing music from TikTok increases the difficulty for consumers to discover these songs. On social media platforms, such as TikTok, where music is often used as background audio to videos, consumers get exposed to songs they may otherwise not become aware of, for example, because they may not typically listen to the artist or the category of music. As a result, such songs can reach new customers. As consumers become aware of songs via TikTok, they become more likely to listen to these songs on streaming platforms such as Spotify.

To test whether the spillover effects we observe may indeed relate to song discovery, we leverage data on song discovery on the music-discovery app Shazam. Because Shazam

Table 2: Effect on number of Spotify streams

	(1) vs. songs present on TikTok	(2) vs. songs not present on TikTok
Treatment x After	-552.87***	-884.57***
	(177.74)	(265.23)
Song F.E	Yes	Yes
Week F.E.	Yes	Yes
Pre-Treatment Mean Universal	24,849.07	24,849.07
Observations	593,590	228,550

Notes: The table presents estimates of Universal's streams on Spotify, after the exit from TikTok, relative to Sony and Warner streams on Spotify. Column (1) uses Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as control. Column (2) uses Sony and Warner songs that were not used in TikTok videos as control from December 4, 2023, to March 3, 2024. Clustered standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

allows consumers to identify songs they were previously not or little aware of, usage of Shazam directly measures music discovery (Aguiar and Chen, 2024).

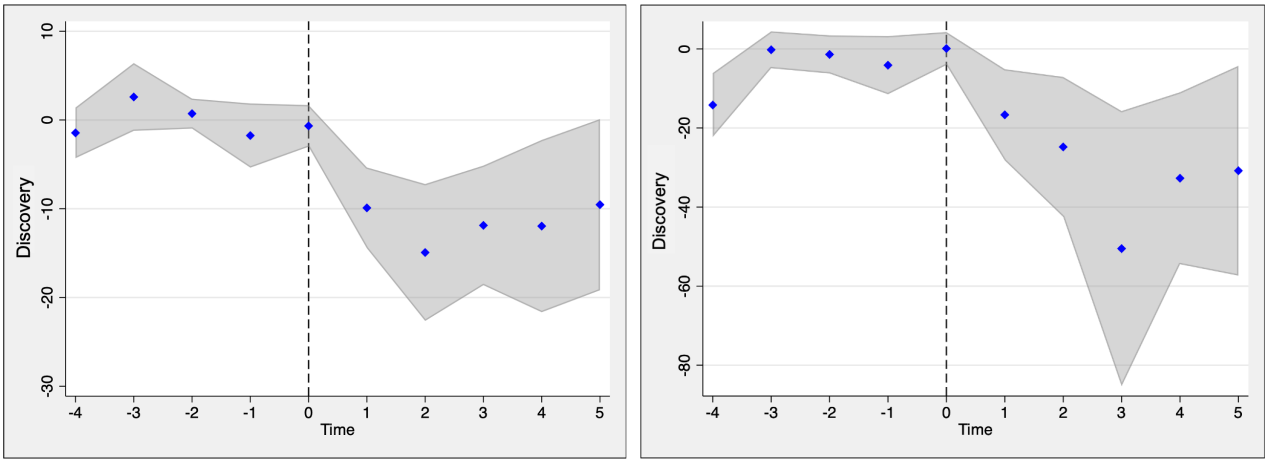
We use the SDiD method to quantify the effect of Universal's exit on song discovery via Shazam.[15] We estimate equation (1), with the dependent variable being the average daily frequency by which song i has been identified in week t using Shazam.

We present our results in both Figure 5 and Table 3. Figure 5 shows the event-study plots of the SDiD treatment effects using our two sets of control groups. Figure 5(a) relies on Sony and Warner songs that were present on TikTok as control group. Figure 5(b) comprises in the control group Sony and Warner songs that were not present on TikTok. The grey area represents the 95% confidence intervals. In both cases, the test for parallel trends fails to reject the null hypothesis of parallel trends in the pre-treatment period (Angrist and Krueger, 1999). Moreover, in Figure 5(a), all pre-treatment estimates contain zero in their confidence intervals, providing evidence for the parallel-trends assumption. In Figure 5(b), all except the first pre-treatment estimates contain zero in their confidence intervals. However, the weight assigned by SDiD to the first pre-treatment period in Figure 5(b) is zero, which means observations from this period are not used in the SDiD estimation. The

[15]In the Shazam data, we do not find evidence of a violation of the parallel-trends assumptions. Therefore, we can use the DiD method. Nonetheless, to be consistent with our previous analysis, and because SDiD dominates DiD (Arkhangelsky et al., 2021), we report results from SDiD here. Our results for the effect on discovery on Shazam are robust to using DiD instead of SDiD. See Section C in Online Appendix.

figure shows that, after the withdrawal of Universal songs from TikTok, the treatment-effect estimates are negative and inch toward 0 in later periods.

Figure 5: SDiD treatment effects on discovery via Shazam



(a) (b)

Notes: SDiD ATTs of Universal's withdrawal from TikTok on discovery via Shazam over time. Time 0 indicates the week before withdrawal. Other times are relative to the week before withdrawal. Figure (a) uses Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as control. Figure (b) uses Sony and Warner songs that were not used in TikTok videos from December 4, 2023, to March 3, 2024 as control.

We quantify the magnitude of the decline in Table 3 using the same two control groups (Columns (1) and (2), respectively). Table 3, Column (1), shows that as a result of Universal's withdrawal from TikTok, the average daily number of times a Universal song has been identified using Shazam decreases by 11.6 relative to songs by Sony and Warner artists ($p < 0.01$). This amount translates into a 10.6% decrease. Column (2) confirms the results are robust to using the second control group. The average daily frequency by which a Universal song had been identified using Shazam decreases by 31.1 relative to Sony and Warner songs ($p < 0.01$).

In sum, our analysis indicates Universal's withdrawal from TikTok makes discovering Universal songs harder for consumers. This reduction in discoverability of Universal songs likely plays a role in the decreased consumption of Universal songs on streaming platforms such as Spotify.

Table 3: Effect on discovery via Shazam

	(1) vs. Songs present on TikTok	(2) vs. Songs not present on TikTok
Treatment x After	-11.64***	-31.09***
	(3.35)	(7.84)
Song F.E	Yes	Yes
Week F.E.	Yes	Yes
Pre-Treatment Mean Universal	109.82	109.82
Observations	446,270	179,240

Notes: The table presents estimates of the number of times a song was identified on Shazam, after the exit from TikTok, relative to Sony and Warner discovery on Shazam. Column (1) uses Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as control. Column (2) uses Sony and Warner songs that were not used in TikTok videos from December 4, 2023, to March 3, 2024 as control. Clustered standard errors in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.4 Robustness Checks

To further test for the robustness of the results, we conduct two sets of robustness checks. First, we exclude from our analysis those songs that were classified as being Universal, Sony, or Warner, using ChatGPT. In the second robustness check, we include in our analysis Universal songs that were present on TikTok between November 24, 2023, and January 31, 2024, and not removed by TikTok after Universal's exit.

Table 4 shows the results for Spotify streams. Columns (1) and (2) show the results for Spotify streams using the two control groups if we remove from our analysis songs classified by ChatGPT. In both instances, we find that our results hold. Columns (3) and (4) demonstrate these results also hold when we include in the estimation the Universal songs that TikTok had not yet removed after February 6.

Table 5 shows the corresponding robustness tests for the effect on discovery using Shazam. Columns (1) and (2) show the results for discovery on Shazam using the two control groups are robust to the exclusion of songs that were classified as being Universal, Sony, or Warner, using ChatGPT from our analysis. Columns (3) and (4) demonstrate that the results for Shazam discovery are also robust to including in the estimation Universal songs that TikTok had not yet removed after February 6.

Overall, the effects we find on streams on Spotify and discovery on Shazam are similar

Table 4: Effect on number of Spotify streams

	w/o ChatGPT-classified songs		With Universal songs on TikTok post exit	
	(1) vs. Songs present on TikTok	(2) vs. Songs not present on TikTok	(3) vs. Songs present on TikTok	(4) vs. Songs not present on TikTok
Treatment x After	-581.31**	-1080.14***	-505.4648***	-867.40**
	(249.89)	(295.69)	(171.4842)	(371.60)
Song F.E	Yes	Yes	Yes	Yes
Week F.E.	Yes	Yes	Yes	Yes
Pre-Treatment Mean Universal	26,001.10	26,001.10	24,884.42	24,884.42
Observations	502,870	213,140	669,380	276,610

Notes: "w/o ChatGPT-classified songs" refers to the sample of songs without songs classified as Universal, Sony, or Warner by ChatGPT. "With Universal songs on TikTok post exit" refers to the sample of songs that includes those Universal songs that TikTok did not remove after Universal's withdrawal. The table presents estimates of Universal's streams on Spotify, after the exit from TikTok, relative to Sony and Warner streams on Spotify. Columns (1) and (3) use Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as control. Columns (3) and (4) use Sony and Warner songs that were not used in TikTok videos from December 4, 2023, to March 3, 2024 as control. Clustered standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Effect on discovery via Shazam

	w/o ChatGPT-classified songs		With Universal songs on TikTok post exit	
	(1) vs. Songs present on TikTok	(2) vs. Songs not present on TikTok	(3) vs. Songs present on TikTok	(4) vs. Songs not present on TikTok
Treatment x After	-11.75***	-26.23***	-9.41***	-28.48***
	(3.88)	(6.22)	(2.69)	(9.10)
Song F.E	Yes	Yes	Yes	Yes
Week F.E.	Yes	Yes	Yes	Yes
Pre-Treatment Mean Universal	114.23	114.23	110.66	110.66
Observations	392,310	168,870	489,580	222,550

Notes: "w/o ChatGPT-classified songs" refers to the sample of songs without songs classified as Universal, Sony, or Warner by ChatGPT. "With Universal songs on TikTok post exit" refers to the sample of songs that includes those Universal songs that TikTok did not remove after Universal's withdrawal. The table presents estimates of Universal's discovery via Shazam, after the exit from TikTok, relative to Sony and Warner discovery via Shazam. Columns (1) and (3) use Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as control. Columns (3) and (4) use Sony and Warner songs that were not used in TikTok videos from December 4, 2023, to March 3, 2024 as control. Clustered standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

to our main estimation in both size and significance.

4 Heterogeneous Effects on Songs Withdrawn from TikTok

Our results demonstrate Universal's withdrawal from TikTok leads to a decrease in streams on Spotify. In addition, the decrease in discovery on Shazam points to the reduction in streams being a result of reduced music discovery. To further explore the role of music discovery, we conduct two sets of analyses that focus on heterogeneous effects across songs. First, we suggest recently released songs are affected more strongly because they are likely to be less well known and more reliant on discovery. Second, if TikTok serves as a channel of discovery that in turn drives streams on Spotify, we should see a disproportionately high impact on the discovery of those Universal songs that are more frequently used to create videos on TikTok and are thus likely to have more reach on TikTok than songs that are used less often to create videos.

4.1 Recency of Songs

Research on innovation diffusion suggests social media can serve as an important channel for the diffusion of new products, because social media can expose users to new products they are not yet aware of and may otherwise not easily, or not as quickly, learn about (Peres et al., 2010). This logic implies that, on average, songs that have been released more recently should benefit to a greater degree from their presence on a platform such as TikTok than songs with a more distant release data. As a result, Universal's withdrawal from TiktTok should hurt more recent songs to a greater degree than older songs. We test for this possibility empirically.

We classify songs by Universal, Sony, and Warner that were released in the two months prior to the time period of our analysis, that is, in November and December 2023, as being recently released. We later check the robustness to using a shorter and longer window for defining whether a song had recently been released. We classify songs released before two

months prior to the start of our period of analysis, that is, prior to November 2023, as not being recently released.[16] We expect the effect of Universal's withdrawal on Spotify streams and the frequency with which they have been identified using Shazam to be more pronounced for recently released than for older songs.

Column (1) of Table 6 shows that as a result of Universal's withdrawal from TikTok, the average number of Spotify streams of recently released Universal songs decreases by 49,899.8 relative to streams of recently released Sony and Warner songs ($p < 0.01$). This amount translates into a 27.3% decrease in Spotify streams. Column (2) shows that for Universal songs not recently released, the average number of Spotify streams decreases by 544.6 ($p < 0.01$), a 2.2% reduction, relative to not recently released Sony and Warner songs. The confidence interval of this 49,355.2 difference in ATTs (95% CI: -79,883.2, -18827.2) is significantly different from zero at a p-value < 0.01. Columns (3) and (4) show the effects on the number of times a song is discovered on Shazam mirror these findings. The daily average frequency a recently released Universal song was discovered using Shazam decreases by 272.5 relative to discovery of recently released songs by Sony and Warner ($p < 0.01$), a drop of 25.0%. For songs not recently released, the drop is only 8.8 on average a day relative to songs by Sony and Warner ($p < 0.01$), an 8.5% reduction. The confidence interval for this difference of 263.7 (95% CI: -464.7, -62.5) is significantly different from zero at p-value < 0.05. Although this analysis defines recently released songs as those released within two months prior to our data period, our results are robust to instead focusing on songs that have been released within one month or three months prior to our data period (see Tables D1 and D2 in the Online Appendix D.1).[17]

[16] Our data do not record the release date of 2,383 songs. We drop these songs from this analysis.

[17] We are unable to examine the robustness of these results to using the set of Sony and Warner songs not present on TikTok as the control group, because no songs in this group were released in the two months preceding our period of analysis.

Table 6: Effect on number of Spotify streams and discovery via Shazam by recency of release

	Spotify streams		Shazam discovery	
	(1) Recent (<= 2 months)	(2) Not recent (> 2 months)	(3) Recent (<= 2 months)	(4) Not recent (> 2 months)
Treatment x After	-49899.81***	-544.57***	-272.52**	-8.83***
	(18320.04)	(199.11)	(106.24)	(3.05)
Song F.E	Yes	Yes	Yes	Yes
Week F.E.	Yes	Yes	Yes	Yes
Pre-Treatment Mean Universal	182,626.60	24,844.34	1,089.66	103.53
Observations	1,420	568,340	3,490	442,780

Notes: Dependent variable in columns (1) and (2) is the number of Spotify streams, and in columns(3) and (4), is is the number of times a song was discovered using Shazam. "Recent (<= 2 months)" refers to songs released after October 31, 2023. "Not recent (< 2 months)" refers to songs released on or before October 31, 2023. The table presents estimates of Universal's Spotify streams and discovery via Shazam, after the exit from TikTok, relative to Sony and Warner songs based on the recency of the release of songs. Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as the control group. Clustered standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2 Popularity of Songs on TikTok

We then turn to songs' popularity on TikTok. We expect that Universal's withdrawal from TikTok leads to a disproportionately high impact on discovery of Universal songs that are used more frequently as background sounds in TikTok videos, relative to songs that are rarely used in TikTok videos. In other words, the intensity of treatment is higher for songs used in more TikTok videos. This difference should manifest itself in a more pronounced effect on streams on Spotify as well as in greater discovery using Shazam.

To measure a song's popularity for video creation on TikTok, we rely on the number of TikTok videos in which each song was used in the week preceding Universal's withdrawal from TikTok, that is, January 23 to January 30. We classify songs in the top 30th percentile of the distribution of the number of videos as being popular on TikTok and songs in the bottom 30th percentile as being not popular.

Column (1) of Table 7 shows that for popular songs on TikTok, the average number of Spotify streams of Universal songs decreases by 1822.5 ($p < 0.01$), a 2.5% decrease, relative to songs by Sony and Warner. By contrast, the reduction in Spotify streams of songs not popular on TikTok is not significant (Column (2)). The difference in ATTs of -1454.6 (95%

CI: -2962.3, -174.7) is significantly different from zero at a p-value of less than 0.05. Columns (3) and (4) show the effect on discovery via Shazam mirrors these findings. Due to Universal's exit from TikTok, the average discovery on Shazam decreases by 27.2, a 10.7% decrease for songs popular on TikTok. However, we do not detect a significant decrease in discovery via Shazam for songs that are not popular on TikTok. The difference in point estimates of 18.4 between popular and not popular songs (95% CI: -34.1, -2.6) is significantly different from zero at a p-value less than 0.05. Our results are robust to using different cutoffs to classify songs as being popular on TikTok (see Tables D3 and D4 in the Online Appendix D.2).[18]

Table 7: Effect on number of Spotify streams and discovery via Shazam by popularity on TikTok

	Spotify streams		Shazam discovery	
	(1)	(2)	(3)	(4)
	Popular	Not popular	Popular	Not popular
Treatment x After	-1822.52***	-367.94	-27.18***	-8.81
	(611.69)	(238.46)	(6.15)	(5.56)
Song F.E	Yes	Yes	Yes	Yes
Week F.E.	Yes	Yes	Yes	Yes
Pre-Treatment Mean Universal	73,085.74	8185.69	254.92	86.41
Observations	178,090	177,500	141,100	134,570

Notes: The dependent variable in columns (1) and (2) is the number of Spotify streams. In columns(3) and (4), it is the number of times a song was identified on Shazam. "Popular" refers to the top 20% most popular songs on TikTok based on the number of TikTok videos. "Not popular" refers to the bottom 20% most popular songs on TikTok based on the number of TikTok videos. The table presents estimates of Universal's Spotify streams and discovery via Shazam, after the exit from TikTok, relative to Sony and Warner songs based on the popularity on TikTok. Analysis uses Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as the control group. Clustered standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Together, the patterns we find when exploring heterogeneous effects across songs, accounting for differences in songs' recency or their popularity on TikTok further support that social media platforms play an important role in helping users discover music.

[18]We do not examine the robustness of these results to using the set of Sony and Warner songs not present on TikTok as the control group, because, by definition, these songs were not present on TikTok in the weeks preceding Universal's withdrawal and not used to create videos.

5 Conclusion

Social media platforms allow users to consume digital content such as music and videos that originate from other creators on the platform. This possibility has lead to a discussion on spillover effects across platforms and raised the question whether consumption on one platform helps or hurts consumption on another platform. Our paper investigates the spillover effects of music consumption on TikTok on consumption on the leading music streaming platform Spotify. We leverage as exogenous shock Universal's decision at the end of January 2024 to withdraw its licensing for music content from TikTok. This allows us to identify the causal effect of the unavailability of a large portfolio of songs' on TikTok on streaming on Spotify. We leverage the synthetic difference-in-difference (SDiD) method to estimate the effect on Spotify streams of Universal songs relative to two alternative control groups of songs by the other two dominant music labels, Sony and Warner. We then study the possible role of content discovery in driving any cross-platform spillover effects, relying on data recording the use of the music discovery app Shazam. Finally, we turn our attention to heterogeneous effects across songs considering songs' recency and their popularity on TikTok.

Our analysis yields three main results. First, we find consistently that Universal withdrawing songs from TikTok reduces consumption of these songs on Spotify, suggesting at least short-run spillover effects. Second, we document that withdrawing songs from TikTok likewise leads to a drop in discovery of songs via Shazam, suggesting that content discovery is an important factor driving those spillover effects. Third, we demonstrate that songs that have been more recently released, and so are more likely to be in need of discovery, suffer more than songs that had previously been released. Further, we find a stronger drop in Spotify streams and discovery on Shazam for songs that are featured in more TikTok videos and so are likely to lose greater exposure to consumers, further emphasizing the role of discovery in cross-platform spillover effects.

For content creators and their labels, our results point to the importance of availability through multiple channels and the need to consider potential cross-platform spillover effects

in distribution and pricing decisions. For platforms such as Spotify, our findings suggest that current activity is to at least some extent contingent on discovery through other channels and suggest that enabling discovery may be important to broaden music consumption, which could potentially increase revenue and retention. Last, while public policy is increasingly concerned about the role of dominant platforms, our findings point to the possibility that the same platforms may in fact facilitate the discovery of a broad range of content that users may otherwise not be exposed to.

Of course, our paper has limitations. First, although the removal of Universal music from TikTok represents an exogenous shock to consumers, we are unable to ascertain whether Universal implemented any mitigating measures, for example, by increasing or refocusing marketing expenditures. If Universal took such actions, we may underestimate the true effect of removing content from TikTok. Second, our study is focused on the short-term effects of Universal's exit from TikTok; we are unable to measure long-run changes in consumption across platforms. Third, our analysis relies on aggregate data and we are unable to track the behavior of individual users across platforms. Fourth, we do not have insights into the algorithm used by Spotify to recommend content to users or design playlists and the degree to which this algorithm may have mitigated any immediate effect. Further, while it seems unlikely that Universal withdrawing its content from TikTok would have lead to an immediate change in Spotify's algorithms, we cannot exclude that possibility. Notwithstanding these limitations, we believe our paper, by documenting the role of social media platforms such as TikTok in popularizing content and aiding discovery, represents a useful contribution to our understanding of cross-platform spillover effects.

References

Aguiar, Luis (2017), 'Let the music play? free streaming and its effects on digital music consumption', *Information Economics and Policy* **41**, 1–14.

Aguiar, Luis and Zhizhong Chen (2024), 'Let that sync in: The effect of music reuse on product discovery'.

Aguilar, Luis and Joel Waldfogel (2015), 'Streaming reaches flood stage: does spotify stimulate or depress music sales', *NBER working paper* .

Akca, Selin and Anita Rao (2020), 'Value of aggregators', *Marketing Science* **39**(5), 893–922.

Angrist, Joshua D and Alan B Krueger (1999), Empirical strategies in labor economics, *in* 'Handbook of labor economics', Vol. 3, Elsevier, pp. 1277–1366.

AppleNewsroom (2022), 'Shazam turns 20'. (accessed on July 28, 2024).
URL: *https://www.apple.com/newsroom/2022/08/shazam-turns-20/*

Arkhangelsky, Dmitry, Susan Athey, David A Hirshberg, Guido W Imbens and Stefan Wager (2021), 'Synthetic difference-in-differences', *American Economic Review* **111**(12), 4088–4118.

Athey, Susan, Markus Mobius and Jeno Pal (2021), The impact of aggregators on internet news consumption, Technical report, National Bureau of Economic Research.

Calzada, Joan and Ricard Gil (2020), 'What do news aggregators do? evidence from google news in spain and germany', *Marketing Science* **39**(1), 134–167.

Cheng, Mengjie Magie, Elie Ofek and Hema Yoganarasimhan (2024), 'The value of silence: The effect of umg's licensing dispute with tiktok on music demand', *working paper* .

Chiou, Lesley and Catherine Tucker (2017), 'Content aggregation by platforms: The case of the news media', *Journal of Economics & Management Strategy* **26**(4), 782–805.

Clarke, Damian, Daniel Pailañir, Susan Athey and Guido Imbens (2023), 'Synthetic difference in differences estimation', *arXiv preprint arXiv:2301.11859* .

Datta, Hannes, George Knox and Bart J Bronnenberg (2018), 'Changing their tune: How consumers' adoption of online streaming affects music consumption and discovery', *Marketing Science* **37**(1), 5–21.

Deng, Yiting, Anja Lambrecht and Yongdong Liu (2023), 'Spillover effects and freemium strategy in the mobile app market', *Management Science* **69**(9), 5018–5041.

Forbes (2024), 'Top streaming statistics in 2024'. (accessed on May 29, 2024).
URL: *https://www.forbes.com/home-improvement/internet/streaming-stats/*

Greifer, Noah and Elizabeth A Stuart (2021), 'Choosing the causal estimand for propensity score analysis of observational studies', *arXiv preprint arXiv:2106.10577* .

Greminger, Rafael P (2022*a*), 'Heterogeneous position effects and the power of rankings', *arXiv preprint arXiv:2210.16408* .

Greminger, Rafael P (2022*b*), 'Optimal search and discovery', *Management Science* **68**(5), 3904–3924.

IFPI (2024), 'Global music report 2024'. (accessed on July 12, 2024).
URL: *https://ifpi-website-cms.s3.eu-west-2.amazonaws.com/IFPI˙GMR˙2024˙State˙of˙the˙Industry˙db9*

Kretschmer, Tobias and Christian Peukert (2020), 'Video killed the radio star? online music videos and recorded music sales', *Information Systems Research* **31**(3), 776–800.

McConnell, Brendon (2024), 'Can't see the forest for the logs: On the perils of using difference-in-differences with a log-dependent variable', *working paper* . (previously circulated as 'What's logs got to do with it: On the perils of log dependent variables and difference-in-differences').

NPR (2024), 'Tiktok removes music from umg artists, including olivia rodrigo and taylor swift'. (accessed on July 1, 2024).
URL: *https://www.npr.org/2024/02/01/1228333611/tiktok-removes-music-from-umg-artists-including-olivia-rodrigo-and-taylor-swift*

Peres, Renana, Eitan Muller and Vijay Mahajan (2010), 'Innovation diffusion and new product growth models: A critical review and research directions', *International journal of research in marketing* **27**(2), 91–106.

Rackham, Annabel (2024), 'More music leaving TikTok over Universal Music row'. (accessed on February 28, 2024).
URL: *https://www.bbc.co.uk/news/entertainment-arts-68412642*

Reuters (2024), 'Tiktok begins removing universal music publishing content after deal stalemate'. (accessed on July 1, 2024).
URL: *https://www.reuters.com/technology/tiktok-begins-removing-universal-music-publishing-content-after-deal-stalemate-2024-02-27/*

SoundPlate (2021), 'The major labels – everything you need to know about major record labels'. (accessed on July 28, 2024).
URL: *https://soundplate.com/major-record-labels/*

Statista (2024), 'Spotify - statistics facts'. (accessed on May 29, 2024).
URL: *https://www.statista.com/topics/2075/spotify/topicOverview*

Times, New York (2024), 'For gen z, tiktok isthe new search engine'. (accessed on September 5, 2024).
URL: *https://www.nytimes.com/2022/09/16/technology/gen-z-tiktok-search-engine.html*

Whateley, Dan (2024), 'How tiktok is changing the music industry and the way we discover new, popular songs'. (accessed on September 10, 2024).
URL: *https://www.businessinsider.com/how-tiktok-is-changing-music-industry*

Winkler, Daniel, Christian Hotz-Behofsits, Nils Wlomert, Dominik Papies and Jura Liaukonyte (2024), 'The impact of social media on music demand: Evidence from a quasi-natural experiment', *working paper* .
URL: *https://arxiv.org/abs/2405.14999*

Worldwide, Music Business (2021), '75 (accessed on July 31, 2024).
URL: *https://www.musicbusinessworldwide.com/tiktok-has-over-800m-active-users-worldwide-75-of-them-say-they-discover-new-artists-on-the-platform/*

Worldwide, Music Business (2022), 'When will TikTok start paying the music industry 'properly'?'. (accessed on July 31, 2024).
URL: *https://www.musicbusinessworldwide.com/podcast/tiktok-start-paying-the-music-industry-properly/*

Xposuremusic (2024), 'TikTok Royalties: All You Need to Know — Xposure Music — info.xposuremusic.com'. (accessed on July 31, 2024).
URL: *https://info.xposuremusic.com/article/tiktok-royalties-all-you-need-to-know*

Zhang, Xingyue Luna, Raluca Ursu, Elisabeth Honka and Yuliang Oliver Yao (2023), 'Product discovery and consumer search routes: Evidence from a mobile app', *Available at SSRN 4444774* .

Online Appendix

A Event-Study Plots in SDiD

To visualize how the dynamics of treatment effects evolve over time, we construct an event-study type of plot (see Figures 4 and 5) following the method suggested by Clarke et al. (2023). For each week t, we calculate whether the difference between treated units and the synthetic controls change relative to a baseline difference. Hence, we calculate the following:

$$(\bar{Y}_t^{Tr} - \bar{Y}_t^{Co}) - (\bar{Y}_{baseline}^{Tr} - \bar{Y}_{baseline}^{Co}), \tag{A1}$$

and the confidence interval of this quantity. $\bar{Y}_t^{Tr}$ is the mean for treated units in week t, and $\bar{Y}_t^{Co}$ is the mean for synthetic control units in week t calculated using unit-specific weight $\hat{\omega}_i$ estimated in SDiD in equation (1). $\bar{Y}_{baseline}^{Tr}$ refers to the baseline, that is, the pre-treatment mean for treated units, and $\bar{Y}_{baseline}^{Co}$ refers to the pre-treatment mean for the synthetic control units. The baseline outcomes are the pre-treatment aggregates using the time weights $\hat{\lambda}_t$ estimated in SDiD in equation (1). These are calculated as

$$\bar{Y}_{baseline}^{Tr} = \sum_{t=1}^{T_{pre}} \hat{\lambda}_t^{sdid} \bar{Y}_t^{Tr}$$

and

$$\bar{Y}_{baseline}^{Co} = \sum_{t=1}^{T_{pre}} \hat{\lambda}_t^{sdid} \bar{Y}_t^{Co}$$

Based on these figures, the event study plots the quantities defined in equation (A1). Finally, to calculate the confidence intervals, we use a block bootstrap procedure. In each iteration, the quantity in equation (A1) is re-calculated for each week t. Finally, the confidence interval for each quantity in week t is calculated based on the variance across the block-bootstrapped resamples.

B Effect on Spotify Streams and Shazam Searches with Log-Transformed Dependent Variable

We estimate the effect of Universal's withdrawal from TikTok on the level of Spotify streams and the number of times a song is identified via Shazam. Other research has instead reported results based on the use of log-dependent variables in DiD settings (Winkler et al., 2024; Cheng et al., 2024). However, recent research in economics has pointed to potential challenges associated with such an approach (McConnell, 2024). First, while in non-DiD contexts the usual way to calculate percentage change is by log transforming the dependent variable, in

a DiD context, an estimation of log-transformed dependent variables provides a proxy for relative growth rates among groups, not an estimation of a percentage change in a group. Therefore, the interpretation of an estimate using a log transformed dependent variable in DiD context deviates from that in other specifications.

Second, a concern with using a log-transformation of the dependent variable in DiD contexts is that, under certain conditions such as when there is a sizable difference in baseline means of dependent variable, such a design can be unstable and can potentially result in a reversal of sign of the coefficient of interest, biasing estimates. Using recent empirical studies published in the Quarterly Journal of Economics, McConnell (2024) shows that the log-transformation of a dependent variable can lead to a change in sign of the estimates compared to a levels specification. McConnell (2024) suggests that in a DiD context an OLS estimation with a log transformed dependent variable (which is often used in non-DiD contexts) can be biased and proposes that such a model should rely on a Poisson Pseudo Maximum Likelihood (PPML) estimation.

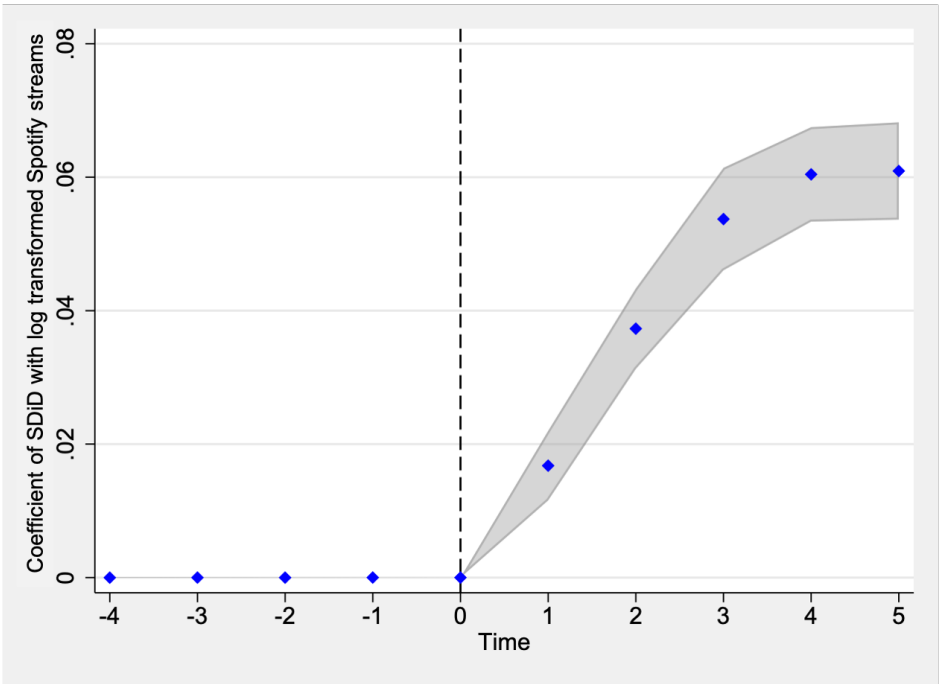
In our research, we rely on estimating changes in levels using OLS specifications. Here, we empirically examine whether a log transformation of dependent variables – number of Spotify streams and the number of times a song is identified on Shazam, could indeed lead to such reversals in our SDiD design. Figure B1 shows the event-study plot of the SDiD treatment effects using Sony and Warner songs that were present on TikTok as control group.[19] The grey area represents the 95% confidence intervals, and the vertical dashed line represents the last day before Universal's withdrawal from TikTok. The figure clearly shows that, when using a log-transformation of number of Spotify streams as the dependent variable, the sign of the treatment-effect estimates switches to becoming positive compared with Figure 4(a). In line with the conditions that McConnell (2024) outlined for leading to a reversal, indeed the pre-treatment means of Spotify streams differ significantly between the control and treatment groups (21352.5 vs. 24849.1).

Figure B2 shows the event-study plot of the SDiD treatment effects on discovery via Shazam using Sony and Warner songs that were present on TikTok as control group. The grey area represents the 95% confidence intervals, and the vertical dashed line represents the last day before Universal's withdrawal from TikTok. The figure shows that, when using a log-transformation of the number of times a song is identified via Shazam as the dependent variable, the sign of the treatment-effect estimate remains the same as in Figure 5(a). This pattern is again consistent with McConnell (2024): here, there is no sizable or significant difference in pre-treatment means of discovery via Shazam between Universal (109.8) and Sony and Warner songs (101.0).

Together, these sets of results suggest that the challenges discussed by McConnell (2024) can also apply in settings more typical to marketing research.

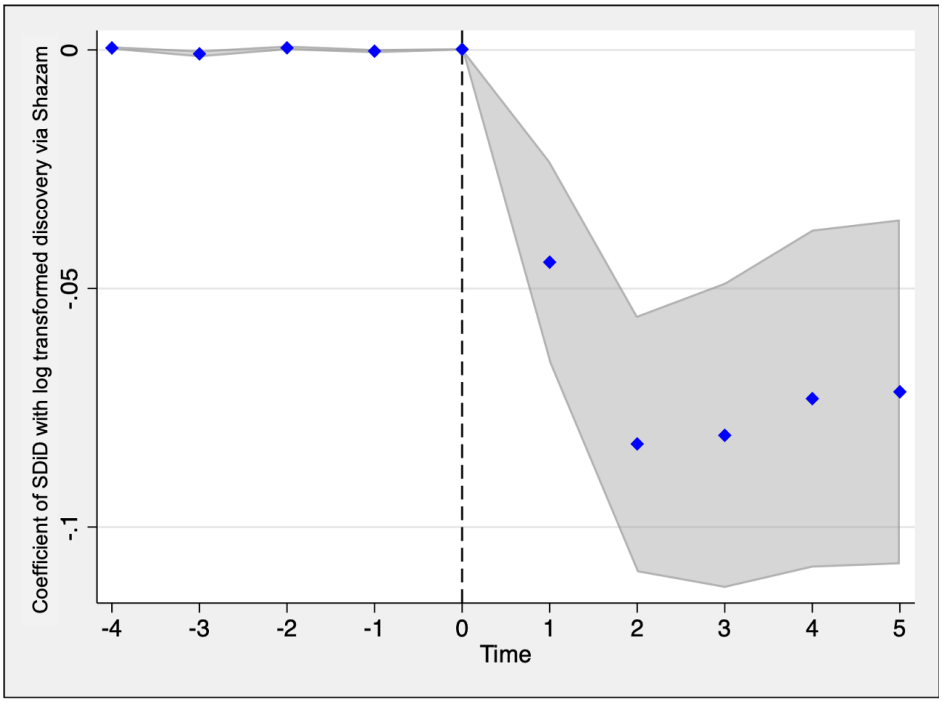
[19] We do not discuss the patterns using Sony and Warner songs that were not present on TikTok as control group since we are unable to achieve parallel trends using a log-dependent variable.

Figure B1: SDiD treatment effects on Spotify streams (log transformed)



Notes: SDiD ATTs of Universal's withdrawal from TikTok on ln(1 + Spotify streams) over time. Time 0 indicates the week before withdrawal. Other times are relative to the week before withdrawal. Figure uses Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as control.

Figure B2: SDiD treatment effects on discovery via Shazam (log transformed)

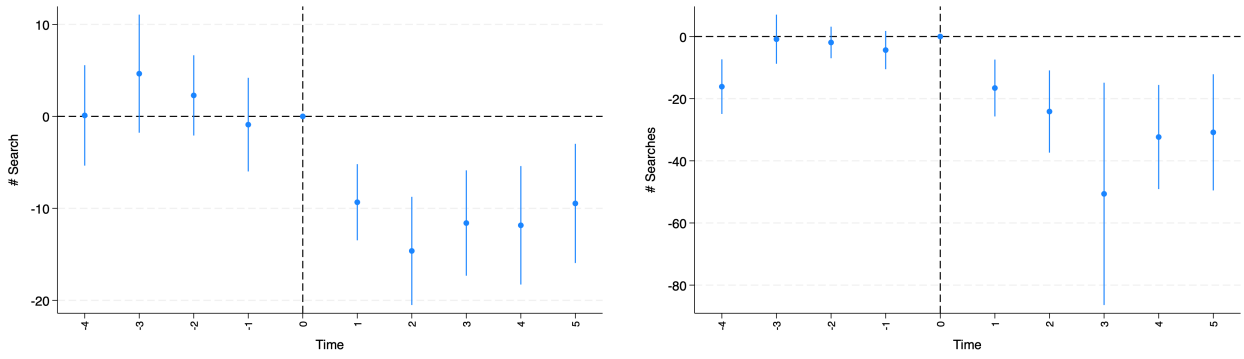


Notes: SDiD ATTs of Universal's withdrawal from TikTok on log transformation of discovery via Shazam over time. Time 0 indicates the week before withdrawal. Other times are relative to the week before withdrawal. Figure uses Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as control.

C Effect on Shazam Searches Using DiD

We quantify the effect of Universal's withdrawal from TikTok on the number of Shazam searches using a DiD method. Because DiD relies on the parallel-trends assumption pre-treatment, we present the event-study coefficient estimates with 95% confidence intervals in Figure C1 using our two sets of control groups. The first control group (Figure C1a) uses Sony and Warner songs that were present on TikTok. The second control group (Figure C1b) comprises Sony and Warner songs that were not present on TikTok. The vertical blue line represents the 95% confidence intervals. In Figure 5(a), all pre-treatment estimates contain zero in their confidence intervals, providing evidence for the parallel-trends assumptions. In Figure 5(b), again all pre-treatment estimates except the first estimate contain zero in their confidence intervals. However, in both cases, the test for parallel trends suggested by Angrist and Krueger (1999) fails to reject the null hypothesis of parallel trends in the pre-treatment period, further supporting the assumption of parallel trends. The figure shows that, after the withdrawal of Universal songs from TikTok, the treatment effect estimates are negative and inch toward 0 in later periods.

Figure C1: DiD treatment effects on discovery via Shazam



(a) (b)

Notes: DiD ATTs of Universal's withdrawal from TikTok on discovery via Shazam over time. Time 0 indicates the week before withdrawal. Other times are relative to the week before withdrawal. Figure (a) uses Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as control. Figure (b) uses Sony and Warner songs that were not used in TikTok videos from December 4, 2023, to March 3, 2024 as control.

We next quantify the magnitude of the decline in Table C1 using the same two control groups (columns (1) and (2), respectively). Table C1, column (1), shows that as a result of Universal's withdrawal from TikTok, the average daily number of times a Universal song has been identified using Shazam decreases by 12.6 relative to songs by Sony and Warner artists ($p < 0.01$). This amount translates into a 11.5% decrease. Column (2) confirms the results are robust to using the second control group. The average daily frequency by which a Universal song had been identified using Shazam decreases by 26.2 relative to Sony and Warner songs ($p < 0.01$).

Table C1: Effect on discovery via Shazam

	(1) vs. Songs present on TikTok	(2) vs. Songs not present on TikTok
Treat x After	-12.60***	-26.25***
	(2.91)	(8.13)
Song F.E	Yes	Yes
Week F.E.	Yes	Yes
Pre-Treatment Mean Universal	109.82	109.82
Observations	446,270	179,240
R sq.	0.84	0.85

Notes: The dependent variable is the number of times a song was identified on Shazam. The table presents estimates of discovery of Universal songs on Shazam, after the exit from TikTok, relative to Sony and Warner discovery on Shazam. Column (1) uses Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as the control group. Column (2) uses Sony and Warner songs that were not used in TikTok videos from December 4, 2023, to March 3, 2024 as the control group. Clustered standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

D Heterogeneity Robustness

D.1 Recency of Songs

Our findings demonstrate that songs that have been released more recently, measured as songs released in the two months preceding the observation window, suffer more. We check the robustness of these results by using different cut-offs to classify songs as having been released recently. Columns (1) and (2) of Table D1 show the results if we classify songs that were released in the previous one month prior to our observation period, that is, released after November 2023, as recent and songs released before that time as not recent. Column (1) shows that as a result of Universal's withdrawal from TikTok, the average number of Spotify streams of Universal songs decreases by 84098.2 ($p < 0.1$) relative to streams of recently released Sony and Warner songs. This amount translates into a 24.8% decrease in Spotify streams. Column (2) shows that for songs not recently released, the average number of Spotify streams decreases by 530.5 ($p < 0.05$), a 2.2% reduction. The difference in ATTs (-83567.6) is significantly different from zero at p-value < 0.05.

Columns (3) and (4) of Table D1 show the results if we classify songs that were released in the previous three months prior to our observation period, that is, released after September 2023, as recent and songs released before that time as not recent. We find that as a result of Universal's withdrawal from TikTok, the average number of Spotify streams of Universal songs decreases by 32632.1 ($p < 0.05$). This amount translates into a 23.9% decrease in Spotify streams. Column (4) shows that for songs not recently released, the average number of Spotify streams decreases by 549.8 ($p < 0.05$), a 2.2% reduction. The 95% confidence interval of the difference in ATTs (-32082.3) is (-59523.3, -4641.3) and is significantly different from zero at p-value less than 0.05.

Table D2 shows the results for Shazam searches are also robust to using different cutoffs to classify songs as recent. Columns (1) and (2) show the results if we classify songs that were released in the previous one month prior to our observation period, that is, released

Table D1: Effect on number of Spotify streams by recency of release

	(1)	(2)	(3)	(4)
	Recent (<= 1 months)	Not recent (> 1 months)	Recent (<= 3 months)	Not recent (> 3 months)
Treatment x After	-84098.16*	-530.51**	-32632.11**	-549.77**
	(47774.39)	(206.08)	(13463.28)	(218.76)
Song F.E	Yes	Yes	Yes	Yes
Week F.E.	Yes	Yes	Yes	Yes
Universal Pre-Treatment Mean	339,625.50	24,570.98	136,728.30	24,794.66
Observations	830	568,930	1,990	567,770

Notes: The table presents estimates of Universal's Spotify streams after the exit from TikTok, relative to Sony and Warner songs, based on the recency of the release of songs. "Recent (<= 1 months)" refers to songs released after November 30, 2023. "Not recent (< 1 months)" refers to songs released on or before November 30, 2023. "Recent (<= 3 months)" refers to songs released after September 30, 2023. "Not recent (< 3 months)" refers to songs released on or before September 30, 2023. Analysis uses Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as the control group. Clustered standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

after November 2023, as recent and songs released before that time as not recent. Discovery of recently released Universal songs (column (1)) on Shazam decreases by 699.6 ($p < 0.01$), that is, by 36.7%, on average per day, relative to recently released songs by Sony and Warner. For songs not recently released (column (2)), we find Shazam discovery decreases by 8.9 ($p < 0.01$), a 8.4% reduction, relative to songs by Sony and Warner. The confidence interval for this difference of 690.8 (95% CI: -1127.1, -254.3) is significantly different from zero at p-value < 0.01.

Columns (3) and (4) show the results if we classify songs that were released in the previous three months prior to our observation period, that is, released after September 2023, as recent and songs released before that time as not recent. We find that as a result of Universal's withdrawal from TikTok, discovery of recently released Universal songs (column (3)) on Shazam decreases by 211.1 ($p < 0.01$) that is by 22.3% on average per day, relative to recently released songs by Sony and Warner. Column (4) shows that for songs not recently released, Shazam discovery decreases by 8.7 ($p < 0.01$), a 8.7% reduction, relative to songs by Sony and Warner. The 95% confidence interval of the difference of -202.3 is (-385.2, -19.3) and is significantly different from zero at p-value < 0.05.

D.2 Popularity of Songs on TikTok

We find the effect of Universal's withdrawal from Titkok on Spotify streams and Shazam searches is more pronounced for Universal songs that previously were present in a particularly large number of TikTok videos, that is, more popular on TikTok, relative to songs that were present in fewer videos on TikTok. We check the robustness of these results by using different cut-offs to classify songs that are the most popular on TikTok. Table D3 shows the results. Column (1) shows our results are robust if we classify songs in the top 10% of the distribution of the number of videos on TikTok as being the most popular. Column (2) shows our results continue to hold if, instead, we classify songs in the top 20% of the distribution of the number of videos on TikTok as being the most popular. Column (4) shows the results are

Table D2: Effect on discovery via Shazam by recency of release

	(1)	(2)	(3)	(4)
	Recent (<= 1 months)	Not recent (> 1 months)	Recent (<= 3 months)	Not recent (> 3 months)
Treatment x After	-699.68***	-8.89**	-211.10***	-8.74***
	(256.03)	(3.87)	(64.02)	(3.22)
Song F.E	Yes	Yes	Yes	Yes
Week F.E.	Yes	Yes	Yes	Yes
Universal Pre-Treatment Mean	1,905.83	105.25	946.78	100.73
Observations	1,630	444,640	5,550	440,720

Notes: The table presents estimates of Universal songs' discovery via Shazam after the exit from TikTok, relative to Sony and Warner songs, based on the recency of release of songs. "Recent (<= 1 months)" refers to songs released after November 30, 2023. "Not recent (< 1 months)" refers to songs released on or before November 30, 2023. "Recent (<= 3 months)" refers to songs released after September 30, 2023. "Not recent (< 3 months)" refers to songs released on or before September 30, 2023. TAnalysis uses Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as the control group. Clustered standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

only marginally significant if we classify songs in the bottom 20% as being less popular.[20]

Table D3: Effect on number of Spotify streams by popularity on TikTok

	(1)	(2)	(3)	(4)
	>=90 pct	>=80 pct	>=70 pct	<20 pct
Treatment x After	-4467.99**	-2608.22***	-1822.52***	-442.93*
	(1883.58)	(994.14)	(611.69)	(256.82)
Song F.E	Yes	Yes	Yes	Yes
Week F.E.	Yes	Yes	Yes	Yes
Universal pre-treatment mean	147,688.80	98,843.53	73,085.74	8581.04
Observations	59,360	118,720	178,090	162,050

Notes: The table presents estimates of Universal's Spotify streams after the exit from TikTok, relative to Sony and Warner songs, based on the popularity on TikTok. ">=90 pct" refers to the top 10% most popular songs on TikTok based on the number of TikTok videos. ">=80 pct" refers to the top 20% most popular songs on TikTok based on the number of TikTok videos. ">=70 pct" refers to the top 30% most popular songs on TikTok based on the number of TikTok videos. "<20 pct" refers to the bottom 20% most popular songs on TikTok based on the number of TikTok videos. Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 is the control group. Clustered standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table D4 shows the results for Shazam search follow a similar pattern.

[20]During the week preceding Universal's withdrawal from TikTok, 27% of Universal's songs already had 0 videos on TikTok. Hence, the bottom 20% segment are all the songs in the bottom 27%.

Table D4: Effect on discovery via Shazam by popularity on TikTok

	(1) >=90 pct	(2) >=80 pct	(3) >=70 pct	(4) <20pct
Treatment x After	-59.08***	-36.48***	-27.18***	-9.33
	(16.75)	(8.14)	(6.15)	(6.19)
Song F.E	Yes	Yes	Yes	Yes
Week F.E.	Yes	Yes	Yes	Yes
Universal pre-treatment mean	511.75	342.42	254.92	91.30
Observations	48,210	94,860	141,100	125,610

Notes: The table presents estimates of Universal songs' discovery via Shazam after the exit from TikTok, relative to Sony and Warner songs, based on the popularity on TikTok. ">=90 pct" refers to the top 10% most popular songs on TikTok based on the number of TikTok videos. ">=80 pct" refers to the top 20% most popular songs on TikTok based on the number of TikTok videos. ">=70 pct" refers to the top 30% most popular songs on TikTok based on the number of TikTok videos. "<20 pct" refers to the bottom 20% most popular songs on TikTok based on the number of TikTok videos. Analysis uses Sony and Warner songs that were used in TikTok videos from November 24, 2023, to February 1, 2024 as the control group. Clustered standard errors are in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$