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

Mimansa Bairathi, Anja Lambrecht, Anita Rao

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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

*Mimansa Bairathi is Assistant Professor of Marketing at University College London (email: *m.bairathi@ucl.ac.uk*). Anja Lambrecht is Professor of Marketing at London Business School (email: *alambrecht@london.edu*). Anita Rao is Asssociate Professor of Marketing at Georgetown University (email: *anita.rao@georgetown.edu*).

1 Introduction

Social media, in addition to connecting users online, allows 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 hurts 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 allows users to find content they would otherwise not have been exposed to.

Understanding whether social media substitutes or complements 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.[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] See IFPI (2024). 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 that were available on TikTok by Universal artists, 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's withdrawal on those songs in its portfolio that were being used in TikTok videos. Therefore, we focus on the average treatment effect on the treated (ATT) rather than the effect of Universal's withdrawal on its overall portfolio of music, a share of which had not been used in TikTok videos.

We find negative short-run spillover effects: streams of Universal songs on Spotify dropped by 552.9 (2.2%), on average, relative to the control group. 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 in both magnitude and significance to our main estimation.

Our results suggest withdrawing songs from TikTok leads to a drop in streams on Spotify. We propose that this reduction might 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, more consumers become aware of individual songs and become more likely to listen to these songs on streaming platforms such as Spotify. Anecdotal evidence suggests TikTok has become a channel for discovery (Times, 2024; Whateley, 2024) and '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.

Our results suggest withdrawing songs from TikTok leads to a drop in streams on Spotify. At the same time, the 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 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 using songs released within one or three months.

Second, if discovery on TikTok is indeed an important driver of streams on Spotify, we should see a disproportionately high impact on Universal songs that previously were present in a particularly large number of TikTok videos. The reason is that these songs are more likely to have received substantial exposure on TikTok; therefore, the song's 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 less popular during that period. We document that songs that are more popular suffer significantly more than songs that are less popular on TikTok. For songs more 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%. The respective effects on less popular songs were not significant. This result is robust to using different cutoffs 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.

Our paper is most closely related to Winkler et al. (2024) who study the spillovers of TikTok using the same exogenous event. Our paper differs in four respects. First, we evaluate spillovers to the largest music streaming platform, Spotify, worldwide while their paper observes streams aggregated across platforms for a sample of users in the US and Germany. Second, our analysis focuses only on songs that were available on TikTok during the ten weeks prior to Universal withdrawing its licenses from TikTok while Winkler et al. (2024) account for all songs. Thus, while we identify an average treatment effect on the treated, they focus on an intent to treat effect. This may explain why we find a decrease in streams on Spotify while they document an increase. Third, we additionally measure spillover effects to Shazam which allows us to point to discovery as an important mechanism. Fourth, we further observe the number of TikTok videos using individual songs. This feature of our data enables us to construct alternate control groups and allows us to stratify our results based on a song's popularity on TikTok which provides additional evidence for the importance of discovery on social media.

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. 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 on other platforms. For digital platforms such as Spotify, our results suggest consumption 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[3] 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.[4] TikTok allows users to create, 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.

[3] `https://newsroom.spotify.com/company-info/`
[4] `https://backlinko.com/tiktok-users`

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. Importantly, in our context, a focus on the ATT, rather than on the ATE, does not imply some units that should have been treated were not treated

because of selection effects. Instead, in our setting, the ATT is more informative than the ATE for two reasons.

First, Universal's withdrawal from TikTok only affected 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. Indeed, 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, for record labels, platforms, and artists, understanding the impact of social media platforms on the consumption of music that is used on these social media platforms is more important than the overall portfolio of music of the record label.

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 (details on the window in section 2.3).

We use two alternative control groups. First, we use songs by artists managed by Sony and Warner, or labels owned by them, that similarly were present on TikTok in at least a single video on TikTok in a specific time window. This approach has the advantage that these songs are similar to the treated Universal songs in their pre-treatment TikTok presence. At the same time, 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 the control group songs by artists managed by Sony and Warner, or labels owned by them, that were not present on TikTok during our observation period but were present on TikTok prior to that period. Because these songs were not present on TikTok, they were by definition not used to substitute for Universal songs removed from TikTok. In other words, because these songs were not used by TikTok creators in our observation window, 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 across various platforms. 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, label information. per song. 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.[5]

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.[6] Because these songs were not used by TikTok creators

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

[6]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

in 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 8, 2024.[7] 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.[8]

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.[9] Importantly, for songs 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 clearly linked 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

day of data collection. We extracted this list on March 3, 2024.

[7]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 8, 2024.

[8]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.

[9]`https://www.warnerrecordedmusic.com/labels-and-distribution/`, `https://www.sonymusic.com/labels/`, `https://www.universalmusic.com/labels/`, `https://www.universalmusic.com/labels/global/`. Accessed April 2024.

this is not the case.[10] This process results in a total of 69,945 songs. We then follow the same process to aggregate the number of times a song was identified on Shazam on a weekly level.

We then 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 is likely due to a subsequent withdrawal on February 27, 2024, where even 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. Our results are robust to including these songs in our analysis.[11] 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 1 shows that after TikTok withdrew Universal songs, the average number of TikTok videos per song in our sample dropped significantly and reached zero two weeks later.[12] To verify that the number of TikTok videos do not disproportionately belong to just a few songs, we also plot in Figure 2 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 1 and Figure 2 confirm that, indeed, the sudden withdrawal of Universal music from TikTok resulted in Universal

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

[11]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.

[12]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.

songs no longer being available and validate our empirical design is appropriate.

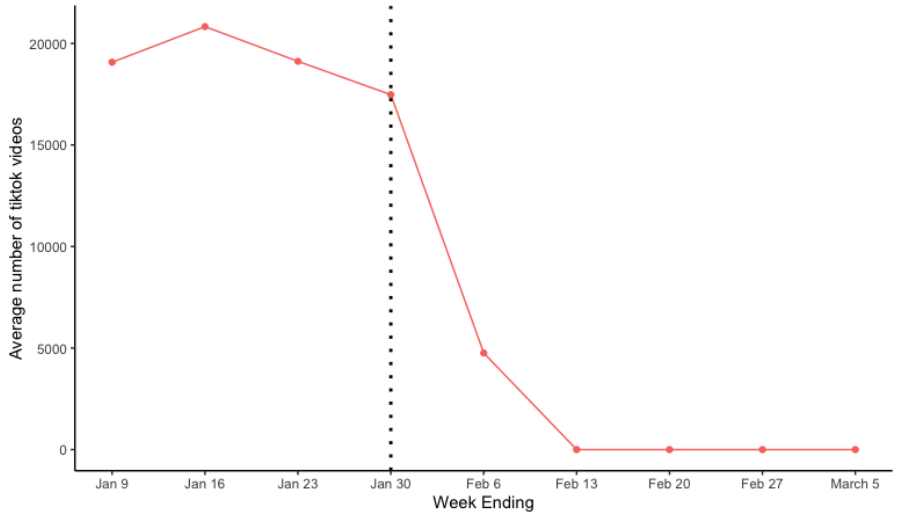


Figure 1: Average number of Universal's TikTok videos

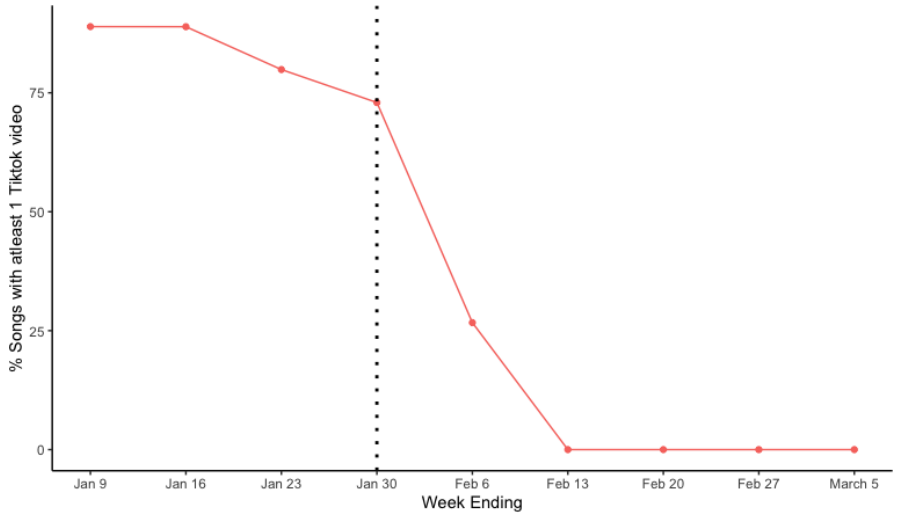


Figure 2: Proportion of Universal's songs with at least one TikTok video

Table 1 reports the summary statistics for the data. Panel A shows the 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. Finally, the Sony and Warner songs not present on TikTok during the past 90 days, are played frequently on Spotify.

Panel B shows the average daily discovery on Shazam for songs 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, including that a user would discover a song only once but listen to it many times, and that even 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 8, 2024. Given heterogeneity across songs, using a straightforward DiD estimation is difficult. Instead, we rely on the synthetic DiD (SDiD) approach (Arkhangelsky et al., 2021). The SDiD method 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:

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

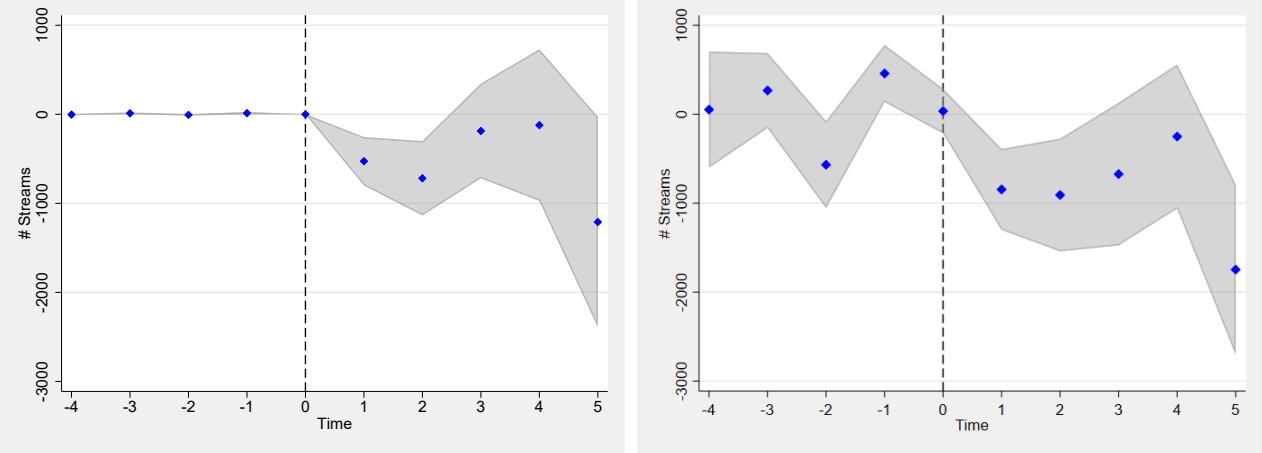
where the outcome of interest Y_{it} is average daily streams on Spotify for song i in week t. We include song fixed effects α_i. Song characteristics such as artist, genre, persistent popularity, and any time-invariant differences across songs are accounted for via α_i. We also include week fixed effects with γ_t to control for common 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.

3.2 Effect on Spotify Streams

We present our results in both Figures 3 and Table 2. First, Figure 3 shows the event-study plots of the SDiD treatment effects using our two sets of control groups. The first control group (Figure 3a) uses Sony and Warner songs that were present on TikTok. The second (Figure 3b) uses Sony and Warner songs that were not present on TikTok. 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 3(a), all pre-treatment estimates contain zero in their confidence intervals, providing evidence for the parallel-trends assumptions. In Figure 4(b), again all pre-treatment estimates except the two pre-treatment periods contain zero in their confidence intervals. However, in both cases (including Figure 3(b)), 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.[13]

Figure 3: 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 as control. Figure (b) uses Sony and Warner songs that were not used in TikTok videos as control.

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 ($p < 0.01$). This amount translates

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

into a 2.2% decrease in average daily streams. Column (2) demonstrates our results are robust to using the second control group. 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 ($p < 0.01$).

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: "Songs present on TikTok" refers to Universal, Sony, and Warner songs used in TikTok videos from November 24, 2023, to February 1, 2024. "Songs not present on TikTok" refers to Universal, Sony, and Warner songs not used in TikTok videos from December 4, 2023, to March 3, 2024. The dependent variable is the # of Spotify streams. 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 as control. Column (2) uses Sony and Warner songs that were not used in TikTok videos as control. Clustered standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Our result that Universal's withdrawal from TikTok led to a decrease in music consumption of Universal songs on Spotify suggests the significance of spillover effects from social media platforms such as TikTok on music consumption on other digital platforms.

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 this drop in Spotify streams is due to the removal of music from TikTok increasing 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 for whether, indeed, the spillover effects we observe may relate to song discovery, we leverage data on song discovery on the music-discovery app Shazam. Because Shazam allows consumers to identify songs they were previously not or little aware of, usage of Shazam directly measures music discovery (Aguiar and Chen, 2024).

To examine whether Universal's withdrawal from TikTok affected music discovery, we use the SDiD method to quantify the effect of Universal's exit on song discovery via Shazam.[14] 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.

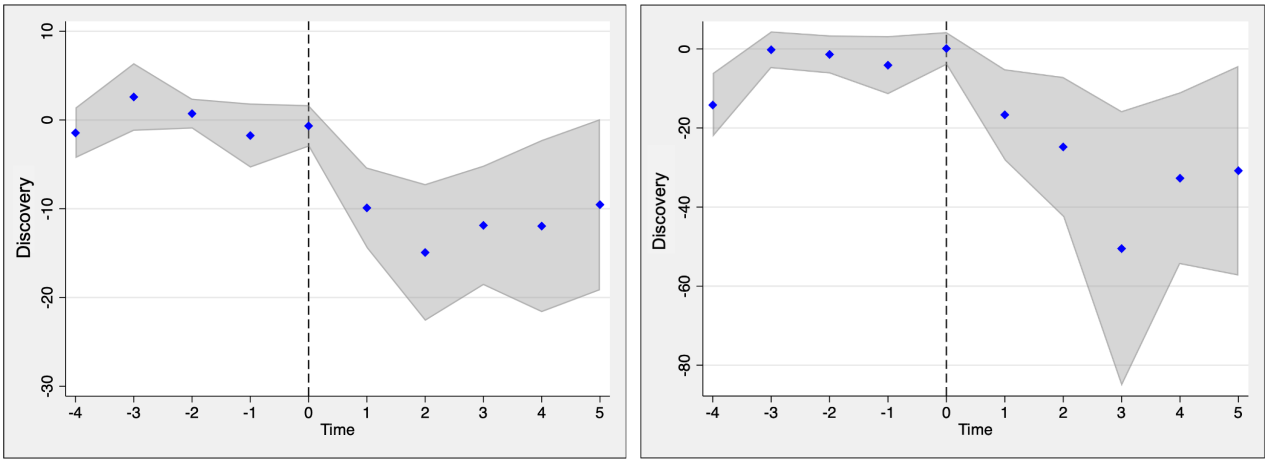
We present our results in both Figure 4 and Table 3. First, Figure 4 shows the event-study plots of the SDiD treatment effects using our two sets of control groups. The first control group (Figure 4a) uses Sony and Warner songs that were present on TikTok. The second control group (Figure 4b) comprises 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 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. Moreover, in Figure 4(a), all pre-treatment estimates contain zero in their confidence intervals, providing evidence for the parallel-trends assumptions. In Figure 4(b), again all pre-treatment estimates except the first estimate contain zero in their confidence intervals. However, the weight assigned by SDiD to the first pre-treatment period in Figure 4(b) is zero, which means observations from this period are not used in the SDiD estimation. 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.

We next 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

[14]Here, 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 B in Online Appendix.

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 ($p < 0.01$).

Figure 4: 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 as control. Figure (b) uses Sony and Warner songs that were not used in TikTok videos as control.

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.

3.4 Robustness Checks

To further test for the robustness of these 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, in our analysis, we include

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

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 against the two control groups if we remove from our analysis songs classified by ChatGPT. We find our results are robust to the exclusion of songs classified by ChatGPT. Column (1) shows that as a result of Universal's withdrawal from TikTok, Spotify streams of Universal songs decrease by 581.3 relative to the control group of Sony and Warner songs ($p < 0.01$), a 2.2% decrease. Column (2) demonstrates the average number of Spotify streams of a Universal song decreases by 1080.1 relative to the control group of Sony and Warner songs not present on TikTok ($p < 0.01$). Columns (3) and (4) demonstrate these results are also robust to the inclusion of Universal songs not removed from TikTok after Universal's withdrawal in our analysis.

Table 5 shows robustness tests for the effect on discovery on Shazam. Columns (1) and (2) show the results for discovery on Shazam against 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. Further, we find the results for Shazam discovery are also robust to including Universal songs that TikTok did not remove after Universal's withdrawal of its

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. "Songs present on TikTok" refers to Universal, Sony, and Warner songs used in TikTok videos from November 24, 2023, to February 1, 2024. "Songs not present on TikTok" refers to Universal, Sony, and Warner songs not used in TikTok videos from December 4, 2023, to March 3, 2024. The dependent variable is the # of Spotify streams. 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 as control. Columns (3) and (4) use Sony and Warner songs that were not used in TikTok videos as control. Clustered standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

licences (columns (3) and (4)).

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. "Songs present on TikTok" refers to Universal, Sony, and Warner songs used in TikTok videos from November 24, 2023, to February 1, 2024. "Songs not present on TikTok" refers to Universal, Sony, and Warner songs not used in TikTok videos from December 4, 2023, to March 3, 2024. The dependent variable is discovery via Shazam. 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 as control. Columns (3) and (4) use Sony and Warner songs that were not used in TikTok videos as control. Clustered standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Overall, the effects we find on streams on Spotify and discovery on Shazam are similar 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.[15] 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 is 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 ($p < 0.01$), a 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 C1 and C2 in Online Appendix C.1).[16]

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

[16] 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 # of Spotify streams, and in columns(3) and (4), is is the # of times a song was discovered on 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. Analysis uses Sony and Warner songs that were used in TikTok videos serves 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 to see 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 most popular on TikTok and songs in the bottom 30th percentile as being less popular.

Column (1) of Table 7 shows that for the most 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. However, we do not detect a significant decrease in discovery via Shazam for songs that are not very popular on TikTok. The difference of 18.4 between the most and the least 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 C3 and C4 in Online Appendix C.2).[17]

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

	Spotify streams		Shazam discovery	
	(1)	(2)	(3)	(4)
	Most popular	Not popular	Most 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
Universal pre-treatment mean	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 # of Spotify streams. In columns(3) and (4), it is the # of times a song was identified on Shazam. "Most 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 as the control group. Clustered standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

These results further support the assertion that social media platforms play an important role in helping users discover music.

[17]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, which might have spillover effects on the consumption on other platforms. Our paper investigates the spillover effects of music consumption on TikTok on consumption on other music streaming platforms such as Spotify. Relying on Universal's withdrawal of licensing from TikTok at the end of January 2024 to causally study the impact on music consumption on Spotify, we find a short-run decrease in streams of Universal's songs on Spotify.

Furthermore, we find that, following Universal's withdrawal from TikTok, content discovery on Shazam—a popular music discovery app—decreases. This decrease speaks to the mechanism of why spillover effects might occur: via reduced music discovery. Heterogeneity along two dimensions further speaks to the role of discovery as an important mechanism for music consumption. More recent songs, and songs that are featured in more TikTok videos, are impacted the most. Throughout, our results suggest social media platforms such as TikTok aid music discovery and have positive spillover effects on other platforms.

Our paper has some limitations. First, although the removal of Universal music from TikTok represents an exogenous shock to consumers, we are unable to ascertain whether Universal implemented mitigating measures. If it did, 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, we are unable to track the behavior of individual users across TikTok, Spotify, and Shazam. Hence, the results on Shazam discovery are only indicative of the discovery mechanism. Fourth, Spotify might have adjusted its algorithm to Universal's exit from TikTok, in which case, we underestimate the true effect of removing content from TikTok. Finally, music consumption on Spotify is not fully driven by users actively searching for songs. Hence, for streaming platforms that rely more on users searching for songs more actively, the effects might be more pronounced. 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 knowledge about spillovers across platforms.

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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 3 and 4) 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 aggregate 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

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

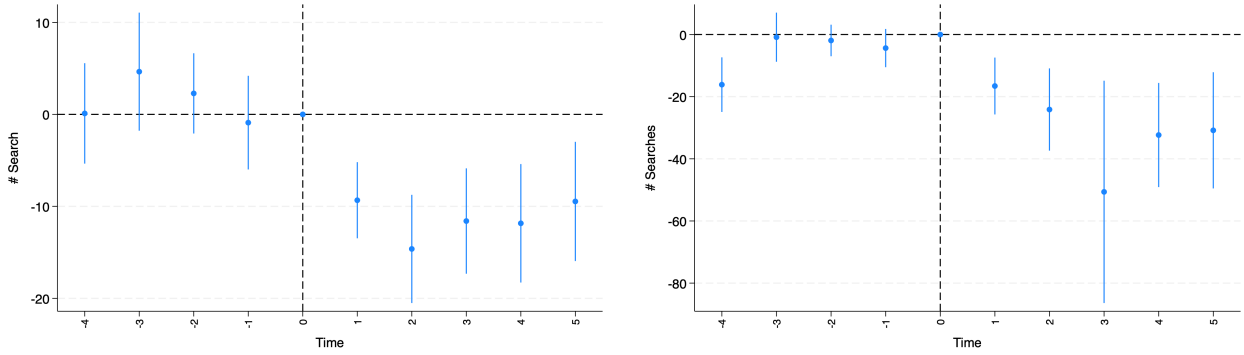
. Based on these figures, the event study plots the quantities defined in equation (A1). Finally, to calculate the confidence intervals, we use a block bootstrap procedure. In each iteration, the quantity in equation (A1) is re-calculated for each week t. Finally, the confidence interval for each quantity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

B Effect on Shazam Searches Using DiD

We quantify the effect of Universal's withdrawal from TikTok on the number of Shazam searches using a difference-in-difference method. Since DiD relies on the parallel trends assumption pre-treatment, we present the event study coefficient estimates with 95% confidence intervals in Figure B1 using our two sets of control groups. The first control group (Figure B1a) uses Sony and Warner songs that were present on TikTok. The second control group (Figure B1b) comprises Sony and Warner songs that were not present on TikTok. The vertical blue line represents the 95% confidence intervals. In Figure 4(a) all pre-treatment

estimates contain zero in their confidence intervals providing evidence for the parallel trends assumptions. In Figure 4(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 towards 0 in later periods.

Figure B1: 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 as control. Figure (b) uses Sony and Warner songs that were not used in TikTok videos as control.

We next quantify the magnitude of the decline in Table B1 using the same two control groups (columns (1) and (2) respectively). Table B1, 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 translates into a 11.5% decrease. Column (2) confirms that 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 B1: 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: 'Songs present on TikTok' refers to Universal, Sony, and Warner songs used in TikTok videos from November 24, 2023 to February 1, 2024. 'Songs not present on TikTok' refers to Universal, Sony, and Warner songs not used in TikTok videos from December 4, 2023 to March 3, 2024. Dependent variable is # times a song was identified on Shazam. Table presents estimates of Universal's discovery 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 as control group. Column (2) uses Sony and Warner songs that were not used in TikTok videos as control group. Clustered standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

C Heterogeneity Robustness

C.1 Recency of Songs

Our findings demonstrate that songs that have more recently been released, measured as songs released in the 2 months preceding the observation window, suffer more since discovery is particularly important in driving streams of such songs. We check the robustness of these results by using different cut-offs to classify songs that have been released recently. Columns (1) and (2) of Table C1 show the results if we classify songs which were released in the previous 1 month prior to our observation period i.e. released after November 2023 as recent and songs released before that 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 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 C1 show the results if we classify songs which were released in the previous 3 months prior to our observation period i.e. released after September 2023 as recent and songs released before that as not recent. We find 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 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 C2 shows the results for Shazam searches are also robust to using different cutoffs

Table C1: 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: Dependent variable is # Spotify streams. '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. Table presents estimates of Universal's Spotify streams after the exit from TikTok, relative to Sony and Warner songs for based on the recency of release of songs. Analysis uses Sony and Warner songs that were used in TikTok videos as control group. Clustered standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

to classify songs as being recent. Columns (1) and (2) show the results if we classify songs which were released in the previous 1 month prior to our observation period i.e. released after November 2023 as recent and songs released before that 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 that 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 which were released in the previous 3 months prior to our observation period i.e. released after September 2023 as recent and songs released before that as not recent. We find 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.

C.2 Popularity of Songs on TikTok

We find that 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 which were present in fewer videos on TikTok. We check the robustness of these results by using different cut-offs to classify songs that are most popular on TikTok. Table C3 shows the results. Column (1) shows that our results are robust if we classify songs in the top 10 percentile of the distribution of the number of videos on TikTok as being most popular.

Table C2: 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: Dependent variable is # times a song was discovered on Shazam. '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. Table presents estimates of Universal songs' discovery via Shazam after the exit from TikTok, relative to Sony and Warner songs for based on the recency of release of songs. Analysis uses Sony and Warner songs that were used in TikTok videos as control group. Clustered standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Column (2) shows that our results continue to hold if, instead, we classify songs in the top 20 percentile of the distribution of the number of videos on TikTok as being most popular. Column (4) shows that the results are only marginally significant if we classify songs in the bottom 20 percentile as being less popular.[18]

Table C3: 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: Dependent variable is # Spotify streams. '>=90 pct' refers to the top 10% most popular songs on TikTok based on number of TikTok videos. '>=80 pct' refers to the top 20% most popular songs on TikTok based on number of TikTok videos. '>=70 pct' refers to the top 30% most popular songs on TikTok based on number of TikTok videos. '<20 pct' refers to the bottom 20% most popular songs on TikTok based on number of TikTok videos. Table presents estimates of Universal's Spotify streams after the exit from TikTok, relative to Sony and Warner songs for based on the popularity on TikTok. Analysis uses Sony and Warner songs that were used in TikTok videos as control group. Clustered standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C4 shows that the results for Shazam search follow a similar pattern.

[18]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 C4: 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: Dependent variable is # times a song was discovered on Shazam. '>=90 pct' refers to the top 10% most popular songs on TikTok based on number of TikTok videos. '>=80 pct' refers to the top 20% most popular songs on TikTok based on number of TikTok videos. '>=70 pct' refers to the top 30% most popular songs on TikTok based on number of TikTok videos. '<20 pct' refers to the bottom 20% most popular songs on TikTok based on number of TikTok videos. Table presents estimates of Universal songs' discovery via Shazam after the exit from TikTok, relative to Sony and Warner songs for based on the popularity on TikTok. Analysis uses Sony and Warner songs that were used in TikTok videos as control group. Clustered standard errors in parentheses.

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