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Did the COVID-19 Pandemic trigger nostalgia? Evidence of Music Consumption on Spotify

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By scraping data of almost 17 trillion plays of songs on Spotify in six European countries, this work provides evidence that the lockdown imposed in the midst of the COVID-19 pandemic significantly changed the music consumption in terms of nostalgia. This work constructs a binary measure of nostalgia consumption of music and employs country-specific logistic regressions in which lockdown is taken as a treatment that interacts with a quadratic trend. The lockdown altered the trend of nostalgia consumption upward, which peaked roughly 60 days after the lockdown. A placebo test shows that the upward turn of slope is not an annual pattern. On the other hand, COVID incidence rate does not provide significant additional explanatory power to the model. This work shows that Spotify's users react to the lockdown even when COVID incidence rate is low and the impact stays high even the incidence rate has peaked, suggesting that demand for nostalgia tends to respond to the drastic and lasting change caused by the lockdown rather than to the fluctuations in the viral infection.

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1 Introduction

A comment on Radiohead's 1995 classic *Fake Plastic Trees* YouTube video by an user Luiza Martins:

> "Who is listening to this song in quarantine against covid-19? :D"

attracted more than 2600 likes in four months time since April 2020. Many other examples could be found in other music videos.

Did the COVID-19 pandemic trigger widespread nostalgia? Nostalgia was considered as a form of melancholia or depression (McCann, 1941; Rosen, 1975). Gradually researchers move on to recognize the causes and the positive aspects of nostalgia. Researchers found that negative moods trigger nostalgia and nostalgia induces positive affects (Wildschut et al., 2006), while sadness predicts nostalgia (Barrett et al., 2010). Given its scale and the adverse socio-economic impact caused (Martin et al., 2020), it is natural to hypothesize that the COVID-19 pandemic induced a widespread nostalgic feeling.

A crisis, either personal, national or global, certainly changes human behaviors and in particular consumption pattern. Women tend to consume more on beauty products during recessions, known as lipstick effect in consumer psychology that could be explained by mating and professional motives (Hill et al., 2012; Netchaeva and Rees, 2016). Unemployment is found to correlate with heavier alcohol and drug consumption (Layne and Whitehead, 1985; Janlert and Hammarström, 1992; Power and Estaugh, 1990; Henkel, 2011), though Catalano et al. (2011) challenged and claimed that the answer remains mixed. Although music is often discussed and consumed alongside alcohol, the academic literature is silent on the change in music consumption during a time of difficulty. If alcohol consumption is considered as a remedy, music could also take this role. Drinking is arguably an effective way to forget the present difficulties, to avoid dealing with current problems and to keep one's world isolated from others. Music could also achieve partially these goals. Music of the past can in addition bring in nostalgia or reminiscence that contributes to certain healing effects (Barrett et al., 2010; Lazar et al., 2014). Music therapy aiming at evoking nostalgia has been shown effective towards patients of dementia (Glynn, 1992; Mills and Coleman, 1994; Beard, 2012).

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Nostalgia has long been a research topic in consumer psychology (Holbrook, 1993; Holbrook and Schindler, 2003; Sierra and McQuitty, 2007; Holak et al., 2007) and marketing strategies based on nostalgic feelings have been widely adopted (Unger et al., 1991; Russell, 2008; Cui et al., 2015). Hirsch (1992) suggested that by defining nostalgia as a yearning for an idealized past, nostalgia marketing induces displacement of idealized past emotions onto objects. Difficult times are thus the successful times for nostalgia marketing that alludes to a better past (Spaid, 2013).

The COVID-19 pandemic has undoubtedly altered consumers' consumption patterns (Hall et al., 2020; Baker et al., 2020) and affected heavily the consumption on cultural goods. Sim et al. (2020) studied the music consumption on Spotify of 60 countries and found that music consumption online had declined during the COVID-19 pandemic. Weed (2020) discussed the cancellation of sport events had led TV channels to replay matches in the past and discussed the potential restorative nature of such a form of lockdown nostalgia in supporting well-being during the lockdown. Gammon and Ramshaw (2020) discussed the role of nostalgia consumption during the COVID-19 pandemic. The current work is, to the best of the author's research, the first quantitative study of nostalgia consumption of music during the COVID-19 pandemic.

The pandemic manifests itself in many dimensions of our daily life. The viral infection is only the surface layer and in fact does not impact directly most of the population. Instead, the threat of the virus and the resulting distress has substantially changed the costs and benefits of our behaviors. Since some people were reluctant or not willing to comply to orders or to keep social distance, governments took actions to impose exceptional measures and even "locked down" a whole nation. Under a lockdown or a quarantine, people's freedom is heavily limited and physical interactions among people outside their close families are almost non-existent. For example, under the Belgian national lockdown order, citizens were required to stay at home and to go out of doors only for reasons deemed "essential".[1] Outdoor exercise was still allowed, provided that social distancing guidelines were upheld. Temporary police check points were set up to ensure that citizens complied with the rules. The measures adopted by Belgian authorities were, in several respects, less restraining than those enacted by neighboring countries. In France, citizens were required to sign a document attesting the reason for going out of doors

[1]Details of the measures can be found at https://www.belgium.be/en/news/2020/coronavirus_reinforced_measures.

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and were only permitted to roam within one kilometer of their home for an hour each day. Children in Spain were barred from leaving home for nearly two months. The scale of the lockdown is unprecedented. The lockdown and the viral infection should not be considered equivalent in determining human behaviors and estimations of their respective effects are the focus of the current work.

To quantify nostalgia seems to be a prohibitive challenge. This work measures nostalgia by an individual's music consumption on a popular music streaming platform *Spotify*. Spotify publishes daily charts of top 200 songs of different countries and, through its API, users can scrap the information of the tracks. Each song is associated with its release information on which this work arbitrarily classifies a song as a nostalgia consumption if the number of days since release is more than 1095 days (3 years).[2] Using COVID incidence rate and taking lockdown as a treatment that interacts with a quadratic trend, a logistic regression weighted by number of plays is employed to explain nostalgia consumption of music based on the information of the daily top 200 tracks over a period of seven months.

The current work finds that nostalgia consumption took a sharp upward change in the beginning of the lockdown and fell when time went on and COVID incidence rate does not significantly improve the model's explanatory power. This work aims to discover individuals' consumption preference on cultural goods, music in this particular case, and to provide evidence of nostalgic consumption during a time of widespread difficulty. Last but not least, this work points to a possible and relatively low-cost remedy in the time of the pandemic.

2 Data

Spotify is a Swedish music streaming platform, publicly traded in the NYSE through the holding company *Spotify Technology S.A.* Since 2008, Spotify has provided access to over 60 million songs on which users enjoy free service with advertisements. Paying subscribers, like Netflix users, pay a fixed monthly subscription fee and thus enjoy offline and advertisement-free listening. The company announced in July 2020 that active users reached 299 million whereas 138

[2]Results based on different definitions of nostalgia consumption, e.g. five years instead of three years, multiple levels of nostalgia, etc., are similar.

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million users are paying subscribers.[3][4] Number of plays is massive. Top 200 songs in the UK in total were played 20 million times on an average day in 2020.[5] Along with its rise in popularity, Spotify has increasingly drawn attention from the academia (Vonderau, 2019; Mähler and Vonderau, 2017; Meier and Manzerolle, 2019), thanks to its easy-to-use API data query system.

This work fixes the sample period between 1 January and 31 July 2020. The COVID-19 pandemic hit hard most of the European countries in March 2020 and in succession they went into certain forms of lockdown (or a less dramatic term: confinement). The peak of the first wave passed roughly in May and the situation improved significantly towards July. By the end of July, there were signs of a second wave.[6] The sample period is arguably sufficiently long to capture the initial shock and the subsequent adjustment back to the norm. This research relies on data of six European countries, namely, Belgium, France, Italy, Spain, Sweden and United Kingdom, involving almost 17 trillion of plays. These countries, except Sweden, had been under some forms of national lockdown from March to May. Some brief information on the lockdown is provided in Table 1. Although scraping data of some more countries is not a difficult or time-consuming task, this work limits itself to these six countries for two reasons. First, as readers will see in later sections, countries experienced very different music consumption patterns, not only in quantity but also in quality in terms of nostalgia level. Pooling countries into one single sample may not be an appropriate approach, though gathering more information and working with a panel of countries are possible. Second, big nations, for examples, the US, Canada and Australia, had experienced multiple outbreaks of COVID infection at different points of time within the nation and thus lockdown measures were not uniform across the nation. Spotify, on the other hand, does not provide regional consumption information. The misalignment of data aggregation level casts doubt on the validity of such an analysis. The six countries chosen include two heavily affected countries that went into lockdown relatively earlier, Italy and Spain, two less severely affected countries but also went into tight lockdown, France and Belgium, the UK, who reacted relatively later than others, and Sweden, who had not been into restrictive lockdown. Sweden is chosen in the hope that it could serve as a control country.

[3] https://newsroom.spotify.com/2020-02-05/spotify-reports-fourth-quarter-and-full-year-2019-earnings/

[4] https://www.bbc.com/news/technology-52478708

[5] Author's own computation

[6] https://www.bbc.com/news/av/uk-53568967/coronavirus-johnson-says-signs-of-a-second-wave-showing-in-europe

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Spotify publishes daily the top 200 mostly played songs of different countries along with their numbers of plays. Through its API, information on songs' release date is available. A song is defined as a nostalgia consumption if the number of days since release is larger than 1,095 (three years). Figure 1 illustrates the average nostalgia level of the daily top 200 songs of the six countries from 1 August 2018 to 31 July 2020, along with a red vertical line corresponding to the first lockdown day.[7] The average nostalgia level surges in Christmas time and rises gradually after the lockdown. Sweden sees another annual spike in nostalgia consumption of music on the Midsummer Day. To check if the rise during the lockdown is not a annual pattern, Figure 2 matches the average nostalgia level of 2020 and 2019 to the January-July period and shows that, while the case in Sweden is unclear, other countries recorded a higher average nostalgia level in the same period of 2020.

A very first challenge to any correlation between the pandemic and nostalgia consumption is that music companies may publish fewer songs during the pandemic because advertising may heavily be affected. If no hit new songs are supplied to the market, users may revisit older songs to satisfy their demand for music. Figure 3 illustrates the numbers of new tracks among the top 200, defined as released within 30 days before the day of observation, from January 2020 to July 2020, overlaid with the 7-day moving-average of daily new COVID-19 cases per million of population (incidence rate). Counts of daily new COVID-19 cases are collected from EU Open Data Portal.[8] Any fall in the number of new tracks among the top 200 does not perfectly reflect fewer releases of new songs as the chart is certainly endogenously determined. However, the three-year threshold that defines nostalgia consumption is sufficiently far from the day of the observation, any correlation between the pandemic and nostalgia consumption is thus not directly driven by number of new releases. Imagine a hypothetical day having no additional new release. Users' preference may remain unchanged and listen to the same songs so that the overall nostalgia level is the same. Only when people switch to older songs (more than 1,095 days) the overall average nostalgia level would go up. Still, fewer new releases may induce an indirect effect on nostalgia consumption because new songs occupy users' time that would have been consumed on nostalgic songs. Although number of new releases arguably fell together with a rise in COVID infection, whether it is causal is far from clear. Number of new releases seems to be low in the beginning of the year and gradually increases over the

[7]The red line of Sweden corresponds to the date of travel advice within the nation on 24 March.
[8]https://data.europa.eu/euodp/en/data/dataset/covid-19-coronavirus-data

first quarter. A subsequent adjustment possibly follows in the second quarter, coinciding with the rise in COVID infection. In the following regression analysis, the number of new tracks among the top 200 released within the past 30 days will always be included as a control variable.

Table 1: Lockdown Information

Country	Implementation Date	First Relaxation Date	Measures
Belgium	18 March	11 May	Restrictive Quarantine
France	17 March	11 May	Restrictive Quarantine
Italy	10 March	4 May	Restrictive Quarantine
Spain	14 March	11 May	Restrictive Quarantine
Sweden*	18 March	NA	Mild and Voluntary
United Kingdom	24 March	10 May	Restrictive Quarantine

*Sweden had no tight lockdown measures but social distancing and travel advices.

Another concern is about the compositions of users pre-lockdown and in-lockdown are different. Lockdown may draw new users to the platform, perhaps due to having more abundant free time, who tend to listen to older songs. While it is impossible to identify users, data, as shown in Figure 4, suggest that the pandemic caused music consumption to fall, consistent with the finding by Sim et al. (2020). While Belgium saw the number being stable, France, Italy and Spain recorded a dip in the beginning of the lockdown. In the meantime, Sweden and the UK followed their pre-lockdown downward trend. Spikes of plays during the Christmas time in Belgium, Sweden and the UK coincide with spikes in nostalgia consumption. Holiday effects seem to be present, which may then affect the average nostalgia consumption.

Based on the discussion above, any valid regression analysis should take into account seasonal patterns, issues of new tracks and total number of plays. Moreover, any effects of lockdown may not show up right at the beginning of the lockdown period, but gradually reflected by an upward trend.

3 Empirical Analysis

3.1 Empirical Strategy

The empirical analysis will rely on country-specific logistic regressions. Each play is a choice between a set of nostalgic songs (released more than 1,095 days before the day of observation,

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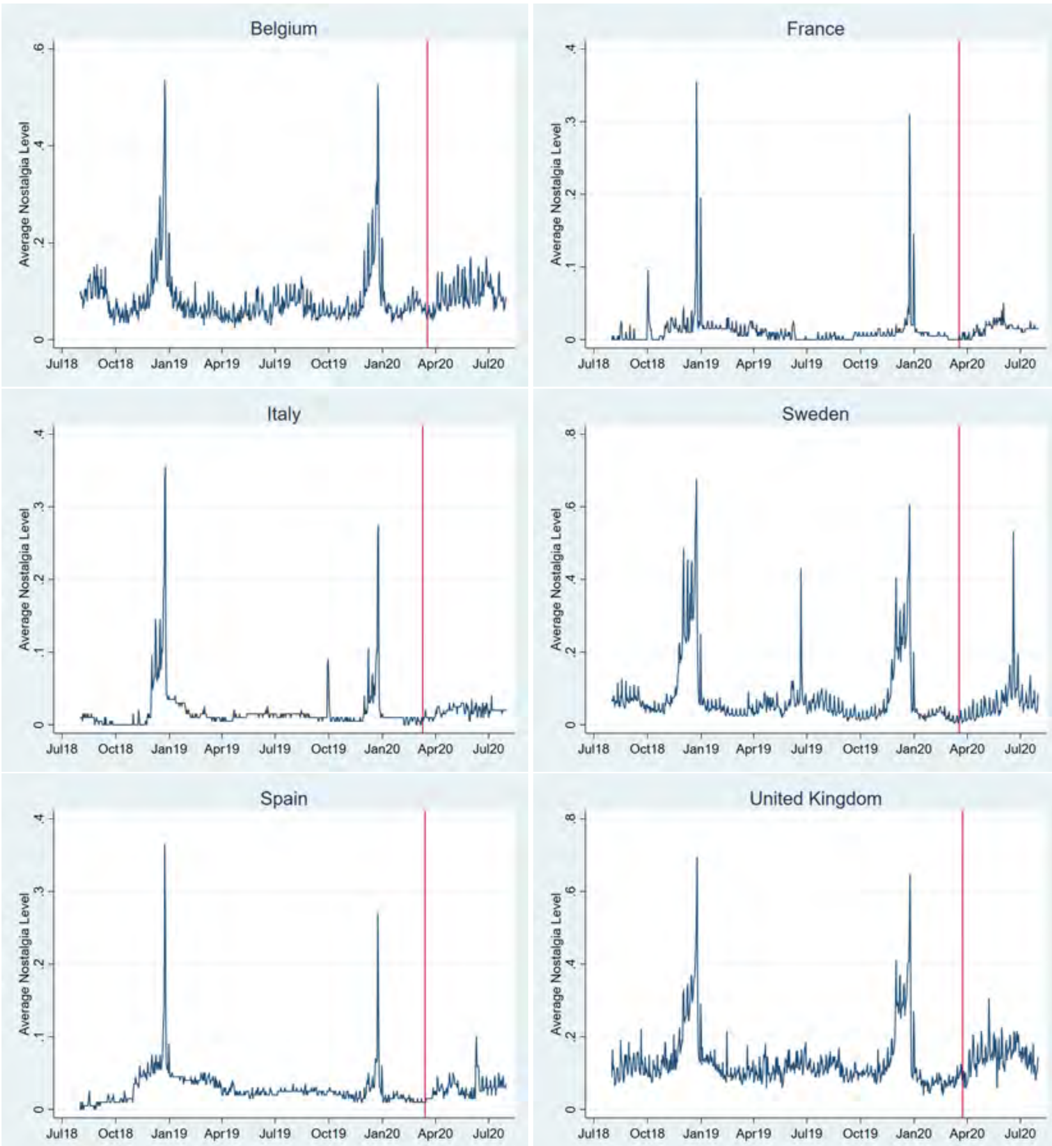
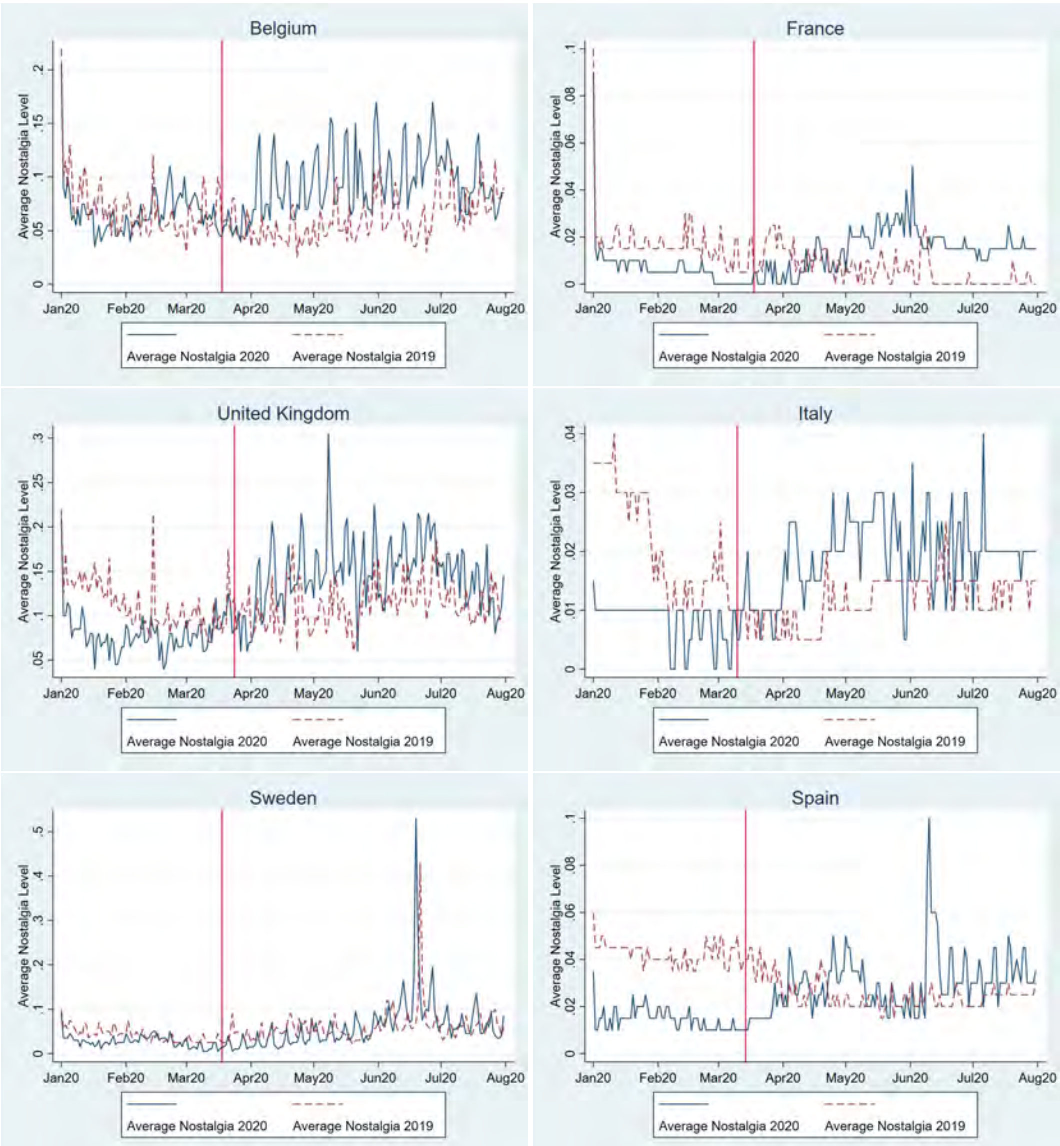
Figure 1: Nostalgia Level August 2018 - July 2020



t) and a set of new songs (released within 1,095 days before day t). The actual implementation is a logistic regression in which the dependent variable (nostalgia consumption = 1) weighted by number of plays. The main explanatory variable is the lockdown indicator (equals 1 if the lockdown implementation day $t^L \leq t$, and 0 otherwise). Note that the no ending date of the lockdown has been coded. The very first reason is that lockdown was gradually relaxed and

Figure 2: Nostalgia Level January 2020 - July 2020 compared to the same period of 2019



the degress of relaxation varies across countries. Secondly, lockdown was announced only a day before the actual implementation because the governments wanted to minimize choatic traffic as much as possible, but the relaxation in phases was announced a week or some weeks before the implementation. One would expect the lockdown induced a shock but the relaxation would only lead to gradual adjustment. As our model allows a quadratic trend during the in-lockdown

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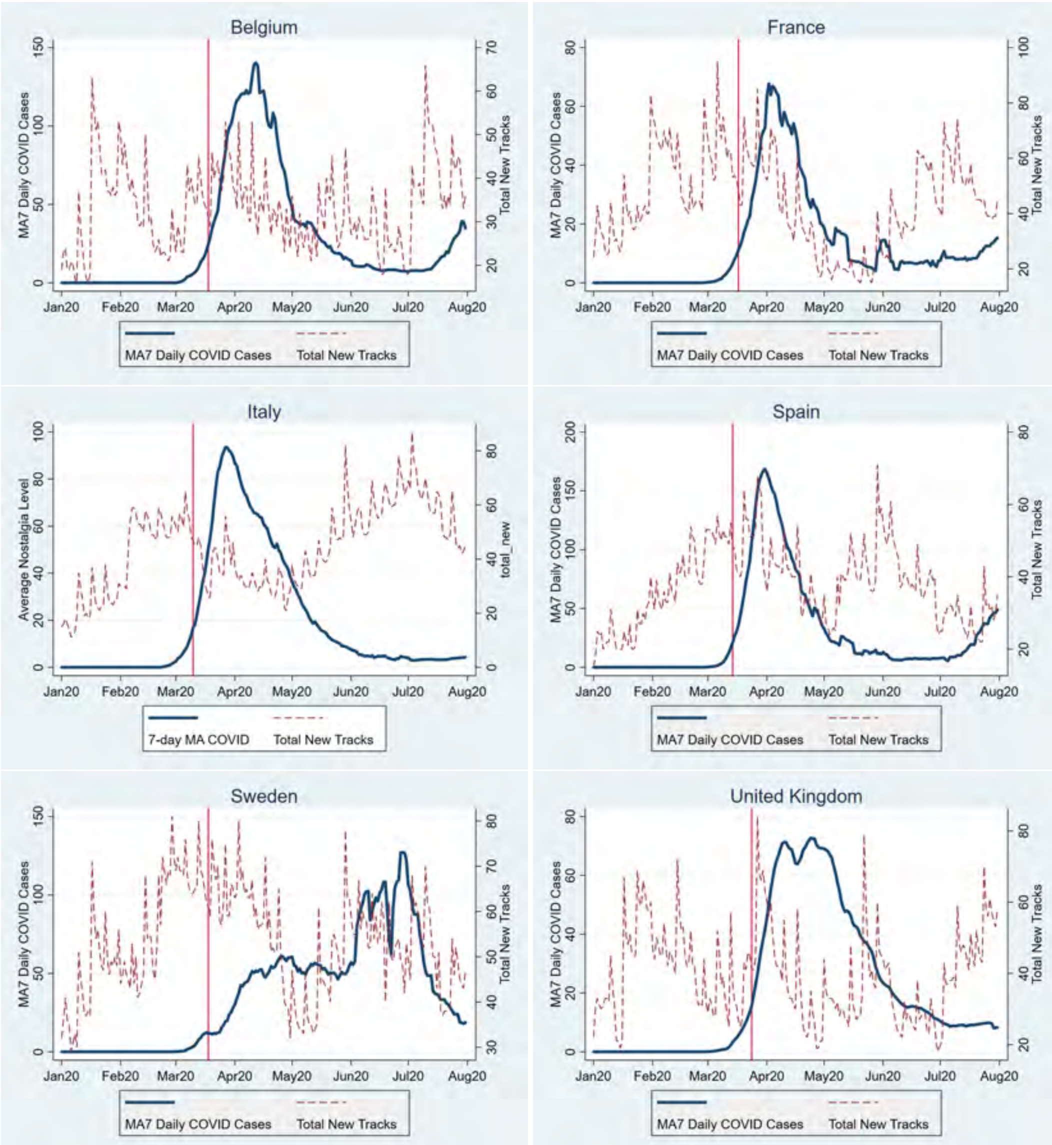
Figure 3: Numbers of New Tracks and COVID Infection, January 2020 - July 2020



period, it should be able to capture the non-linear variation from the beginning of the lockdown to the gradual relaxation towards June and July. Another explanatory variable of interest is the COVID incidence rate, which is precisely the natural logarithmic transformation of the 7-day moving-average of the number of daily new COVID cases per million of population.[9] This work

[9]The 7-day MA is computed by averaging the numbers of new COVID cases per million of the past six days and that of day t.

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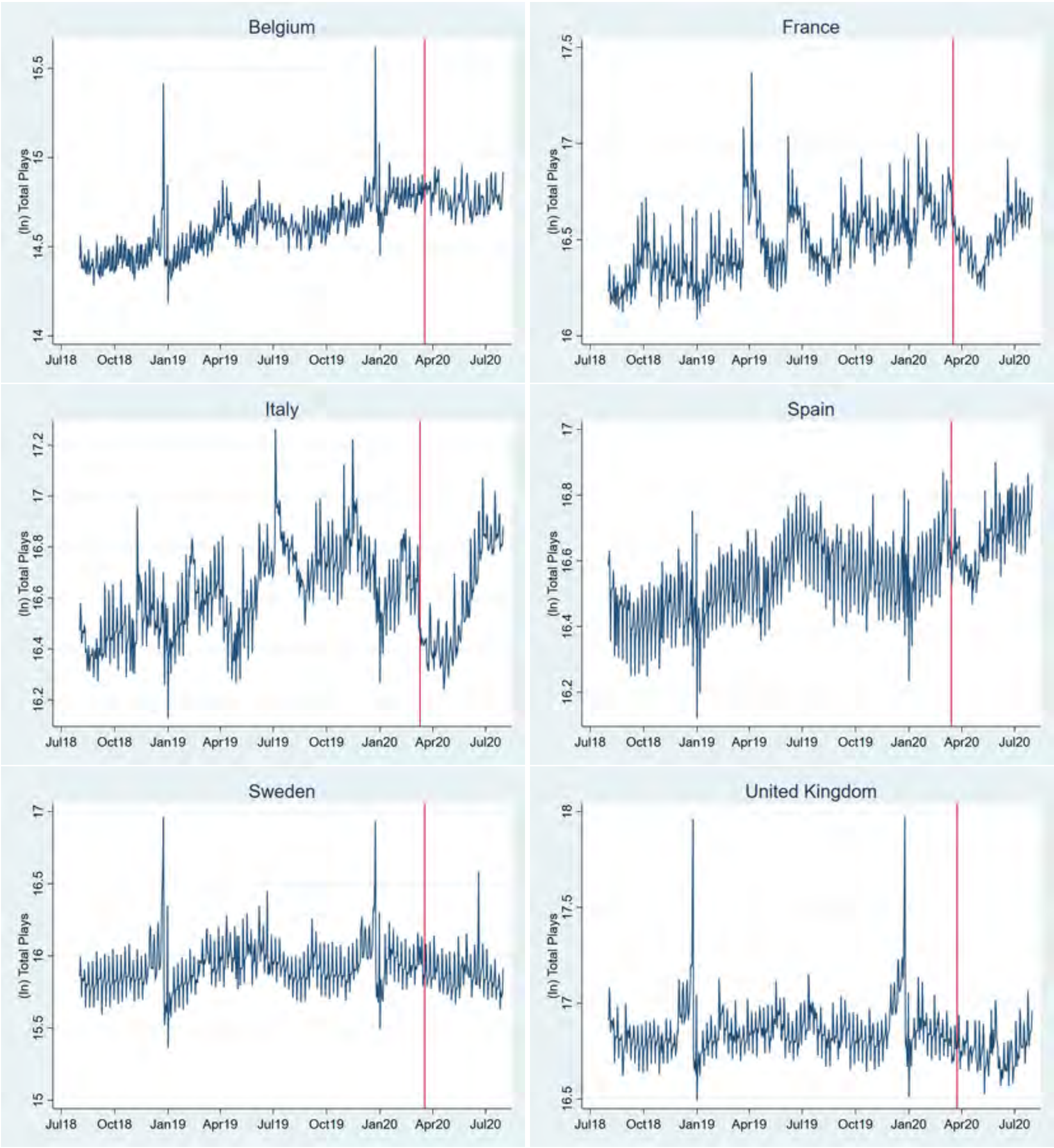
Figure 4: Daily (ln) Total Numbers of Plays, August 2018 - July 2020



employs equal-weighted 7-day moving average to measure daily COVID infection because it gives a better measure of how people perceive the pandemic and also corrects the reporting bias of weekends, holidays and some exceptional negative values (ex-post adjustments). The aim of the regression is to check if the lockdown causes the time trend to change its direction and check if on top of the trend component COVID infection provides additional explanatory power.

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To validate the result, this work proposes the following checks. First, we conduct 10-fold cross-validations to compare five different specifications (Zhang and Yang, 2015). Next, we check if the break of the slope of the trend at the first lockdown day could be defended as the true structural break. Point estimates and confidence intervals of the change in slope at 21 different supposed break points are compared side-by-side. The final check is a placebo test that imposes a hypothetical pandemic on the same period in 2019. The aim is to verify if the sharp change of trend at the break date is not merely an annual pattern. A no-result is thus a piece of evidence supporting that the pandemic indeed changed individuals' nostalgia consumption preference.

3.2 Logistic Regression

The empirical analysis relies on a logistic regression with standard errors clustered in days. The model employs a difference-in-difference approach where lockdown is considered as a treatment and the period since the lockdown is the treated sample. The main focus of the analysis is whether lockdown led to a change in nostalgia consumption preference revealed by changes in constant and slope. Denote the probability of an event $Y = 1$ (a nostalgia song being played) by p. The log-odds is thus:

$$\text{logit}(p) = ln\Big(\frac{p}{1-p}\Big)$$

We assume that the log-odds of $Y = 1$ is explained by a set of explanatory variables that includes a lockdown indicator and its interaction with a quadratic trend and 7-day moving-average of COVID incidence rate. The time variable t is centered at the first lockdown day. The log-odds is modelled as the following:

$$\begin{aligned}\text{logit}(p) &= \alpha_1 + \alpha_2 Lockdown_t + \beta_1 t + \beta_2 t^2 \\ &= +\beta_3 Lockdown_t t + \beta_4 Lockdown_t t^2 + \beta_5 COVID_t + \boldsymbol{x'}\gamma \end{aligned} \tag{1}$$

where the vector $\boldsymbol{x}$ includes the number of newly released songs, the log of total plays of the day, the average nostalgia level of the same day of 2019, the day of the week (Monday, Tuesday and so on), and five relatively more distinctive track features (acousticness, danceability, energy, liveness and valence). The inclusion of track features controls for the music trend of the day. For instance, users may have a preference of more acoustic music to other genres and they might only find the desired mood in old songs.

The logistic regression maximizes the following log-likelihood function:

$$l(\boldsymbol{\beta}) = \sum_{i}^{N} \Big[Y_i ln(p_i) + (1 - Y_i) ln(1 - p_i) \Big]$$

This research proposes the following hypotheses:

1. $\beta_3 > 0$. Lockdown sharply increased the slope.
2. $\beta_1 + \beta_3 \geq 0$ and $\beta_2 + \beta_4 \leq 0$. Nostalgia consumption increased in the beginning of the lockdown and fell when time went on.
3. $\beta_5 \geq 0$. Higher incidence rate induces more nostalgia consumption.

Hypotheses 2 and 3 may be valid simultaneously but may instead exclude one another. Lockdown period covers the days of severe infection, and thus two hypotheses may compete for significance.

Table 2 reports the coefficients of selected variables of the regression results of the six countries. Nostalgia consumption followed a general downward trend before the lockdown in all countries except the UK. A significant β_3 implies that the trend took a sharp turn at the lockdown implementation. Overall, we find support of Hypothesis 1. To better illustrate the evidence, Figure 5 shows the prediction of nostalgia consumption against numbers of days after lockdown. No incremental increase in nostalgia consumption right in the beginning of the lockdown, but it gradually rises and then falls towards the end of the sample period, consistent with Hypothesis 2. The peak is found roughly 80-100 days after the first day of the lockdown, coinciding roughly with the intermediate phase of relaxation in June. It also shows a stark difference from the counterfactual supposing that nostalgia consumption has followed the pre-lockdown trend. The UK actually exhibits a similar pattern. The relatively flat in-lockdown trend is a result of the impreciseness of the pre-lockdown trend that diminishes the scale. Besides, we find no evidence supporting an upward adjustment of the constant term (α_2), except in Spain.

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Table 2: Logit Regression: Baseline Results

	(1) BE	(2) FR	(3) IT	(4) ES	(5) SE	(6) UK
Pre-Lockdown						
time (β_1)	-0.0060	-0.1234***	-0.0162	-0.0267***	-0.0673***	0.0013
	(0.0048)	(0.0158)	(0.0182)	(0.0086)	(0.0195)	(0.0063)
time-sq (β_2)	-0.0001*	-0.0011***	-0.0002	-0.0004***	-0.0007**	0.00005
	(0.00006)	(0.0002)	(0.0002)	(0.0001)	(0.0003)	(0.0007)
in-Lockdown						
time (β_3)	0.0218***	0.1850***	0.0568***	0.0495***	0.0925***	0.0101*
	(0.0055)	(0.0211)	(0.0002)	(0.0140)	(0.0187)	(0.0055)
time-sq (β_4)	0.00001	0.0008***	-0.00001	0.0003***	0.0006**	-0.0001
	(0.00006)	(0.0002)	(0.0002)	(0.00009)	(0.0003)	(0.00009)
$\beta_1 + \beta_3$	0.0158***	0.0616***	0.0406***	0.0228***	0.0252***	0.0114***
$\beta_2 + \beta_4$	-0.0009***	-0.0003***	-0.0002***	-0.0001***	-0.0001**	-0.00006**
Lockdown	-0.0215	0.8815	-0.0981	0.7508**	-0.3358	-0.0290
	(0.0959)	(0.6066)	(0.3662)	(0.3612)	(0.3444)	(0.0980)
COVID	-0.0219	0.1154	-0.0110	-0.0018	0.4111***	0.0788*
	(0.0228)	(0.1313)	(0.1026)	(0.0749)	(0.1001)	(0.0437)
Total plays	0.2128*	-2.0539***	-0.7494*	-0.7303	3.097***	0.2078
	(0.4433)	(0.3749)	(0.3954)	(0.7209)	(0.4337)*	(0.4304)
New tracks	-0.0163***	-0.0125**	-0.0197***	-0.0149***	-0.0269****	-0.0173***
	(0.0017)	(0.0032)	(0.0044)	(0.0749)	(0.0032)	(0.0029)
Nostalgia 2019	4.262**	20.84***	-2.929	17.42	3.327***	1.031
	(1.970)	(2.730)	(8.400)	(11.76)	(0.9605)	(1.140)
Weekday FE	Yes	Yes	Yes	Yes	Yes	Yes
Track features	Yes	Yes	Yes	Yes	Yes	Yes
N	554123431	3373610349	3504103652	3588106348	1713501823	4166040525
Pseudo R2	0.1380	0.1305	0.0852	0.0722	0.2473	0.2068
log-likelihood	-94216643	-1.363e+08	-1.739e+08	-2.315e+08	-1.819e+08	-8.551e+08

Standard errors clustered in days in parentheses * $p < .1$, ** $p < .05$, *** $p < .01$

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As any significant (and insignificant) results could be driven by outliners, Figure 6 plots daily average values of residuals of a model that excludes the time trend and COVID indicence rate against time. The distribution of residuals across time shows what would be explained by the excluded time component and COVID. Roughly speaking, those residuals follow a downward trend before the lockdown and an upward trend after the lockdown, consistent with Hypothesis 2. Figure 7 zooms to the period between 1 February to 31 May to verify if the slope took a sharp change at around the lockdown date. While the case of Spain is unclear, other five countries tend to show some upward shift in slope.

COVID incidence rate is insignificant for Belgium, France, Italy and Spain in the baseline regressions. Its impact may well be absorbed by the change in trend due to the lockdown.[10] In Sweden where no hard lockdown has been imposed, COVID incidence rate is highly significant. One percentage point increase in the incidence rate is associated with an increase in the odds of nostalgia consumption by a factor of 1.5. Note that even Sweden had no tight lockdown measures, it was reported that mobility had decreased significantly within Sweden.[11] Despite that, further checks are necessary before pinning down the effect on nostalgia consumption of music.

Total number of plays are positive and significant in Belgium and Sweden, while negative and significant in France and Italy. These mixed evidence give no answer to the expectation that newly-joined users, may be drawn to Spotify due to the lockdown, tend to listen to older songs.

As shown in Figure 8, the peak of COVID incidence rate predates the peak of nostalgia consumption, except in Sweden. Lockdown broke the trend but the effect became full-blown after the peak had passed. Evidence so far suggest that users tend to react to the lockdown only gradually but COVID incidence fails to explain the rise and fall of nostalgia consumption. This conclusion is intuitive as people may not pay attention to the ups and downs of incidence rate while lockdown is a drastic, encompassing and exceptional measure that produced a lasting effect regardless the incidence rate.

[10] Regressions (not shown) removing any trend components show that COVID incidence rate is positive and significant for all six countries.

[11] http://press.telia.se/pressreleases/svenskarna-stannar-hemma-under-paasklovet-2990179

Figure 5: Prediction of Nostalgia Consumption with 95% CI: Illustrating Changes in Slope before and after Lockdown

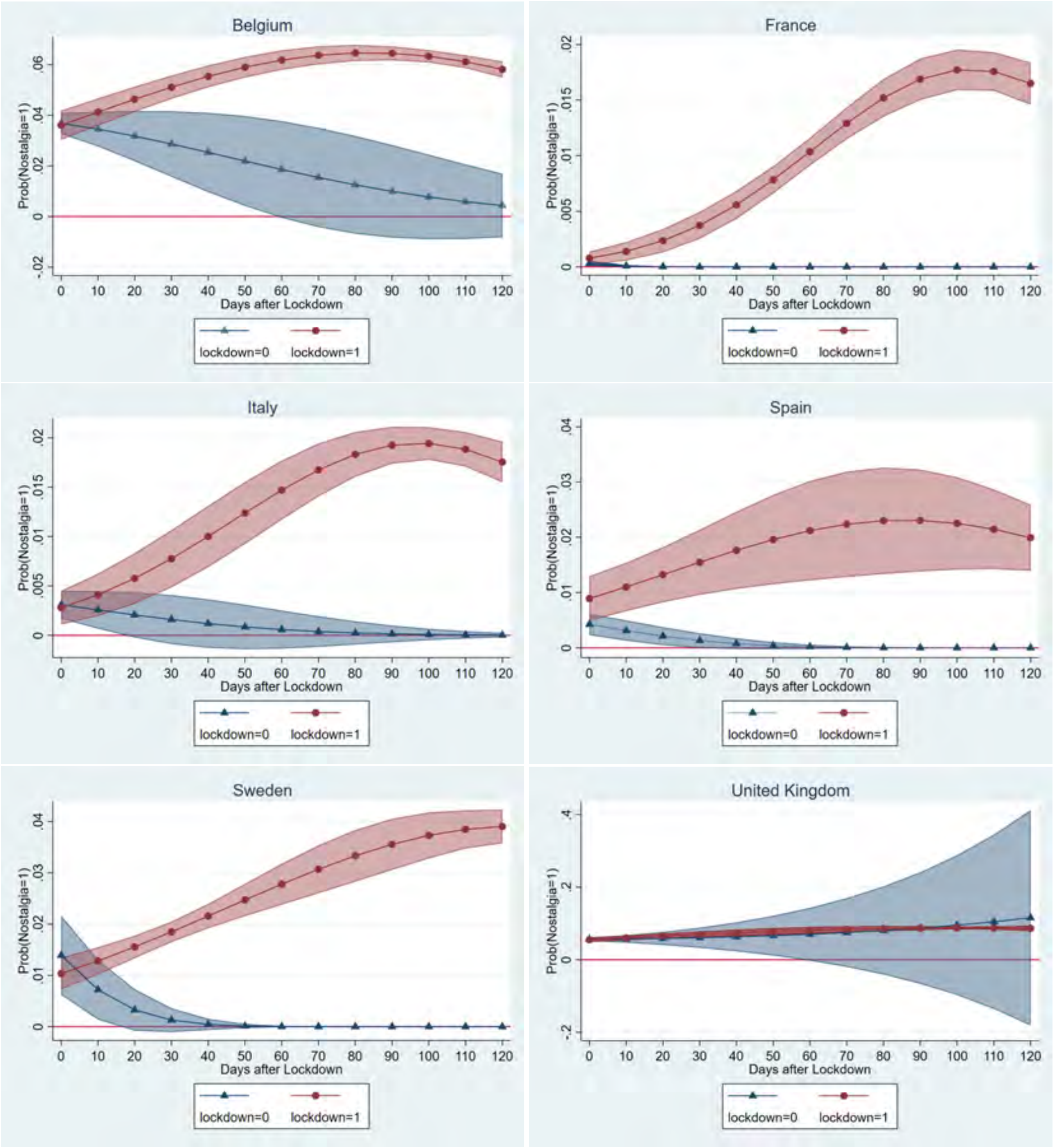

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Figure 6: Residual Plots: Illustrating Nostalgia Level over time

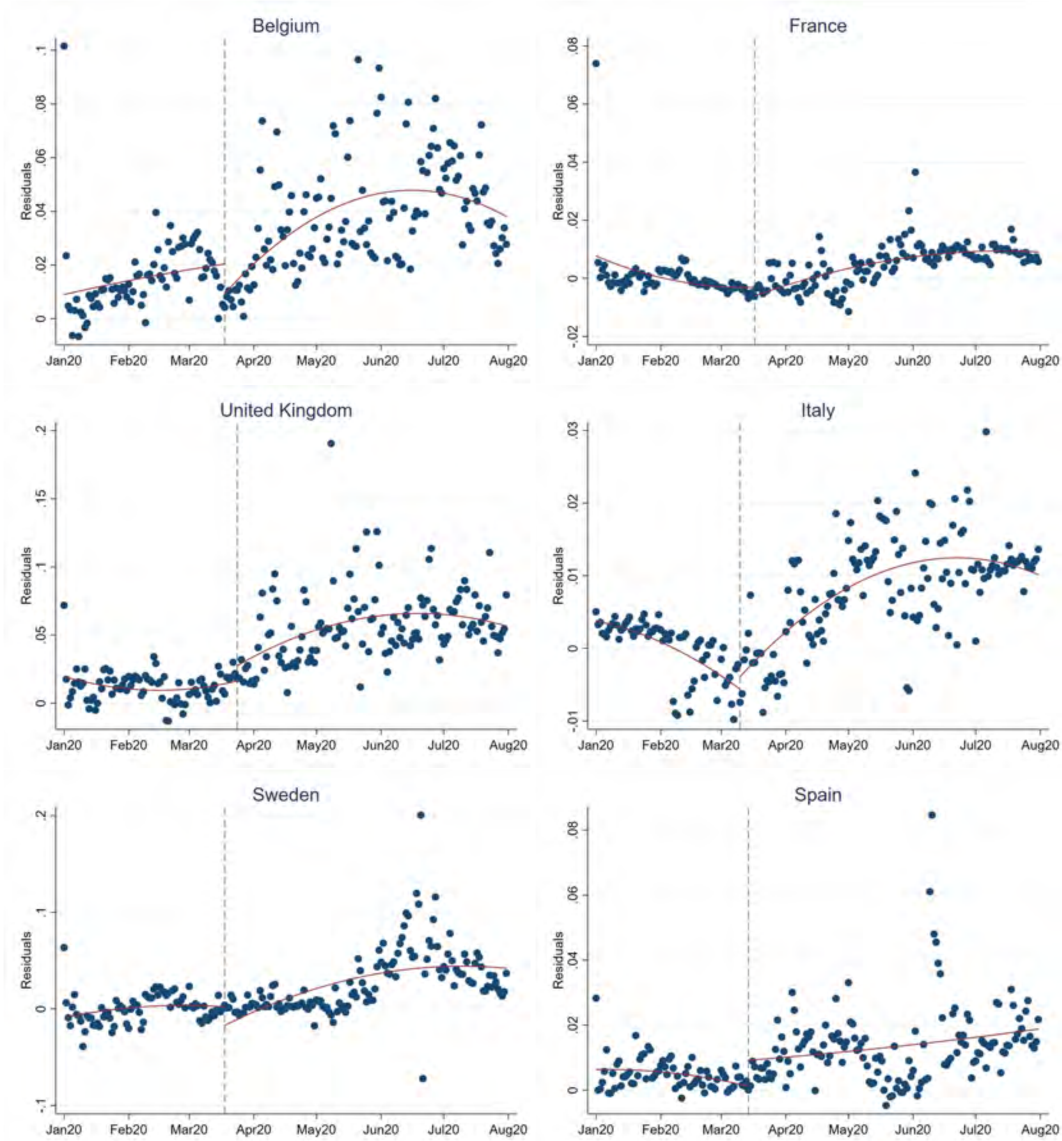

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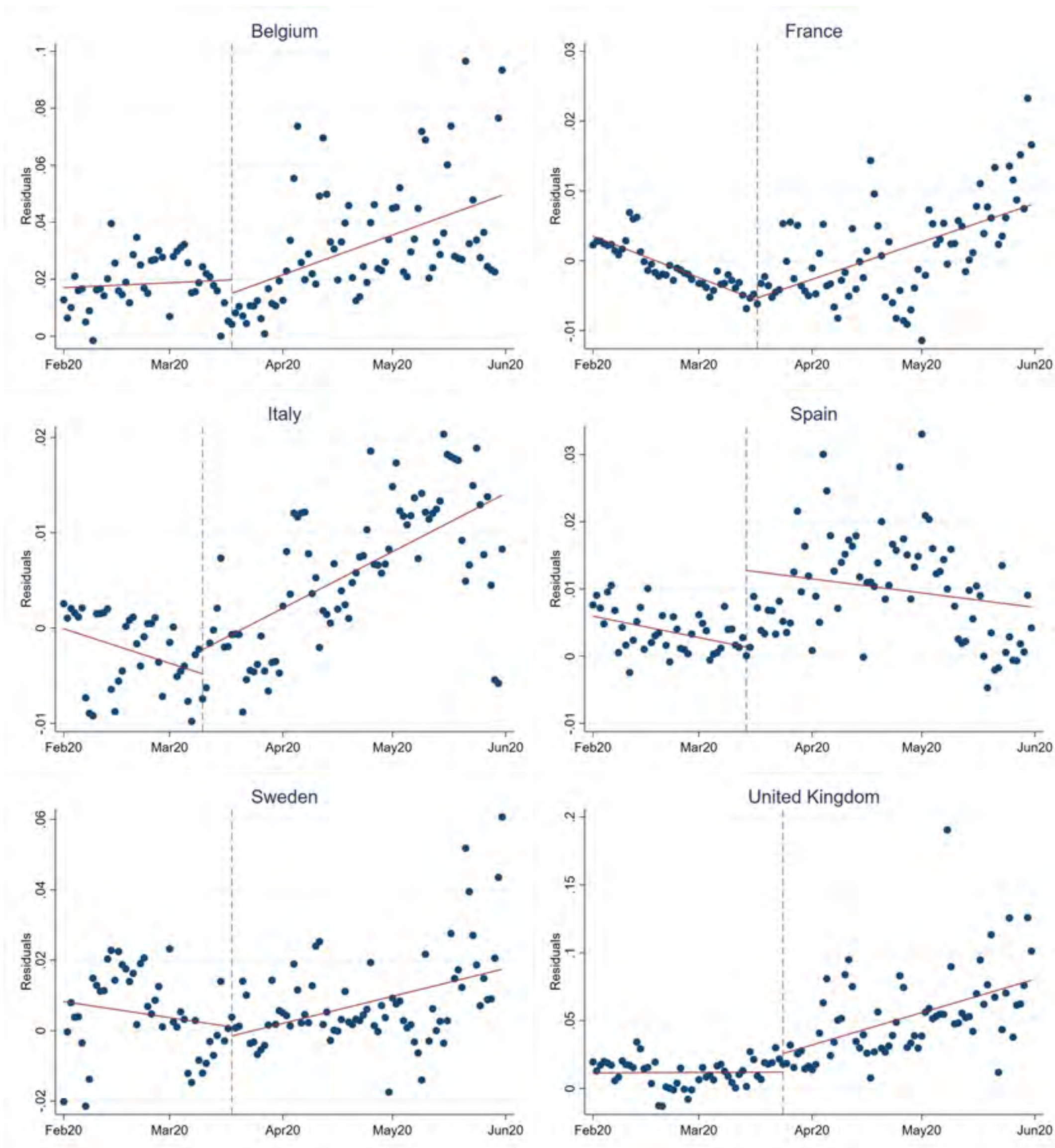
Figure 7: Zoomed Residual Plots: Illustrating Nostalgia Level over time



3.3 Lockdown and COVID Infection: Which one is more shocking?

The baseline regressions show that COVID incidence rate is not a robust and significant factor in explaining nostalgia consumption, given a quadratic trend is modelled. This result seems to suggest that users react to the lockdown but less so to the actual COVID infection figures. How-

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ever, as mentioned, these two factors are certainly competing for significance as both of them measure two different dimensions of the pandemic. Readers may have already noticed that the COVID-19 pandemic appears coinciding the trend of the nostalgia consumption with a delayed peak of the latter. While the baseline model assumes a linear relationship between COVID incidence rate and the log-odds as Equation (1) indicates, this section attempts to explore any non-linear effects of COVID. People might have been negligent when the pandemic first hit the country but then shocked by the incapacity of hospitals to cope with patients. When time went on, people got used to the shock and reverted back to their normal consumption preference. As a result, the effect of COVID incidence is non-linear in time. This hypothesis suggests that people do react to current COVID infection level but such an effect depends on time, perhaps producing an inverted-U shaped curve of nostalgia consumption during the lockdown, as shown by Figure 8.

To test this hypothesis, we modify the logistic regression model by dropping lockdown but interacting the (natural log of) COVID incidence rate with the quadratic trend. The idea is to allow the effect of COVID infection to be non-linear over the time dimension. Instead of reporting a table full of numbers, we plot in Figure 9 the average marginal effects of COVID against days since the first time COVID incidence rate exceeds 1. The effect of COVID infection is very small in the beginning and it increases gradually and becomes significant in France, Italy, Sweden and the UK roughly around 50 days after the first time COVID incidence rate exceeds 1 (Mid-Late April) that corresponds to the time when the peak just passed. However, the effect is insignificant in Italy and Spain while the estimated variance in the UK becomes very large after 75 days. In short, COVID infection could explain some variations of nostalgia consumption but is limited to some countries and to a short window of time. Take France as an example. At the peak, a one percentage change in incidence rate is associated with 0.75% increase in the probability of playing a nostalgic song.

The result points to the statistical limitation that the in-lockdown quadratic trend may actually cover up the influence of COVID infection on nostalgia consumption. Although the baseline result suggests that COVID fluctuations around the trend does not improve explanation, it does not mean people do not react to it. A mood or an emotional state of a person may be triggered by recent events, but could be persistent for some time and do not recover

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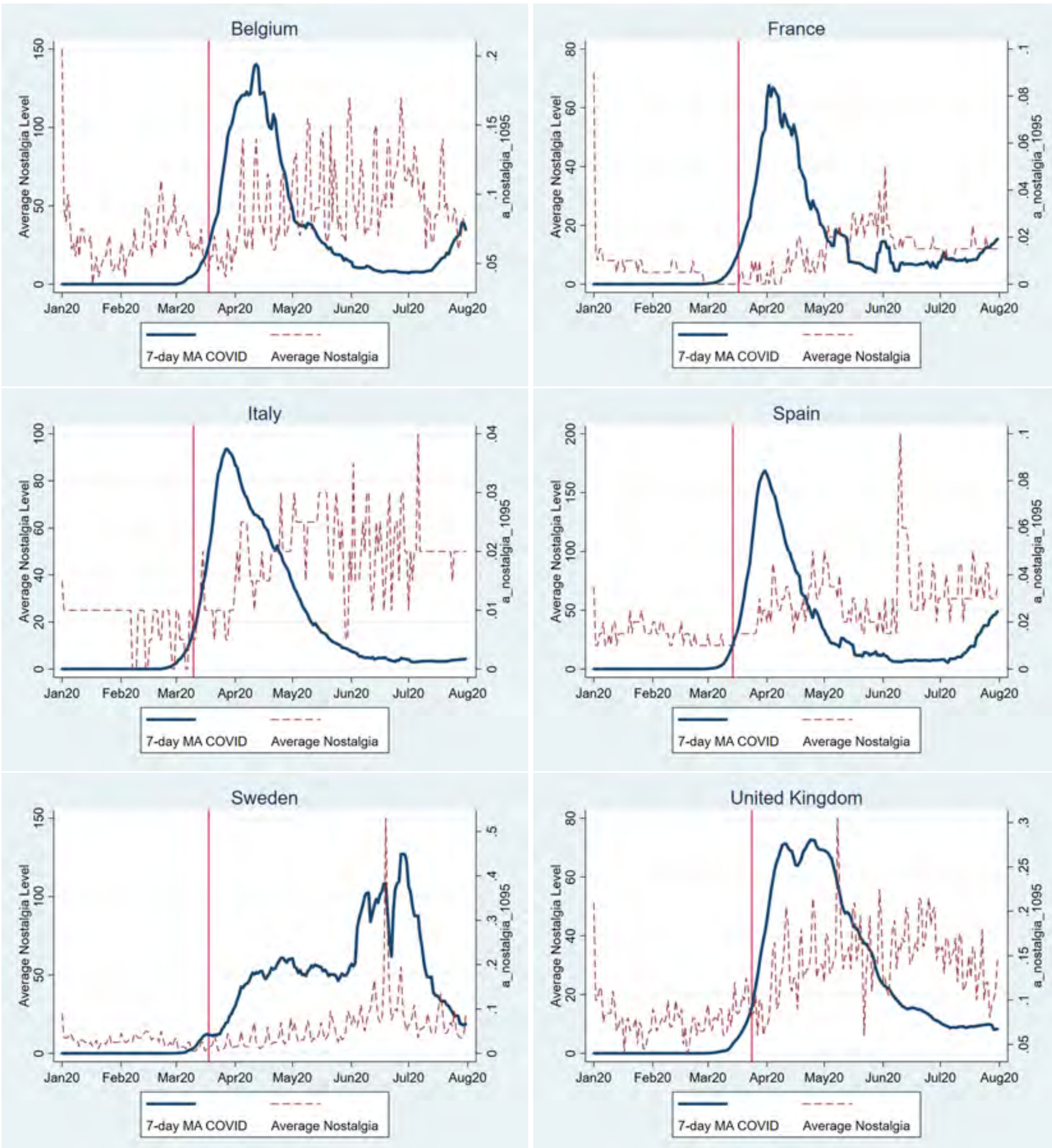
Figure 8: COVID Incidence Rate and Nostalgia Consumption



quickly. It is thus difficult to model any impact of COVID infection on nostalgia consumption and thus not surprising to see COVID infection not satisfactorily significant in the explaining nostalgia consumption.

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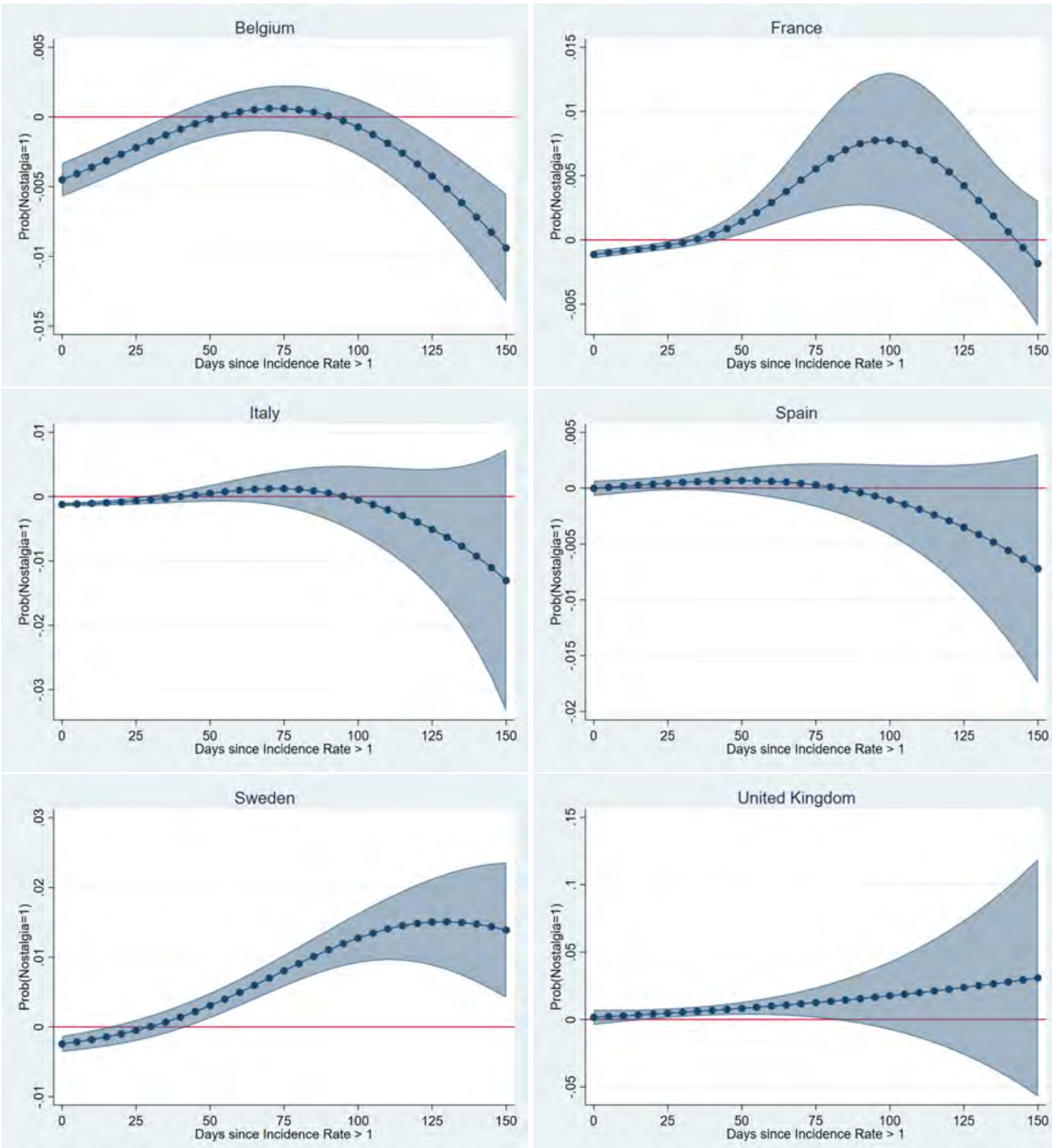
Figure 9: The Average Marginal Effect of COVID Incidence on Nostalgia Consumption



3.4 Robustness Check 1: 10-fold Cross Validation

Evidence so far do not draw any conclusion concerning the model's explanatory power. This section performs k-fold cross validations to choose the best model for each country (Zhang and Yang, 2015). In brief, k-fold cross-validation randomly divides a sample into k folds of equal size and fits the model on $k-1$ folds while taking the remaining fold as a validation

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set. As a result, we conduct k tests and select the best model among a set of models based on minimizing root-mean-square error (RMSE). Despite being increasingly challenged, we take $k = 10$ as most researchers advise (Arlot and Celisse, 2010). As each draw is random, each k-fold cross-validation may generate different results. To strive for a more convincing answer, ten times of 10-fold cross-validation are done to compare the following five different models:

1. Baseline (Lockdown interact with distinct quadratic trend pre- and in-lockdown, COVID)
2. No lockdown; COVID interacted with a quadratice trend
3. No lockdown; COVID, one single quadratic trend over the whole period
4. Lockdown interact with distinct quadratic trend pre- and in-lockdown; No COVID
5. No lockdown; No COVID; a single quadratic trend over the whole period

We have already shown some results of the first two models. Model 3 contains one single quadratice trend over the whole period while COVID enters the model independently. Model 4 excludes COVID from the baseline and Model 5 contains no pandemic-related information at all. All regressions utilize all observations from January to July 2020 and the predicted values are compared against the actual values. Table 3 reports the average root mean square errors (RMSE) of the ten times of 10-fold cross-validation and also the improvement in percentage of the best model over Model 5.[12]

Table 3: Robustness Check: 10-fold Cross-Validation

Model	(1)	(2)	(3)	(4)	(5)	Improvement
BE	0.25862247	0.27784696	0.27298335	*0.25861679*	0.27152588	-4.75%
FR	0.10781144	0.75119275	0.28095738	*0.10773338*	0.54211443	-80.13%
IT	0.12295221	0.12290002	0.1229657	*0.12288158*	0.12966048	-5.23 %
ES	*0.15394131*	0.17979503	0.16019589	0.15397355	0.16018556	-3.90%
SE	*0.19897844*	0.20008971	0.2005303	0.19912872	0.25823649	-22.95%
UK	*0.29446747*	0.29535151	0.29534308	0.2944894	0.3406044	-13.55%

Note: The smallest values are highlighted in italics.

The baseline model performs the best for three countries (Spain, Sweden and the UK) and Model 4 (Baseline without COVID) edges over the baseline for other three countries (Belgium,

[12] Each 10-fold cross-validation produces 10 RMSE. Running 10 times 10-fold cross-validation implies in total 100 RMSE are generated. We only report the average value of the 100 RMSE.

France and Italy). Breaking the trend at the first lockdown day always dominates those without. For those COVID provides additional explantory power, two of them (Sweden and the UK) are positive and significant, as shown in Table 2. Take Sweden as an example, a percentage point increase in the incidence rate is associated with an increase in the odds of nostalgia consumption by a factor of 1.5. Such a significant substantial impact coincides with the fact that Sweden has had no tight lockdown, though it is speculative to conclude that the rather lax policy shifted the source of impact on nostalgia consumption from lockdown to COVID infection.

3.5 Robustness Check 2: When was the actual break?

Readers may question if the lockdown date (the structural break) simply coincided with some reversion of trend and thus the presented results only reflect some natural process that would also have happened without the pandemic. To answer to this challenge, we re-run the baseline regression with 20 other hypothetical break dates, ranging from 10 days before to 10 days after the actual first lockdown day. Figure 10 reports the point estimate and the 95% confidence intervals of β_3, which refers to the change in slope at the corresponding break point.[13] Belgium is the best example, where the peak is exactly at the actual first lockdown day and the confidence intervals expand going into later dates. France is similar but the peak is found at $t^L + 1$. As users' reaction may lag behind the policy implementation, it should be regarded as a consistent result as long as the peak is found not far from t^L . The case of Italy is interesting. The point estimate peaks locally at $t^L - 2$, when the Italian government quarantined the whole Lombardy and 14 other provinces on 8 March, but then the estimate soars since $t^L + 4$. Sweden peaks locally at $t^L + 3$ and the subsequent increases in the point estimate are very small for $t > t^L + 4$. In any case, it is quite difficult to pin down the structural break date as Sweden has not tightly locked down the nation. The UK case is complex. While we reject the actual break happened after t^L as the confidence intervals expand sharply, it is difficult to pin down the actual break date. Note that the magnitude is relatively small compared to other countries and that the UK is the last to lock down its nation (except Sweden). Users in the UK might have already reacted to the pandemic, limiting mobility, storing food, and avoiding seeing each other without the government's advices and orders. Generally speaking, the break check provides additional evidence that nostalgia consumption experienced a structural break around the actual first

[13] The pre-lockdown slope is $\beta_1 + \beta_2 \times t$ and the in-lockdown slope is $\beta_1 + \beta_3 + \Big(\beta_2 + \beta_4\Big) \times t$. The difference is thus β_3 and the quadratic term is irrelevant at the break as we have centered the trend values at the break point.

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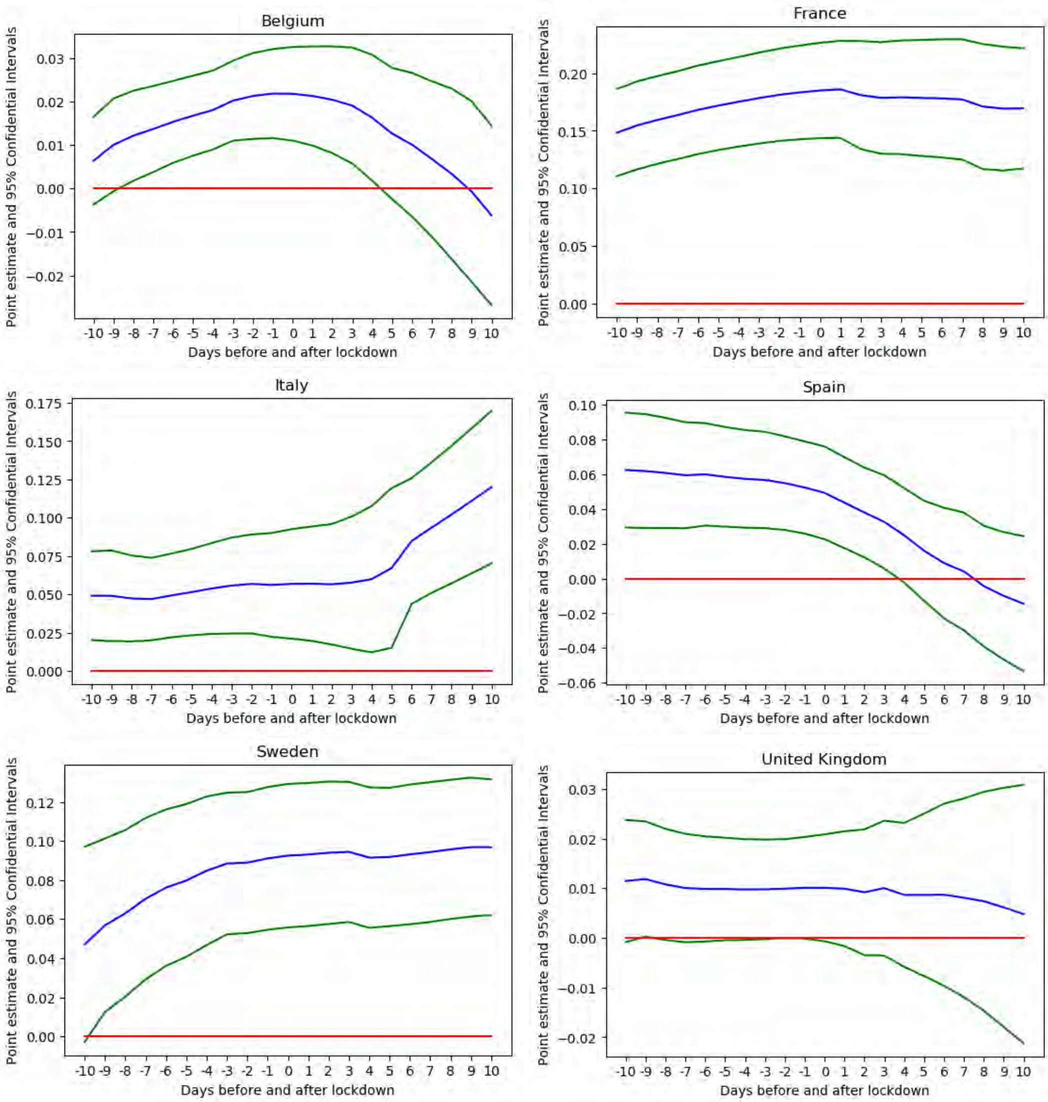
lockdown day. Spain presents a quite different picture and the graph basically reject that the actual break date does not predate the first lockdown day. Judged with evidence such as the residual plot of Figure 6, Spain exhibits a distinctive pattern from other five countries .

Figure 10: The Effect of Lockdown on the Trend with Different Break Points



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3.6 Robustness Check 3: Placebo Test

Despite the previous robustness check, readers may doubt if the change in trend is in fact an annual pattern but not due to the lockdown. It is possible for some reason nostalgia consumption takes a sharp turn and goes up every year in March and then fall towards to summer.[14] This section attempts to explain nostalgia consumption of the period January-July 2019 by the lockdown and COVID data of the 2020 (the baseline specification) matched to the same day of 2019. Again, we check if the slope changes sharply at the break. A no-result of this placebo test is thus a strong evidence supporting that the lockdown is actually a factor driving nostalgia consumption in 2020. Figure 11 reports the point estimate and also the confidence intervals of β_3. For Belgium, its largest estimate comes on $t^L - 1$ but is negative, meaning that the slope turns sharply downward after the break. France peaks at roughly $t^L + 5$. Italy sees all estimates below zero, whereas Sweden peaks at $t^L - 2$. Finally, there is no clear answer to where is the break for Spain and the UK.

No country reproduces a similar pattern, implying that nostalgia consumption during the 21-day period does not exhibit an annual pattern. While most of the point estimates stay above zero in Figure 10, meaning that the trend turned upward in March 2020, the pattern in 2019 is mixed with Belgium, Italy and the UK staying below zero for a large range of hypothetical break dates. Generally speaking, the placebo test rejects the claim that the break in slope is a reflection of an annual pattern, and thus provides substantial support to Hypothesis 1.

Table 4 summarizes the results of sections above. Baseline regression result shows that the lockdown treatment breaks the trend of nostalgia consumption and the change in slope is positive and significant for all six countries. The significant and negative quadratic trend term suggests that the upward shift in slope caused by the lockdown diminishes over time, while the residual plot suggests that the pattern of Spain may be driven by outliners. COVID improves the model's explanatory power and is significant for Sweden and the UK only. By comparing the baseline model using the first lockdown date as the actual break data with 20 other hypothetical break dates, we find strong support for the hypothesis that the sharp change in slope happened at or around the first national lockdown date (or national travel advice announcement date for

[14] The baseline regression has included the daily average nostalgia level of 2019, which should have adequately taken care of this concern.

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Sweden) for Belgium, France and Sweden. The placebo test shows that no country experienced a similar slope break in 2019.

Figure 11: Placebo Test: The Effect of a Counterfactual Lockdown on the Trend with Different Break Points in 2019

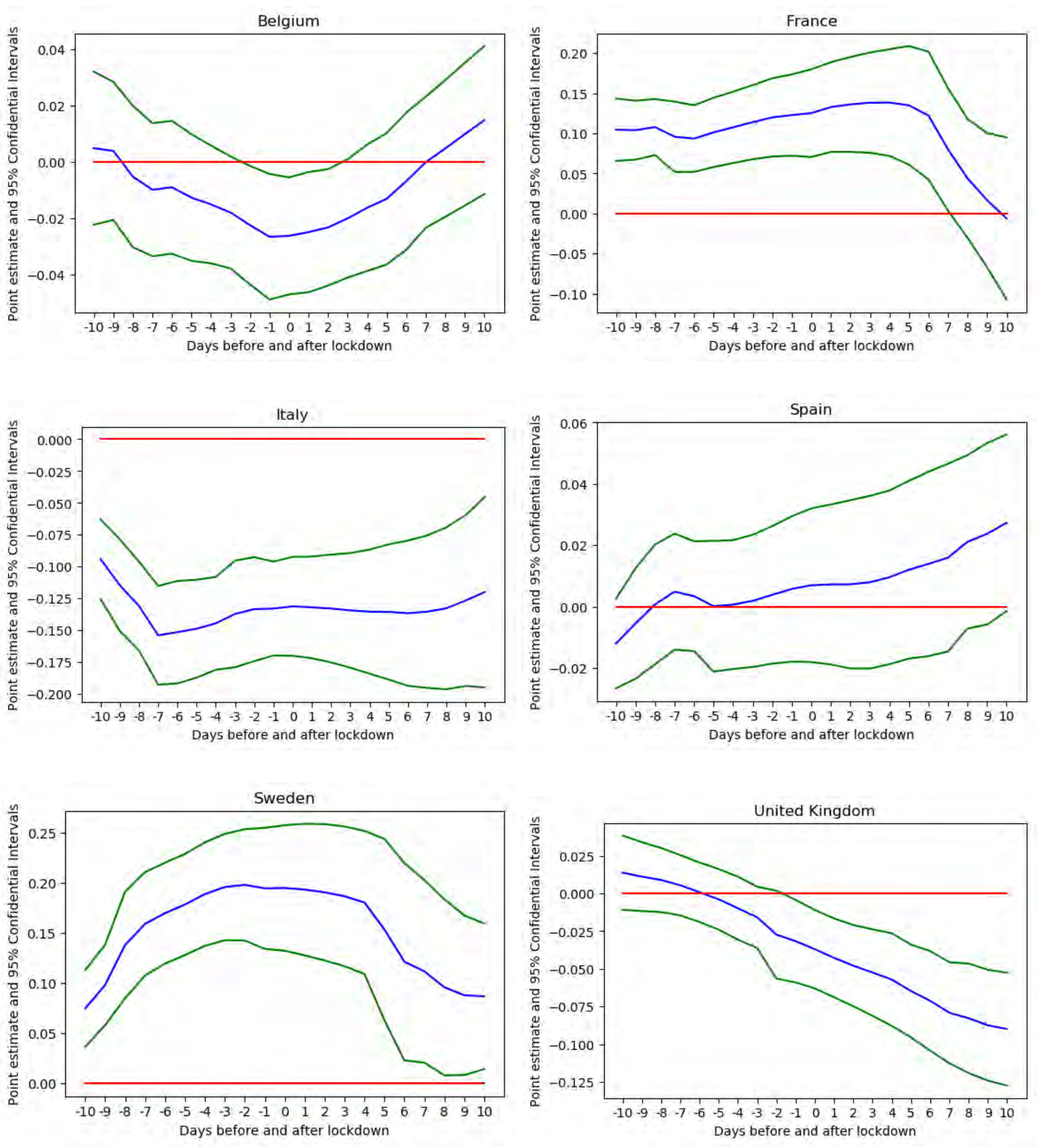

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Table 4: Summary of Results

	BE	FR	IT	ES	SE	UK
Trend turns upward at lockdown	✓	✓	✓	✓	✓	✓
Quadratic Impact of Lockdown	✓	✓	✓	×	✓	✓
COVID improves explanation while significant	×	×	×	×	✓	✓
Support of Break at Lockdown	✓	✓	unclear	×	✓	unclear
Support of Annual Pattern	×	×	×	×	×	×

4 Discussion and Conclusion

By scraping Spotify's, the popular online music streaming platform, public data covering almost 17 trillion of plays in six countries, this research provides some evidence of increasing nostalgia consumption of music caused by the pandemic. While Spotify users respond to the lockdown that significantly breaks the trend, COVID incidence rate is a less significant factor. The difference could be explained by the old tale of substance or style. People with limited attention capacity could only pay attention to the more obvious information. It is arguably true that a lockdown gave a stronger signal of severity than the actual COVID incidence rate. A more convincing explanation is that the lockdown itself not only signaled a negative outlook but also caused significant psychological impacts even when the current incidence rate is low. The lockdown during the pandemic involved many exceptional orders that limit individuals' liberty and affect employment and usual social interactions. These changes might have caused ill emotions and people dived into nostalgic music to escape the reality even if the virus had not caused their or their close relatives' health any harms. Demand for nostalgia grew with frustration as the lockdown remained in place and such a change in behavior was gradual but did not react closely to the change of the severity of the pandemic.

The literature provides abundant evidence of impacts of the COVID-19 pandemic on mental health (Cao et al., 2020; Pfefferbaum and North, 2020; Qiu et al., 2020; Rajkumar, 2020; Odriozola-González et al., 2020; Mucci et al., 2020, and many others). Brooks et al. (2020) identified five stressors during a lockdown, namely, duration of lockdown, fears of infection, frustration and boredom, inadequate supplies, and inadequate information. Psychological impacts of the pandemic may easily translate into change in consumption behaviors as rational individuals seek remedies to counter any adverse psychological distress. A potential cure is to acquire nostalgia and a relatively cheap channel to achieve this goal is to listen to music of the

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"good old days". The relationship of a time of difficulty and nostalgia consumption has been discussed in recent research (Weed, 2020; Gammon and Ramshaw, 2020), while previous work supports that nostalgia induces more positive affects than negative ones (Cheung et al., 2017; Hussain and Alhabash, 2020).

The exceptional orders in this exceptional time have led people to seek nostalgia for pleasure. The current work attempts to identify the more significant factor in determining nostalgia consumption between the lockdown and the infection and concludes that lockdown changes sharply the trend of nostalgia consumption and COVID incidence rate contributes little to the explantory power of the model. This work also shows that the lockdown effect is non-linear as the lockdown nostalgia impact eventually faded away. Although future data are not yet available, the author speculates that the incentive for seeking nostalgia would be much weaker during a second-wave or a second restrictive lockdown.

The result is not only relevant for music producers and music lovers but also for the general public and the policy-makers to better understand individuals' possible responses to crises. Music consumption is a result of personal utility maximization. Users of the streaming platform (no marginal monetary cost of additional consumption) choose whatever they like based on their preferences and moods and implicitly they believe the music they choose pleases them (generates higher utility). If old songs make them feel better, it may be because those song counter some sad emotions during the very special period. Care centres, hospitals, stores and any places where music could be played publicly should consider the positive effects of playing nostalgic music as a response of the adverse effects of the pandemic.

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