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# The Online Vaccination Debate : the Case of France

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# The Case of France

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**Abstract**

We evaluate the controversial aspect of a new vaccination policy announcement in France on Twitter. The objective is to approach the degree of controversy generated by the announcement of a mandatory vaccination policy for children by analyzing the reactions on social networks. Indeed, social networks allow individuals to express themselves publicly on a subject. They provide a platform that reflects public debates, opinions and feelings on a given topic. Thus, we collect tweets around the date of announcement on other similar announcement in Europe and also on other policies with daily binding characteristics in France. We compare the pattern of reactions in order to distinguish if France is particularly sensitive to this type of statements and also to understand if the controversy is due to the topic or to the constraining aspect. We find that online reactions to the vaccination policy announcement last longer over time than other announcements. We use the trend momentum (TM) concept to analyse the magnitude of the reactions after announcements. We first conclude to a higher level of sensitivity on this topic in France compared to identical announcements that have been done in Italy and Germany. The results also indicate a higher intensity of reactions for policies reducing individual freedom in order to protect the population.

JEL codes: I10, I18, J18

keywords: *vaccination policy, social media, Twitter*

# INTRODUCTION

With the increasing availability of vaccines, the question of vaccination acceptance to fight diseases is a key public policy issue because of the need of a vaccination rate high enough to protect the population. The problem is that vaccines, although widely recognized for their benefits among scientists (Floret (2010), Hanslik and Boëlle (2007), Grimprel et al. (1999), Levy-Bruhl (2007), Lepoutre et al. (2008)), may suffer from low levels of confidence among some segments of the population as shown in Yaqub et al. (2014). Confidence is particularly low in Europe as we can see in de Figueiredo et al. (2020). Thus, in 2019, the World Health Organization (WHO) announced in its Thirteenth General Program of Work that combating mistrust of vaccines is one of its ten major areas of work for 2023. Several options of vaccination strategies are available to policymakers, including whether or not to introduce mandatory vaccination. Mandatory immunization would have the merit of achieving a vaccination rate high enough to protect the population against the disease in case there is a low level of acceptance, but would potentially have the disadvantage of creating or increasing an opposition due to the infringement of freedom caused by such policy. This could then be problematic in terms of public support for the implementation of other public health measures. In this paper, by the announcement of mandatory vaccination of children in France, we first quantify the level of controversy generated. We then try to distinguish if the controversy is due to the topic or to the mandatory aspect of the announcement by comparing it with other constraining policy announcements.

In June 2017, it was announced in France that the number of mandatory vaccinations for children would have increased from 3 to 11. In a context of mistrust towards vaccination, France is a particularly noteworthy country because of the controversies it has faced and the degree of doubt about the safety of the vaccine that the population expresses(Larson et al., 2016). Creation of anti-vaccine groups took place in the 1800s (Ozawa and Stack, 2013) at the same time as the discovery of the smallpox vaccine. More recently, several controversies suggesting a link between several vaccines and the occurrence of serious diseases such as multiple sclerosis (1998) following the injection of hepatitis B vaccine, or the link between autism (1998) and the injection of measles, mumps, and rubella (MMR) vaccine[1], have eroded confidence in these vaccines. The controversy that arose after the H1N1 vaccination campaign with the recognition by the French National Agency for Drug Safety (ANSM) of an increased risk of narcolepsy following the inoculation of the vaccine only increased the growing mistrust of vaccines and

[1]Controversy initially coming from the United Kingdom before reaching France

French institutions while Streefland et al. (1999) show that acceptance of vaccination also depends on trust in biomedical technologies and health care personnel.[2] This mistrust creates a particular problem when it comes to the issue of mandatory vaccination because one of the points regularly raised by anti-vaccines is the question of deprivation of liberty.

This paper investigates reactions to this new vaccination requirement on social networks, particularly Twitter. Indeed, social networks serve as an echo chamber for anti-vaccines theories around the world, as shown by Chiou and Tucker (2018) and Yuan and Crooks (2018). Furthermore Twitter is a platform of expression on which everyone can formulate their opinion and debate after an event (Kalsnes et al., 2014; Rajadesingan and Liu, 2014). Consequently tweets can be considered as a good metric to measure the intensity of debates and controversies. Recent studies have focused on the impact of a vaccine policy on vaccination rates without looking at the level of controversy. We therefore try to approach in this study the degree of controversy generated by a political announcement by the number of reactions on Twitter. We first conduct an analysis between similar announcement in Europe to study if a particular level of controversy exist in France. In a second part, we study the situation in France by analysing whether a mandatory vaccination policy is more controversial then other constraining policies. We have selected policies that impose a constraint on the daily life of citizens in order to protect them. These constraints can be perceived as a restriction on freedom, as with the vaccination announcement, or a constraint on their purchasing power. While, Carrieri et al. (2019), Anderberg et al. (2011) and Chang (2018) show that controversies have a negative impact on immunization rates for children, even for vaccines not affected by them, we try to determine which attributes of the mandatory vaccination policy are controversial. In order to make the magnitudes of reactions comparable between announcements we use the Trend Momentum (TM) concept from Lu and Yang (2012).

Our study proposes a new approach using social media to evaluate the degree of controversy due to a vaccination policy announcement in order to improve anticipation of vaccine behaviors. We show that the reactions to the vaccine announcement in France were particularly strong compared of those other announcements. Nevertheless, we distinguish strong reactions as soon as the policy has a constraining character on individual freedom. In the first section, we will discuss the context of the different political announcements followed by the second section that will present the methodology. The results will be presented in the third section. The fourth section will present the robustness tests. Finally, we will discuss the results in the fifth section.

[2] https://ansm.sante.fr/S-informer/Points-d-information-Points-d-information/Vaccins-pandemiques-grippe-A-H1N1-et-narcolepsie-Mise-a-jour-de-l-information-sur-les-dernieres-donnees-scientifiques-Point-d-information

# 1 INSTITUTIONAL BACKGROUND

This section describes the French mandatory vaccination announcement as well as the policies selected in order to compare reactions on Twitter with it. On one hand, we make a comparison with similar vaccination policies in Europe and on the other hand with French policies. With regard to French policies, we select policies that were subject to a strong public debate when they were announced. We favor policies that were close in time in order to maintain the same global context and the same Twitter user demographic. We also select them because of their protective aspect for the population as well as for their constraining characteristics on the daily life of individuals. In order to know if the intensity of the reactions was due to the constraining aspect in general or specifically to the deprivation of individual liberties, we selected policies with a financial constraint impacting the purchasing power of individuals and a policy experienced as a reduction of liberties. First, we describe the policy of compulsory vaccination in France, then we present European policies that have made similar announcements on compulsory vaccination, and finally we detail the context of French policies.

## 1.1 Changes to the vaccination schedule for children in France

Before the implementation of the policy, only three vaccines were mandatory for the children: dyphteria, tetanus and poliomyelitis. For these three diseases the immunization injection is usually combining all of them in one vaccine and the vaccination schedule is consequently the same for each of them: two shots at two months (eight weeks) and four months of age, followed by a recall at eleven months of age. On June $16^{th}$ 2017 the French government announced that it has decided to "make eleven vaccines for children compulsory for a limited period of time". Policymakers argued that an increase in the number of compulsory vaccines was necessary because of an outbreak of measles and, more generally, a decline in immunisation coverage.[3] With this announcement the government decided to extend the number of compulsory vaccines by including eight more that were until then recommended: pertussis, measles, mumps, rubella, hepatitis B, haemophilus influenzae bacteria, pneumococcus and meningococcus C. As the announcement impacted the parents with a child of two years old or less, the number of individuals directly concerned is around 3.8 million according to the French Statistical Institute (INSEE).[4]

The policy of 11 mandatory vaccines was finally approved by the Prime Minister on July

[3] https://www.leparisien.fr/societe/la-ministre-de-la-sante-agnes-buzyn-veut-rendre-rendre-onze-vaccins-obligatoires-15-06-2017-7055664.php

[4] https://www.insee.fr/fr/statistiques/3138828?sommaire=3138843

$4^{th}$, 2017 and implemented on January $1^{st}$, 2018. For our study we are taking the first time such an announcement was publicly made, in this case on June $16^{th}$ 2017, as the date of the event. This event, however, has triggered a controversy as some people argue that such a policy would be a restriction on their freedom. For example, the anti-vaccination website "The National League for Vaccination Freedom"[5] was particularly active and published different elements about this subject, notably an open letter to the Minister of Health to let her know that "increasing the number of mandatory vaccines will not bring anything to public health in terms of infectious diseases", as well as several petitions addressed to the President of the French Republic denouncing the "first vaccine dictatorship in the world" if the policy was implemented.[6]

## 1.2 Other European vaccination policies

In order to compare the magnitude of reactions in France with those in other countries, we consider two announcements of mandatory vaccination policies for children in Europe, Italy and Germany. Comparing the reactions on Twitter to these similar announcements allows us to study whether France is particularly sensitive or not.

### 1.2.1 Changes to the childhood immunisation schedule in Italy

In Italy, the health minister has announced that she has sent a text of law for compulsory vaccination at school entry on May $11^{th}$, 2017. On May $20^{th}$ 2017, the Council of Ministers reintroduced compulsory vaccination in schools as of September 2017. Twelve vaccines were declared mandatory for children: dyphteria, tetanus, poliomyelitis, pertussis, measles, mumps, rubella, hepatitis B, haemophilus influenzae bacteria, chickenpox, meningitis B and C. The announcement of May $11^{th}$, 2017 is consequently very close to the one made by the French government on June $16^{th}$, 2017 by considering a mandatory vaccination schedule for children.

### 1.2.2 Changes to the childhood immunisation schedule in Germany

On March $25^{th}$ 2019, in Germany, the Health Minister indicated that he is in favour of mandatory measles vaccination for school children.[7] Consequently, on March $27^{th}$ 2019, the Associ-

[5] La ligue Nationale pour la liberté des vaccinations: https://www.infovaccin.fr

[6] -https://blogs.mediapart.fr/bruno-jean-palard/blog/110817/vaccinations-obligatoires-lettre-ouverte-de-la-lnplv-la-ministre-agnes-buzyn

-https://www.mesopinions.com/petition/sante/monsieur-macron-sommes-opposes-projet-vaccins/31039

-http://www.preventionvaccin.org/post/En-Marche-Pour-la-Liberté-Vaccinale

[7] https://www.dw.com/en/germany-measles-vaccine-could-be-compulsory-for-kids/a-48050623

ation of German Paediatricians called on the government to agree the following week on an obligation to vaccinate children against measles and then to introduce 7 other compulsory vaccines: rubella, diphtheria, tetanus, polio, pertussis, mumps and chickenpox.[8] However, this policy remained not implemented. We consider the Health Minister's announcement on March $25^{th}$ 2019, as the event date even if only one vaccine was proposed to become mandatory (against eleven for France and twelve for Italy) at this date. We considered the mention of introducing a mandatory vaccine enough to compare it with the announcement made in France.

## 1.3 Other French policies considered

We consider three French policy announcements that have common characteristics with the vaccine policy due to their protective aspect and their constraining aspect. We are therefore interested in a policy of increasing the price of tobacco, a policy of increasing the price of carbon tax, and a policy of speed limits on certain French roads. The first two policies constitute a constraining aspect from a financial point of view for individuals while the last one has been experienced as a deprivation of liberties by some.

### 1.3.1 Tobacco price increase

To reduce the number of smokers in France, a program has been set up by the French government in 2017.[9] In this program one of the notable objectives is to gradually raise the price of tobacco to a price of 10€by 2020. For this reason, an announcement was made on October $17^{th}$, 2017 to increase the price of the tobacco pack by 1€. The policy was effectively implemented on March $1^{st}$, 2018. We chose the policy cause of its restrictive aspect on smokers. Nevertheless it is not a direct attack on freedom but on the purchasing power of individuals. We also select this policy because it affects a large part of the population. In 2017, about 12.2 million of people are smokers in France according to "Santé publique France".[10] Consequently, this policy is concerning around three times more individuals than the vaccination one, we are then supposedly expecting a larger number of tweets in reaction to this announcement. We also expect that part of the individuals affected by the vaccine policy will also be affected by this policy.

[8] https://www.france24.com/en/20190327-german-paediatricians-demand-compulsory-vaccinations

[9] https://solidarites-sante.gouv.fr/IMG/pdf/180702-pnlt_def.pdf

[10] BEH - bulletin epidemiologique hebdomadaire n 14-15, Mai 2018

### 1.3.2 Carbon tax increase

The carbon tax was initially established in 2014 by the French government and was supposed to increase every year. On September $26^{th}$ 2017, an increase of 14€per tonne of carbon has been voted during the finance act for 2018.[11] Accordingly, this policy applies to all individuals driving a vehicle but also all the people heating with gas or electricity of fossil origin. In this situation we obtain the same features concerning the constraint on purchasing power than for tobacco price policy, but we are expecting a larger part of the population being affected by this one: about 40 million individuals hold a driving licence in France and about 16 million households are directly impacted by the way they heat.[12,13] We can then reasonably assume that most people impacted by the vaccine policy were impacted by the carbon tax. As for the tobacco price policy, the carbon tax increase has a restrictive aspect although it does not entail a direct attack on freedom but on the purchasing power.

### 1.3.3 Speed limitation

In order to reduce the number of deaths on the road a policy about the speed limitation on the two-way secondary roads without a central separator was officially announced by the prime minister during a press conference at the end of the Interministerial Committee for Road Safety on January $9^{th}$, 2018.[14] Before the implementation of this policy it was possible to drive at a speed of 90 km/h on this type of roads. The implementation of this limitation reduced the speed to 80km/h on July $1^{st}$, 2018. It presents similarities with the vaccination announcement because it imposes a constraint on citizens through an infringement of their freedom.[15] Furthermore, the speed limitation impacts a large number of the population and has as its main objective the protection of individuals. It has impacted a large part of the population in France with a number of drivers in France around 40 million individuals. Again, we expect that part of the individuals affected by the vaccine policy will also be affected by this policy.

[11] https://www.senat.fr/rap/a17-113-1/a17-113-14.html

[12] https://quelpermis.com/Permis-de-conduire/les-chiffres-du-permis-de-conduire-en-france.html

[13] https://assets.rte-france.com/prod/public/2021-02/Rapport%20chauffage_RTE_Ademe.pdf

[14] https://www.gouvernement.fr/sites/default/files/document/document/2018/01/dossier_de_presse_-_comite_interministeriel_de_la_securite_routiere_-_mardi_9_janvier_2018.pdf

[15] https://www.publicsenat.fr/article/societe/securite-routiere-une-histoire-de-la-limitation-de-vitesse-en-images-81296

# 2 METHODOLOGY

## 2.1 Data collection

We study the reactions on social networks, in particular on Twitter. This social network is a platform where every person can express their feelings. Individuals post tweets following events to express themselves and debate (Kalsnes et al., 2014; Rajadesingan and Liu, 2014). Moreover, the number of reactions seems to be higher following a negative event as shown by comparing the number of reactions following the announcement of layoffs and following the announcement of hirings in Bassanini et al. (2020). The tweets have been collected by a web-scraping method. We examined manually the tweets relative to the policy to extract key words. We then used these keywords to collect the tweets around the announcement date, over the considered period. Concerning the vaccination topic, for each country, we chose the following words: "vaccine", "vaccination" and "anti-vaccine". For the tobacco price increase we chose: "tobacco price increase", "Cigarette price increases" and "Tobacco". For the carbon tax increases: "carbon tax". Finally, for the limitation speed we chose: "80km/h" and "80kmh".[16] Then we fixed the rule of scrambling 45 days before the announcement date and 30 days after (see the details by policy in appendix) to provide a window large enough to have enough details about the situation before and after the event. We then obtain one database per policy. Each database contains one observation per tweet with the name of the user who published the tweet and the date it has been posted. We can therefore work on the number of tweets published per day as well as the number of daily users who have published on one of these specific topics.

## 2.2 Statistical analysis

We compare the announcement of the vaccine policy in France to other policies, in Europe and in France, in order to understand the different aspects of the controversy. We consider two dimensions to capture the intensity of controversy: the number of tweets and the number of Twitter users who posted a tweet on the topic. Our objective is indeed to study the intensity of reactions that the announcement generates via the number of tweets but we also want to analyse whether these reactions are concentrated in a small number of users. The total number of tweets could effectively be driven by a few amount of people.

[16] We take the largest number of key words we can to collect as many tweets as possible. Nevertheless it appears that we do not distinguish the same number of keywords for each policy. It could then explain (a) a difference in term volume of tweets and (b) an over estimated reaction the day of the announcement. In order to address these problems we are using the TM concept (see section 2.2) to make each policies comparable and we are conducting a robustness test with a single key word used for each policy (see section 4.2) in order to address the second problem.

In the first instance, we study graphically the number of tweets and the number of users who posted these tweets by day to establish the duration of the event. We define that online reactions are over when the number of tweets posted per day is close to the pre-announcement level. The graphical analysis also provide the highest number of tweets relative to the studied announcement as well as the highest number of Twitter users who posted these tweets.

In a second stage we use the trend momentum (TM) concept as defined in Lu and Yang (2012). By using the difference between two moving averages (MA), this concept detects the time of the event and normalizes the initial level of reactions to capture the volatility of the number of tweets and the number of users during the event. We can then compare directly between them the reactions on the announcements. The trend momentum is defined as follows :

$$TM(n) = MA(n, k_s) - MA(n, k_l) \tag{1}$$

with n the time slice, $k_s$ a short time window and $k_l$ a long time window. The time slice is the lag window for calculating each moving average. In this analysis, we use a lag of one in order to observe the relative change of reactions instantaneously. We present the results for $k_s$=4 and $k_l$=5 in section 3.3. Further results are presented in the appendix as robustness tests.

Moving averages are defined as follow:

$$MA(n, k) = \frac{\sum_{i=n-k+1}^{n} f(t_i)}{k} \tag{2}$$

with $f(t_i)$ the number of occurrences in time slice $t_i$, and $k$ the time-size window.

Therefore, when there is a sudden increase in the number of tweets (resp. users) the moving average with the widest window will capture this increase relatively to the usual level of tweets (resp. users), measured by the shortest moving average. We thus obtain the fluctuations in the number of tweets (resp. users) relative to a baseline normalized to zero in the absence of event. The concept of TM then enables to define the intensity of reactions for each of the announcements and to compare them with each other in order to understand which aspects of the policy are controversial.

# 3 RESULTS

## 3.1 Descriptive statistics

Tables 1 and 2 in appendix show us that vaccination is a subject particularly discussed in France but also in the two other European countries studied. Nevertheless we have to take in consideration the number of Twitter users by area. The number of Twitter users seems to be higher in France than in Germany, which explains the difference in the number of tweets (only 17,733 in Germany). In Germany, there were 3.9 million active users per month in the third quarter of 2019 (against 19.4 million monthly users at the date of the French policy announcement).[17,18]. As we can see in Table 1 the highest number of tweets over the period around the announcement date is held by Italy. This high number (91,422) can be explained in part by the many events other than the announcement concerning vaccination, which will be discussed in section 6. We note that the standard deviation of the number of tweets per day is particularly high. The minimum number of tweets per day relative to vaccination is approximately the same for Italy and France (resp. 70 and 69), it could indicate a topic equally sensitive in both countries.

Tables 1 and 2 also show the descriptive statistics for each subject studied. Column 1 indicates the total number of tweets retrieved over the study period, while the other columns show other descriptive statistics such as the mean number of tweets per day, the daily standard deviation, or the 5th and 95th deciles. We also have the minimum and maximum number of tweets in a day. Regarding the tweets related to the French advertisements, we note that the most discussed topic in daily life is vaccination. Indeed, we observe a total of 43,614 tweets published from May 2 to July 16, 2017 for a daily average of 571.97 tweets. After the vaccination topic comes the topic related to the speed limit with a total of 12,882 tweets over the entire period and an average of 169.5 tweets per day. Nevertheless, we observe that the maximum number of tweets published in a day is of the same order of importance between the two topics. The maximum number of tweets in one day over the period is 5,234 for vaccination versus 4,368 for speed. We note that tweets related to carbon tax and tobacco are much less numerous over the entire period with 730 and 3,559 respectively.The daily average is also significantly lower with an average of 9.86 tweets per day for the carbon tax and 46.83 tweets per day for tobacco. These initial statistics seem to indicate a higher daily popularity of the vaccine subject compared to other subjects. Table 2 seems to go in this direction with always a higher number of users

[17]https://we-like-travel.com/chiffres-reseaux-sociaux-2019/

[18]https://www.journaldunet.com/media/publishers/1207513-audience-internet-octobre-2017/

having posted at least one tweet about vaccination than for the other subjects. A total of 18,861 people have talked about vaccination in their publication over the period, compared to 7,841 for speed, 1,640 for tobacco and 538 for carbon tax. Similarly, the daily average of the number of users publishing a tweet on vaccination is higher than for the other topics. These differences of proportions cannot be explained by a fluctuation of the number of Twitter users in France which was around 15.3 million monthly users in November 2018 (which correspond to the scrapping date of the carbon tax policy) and 19.4 million monthly users in October 2017 ( scrapping date of the French vaccination, the tobacco price increase and the speed limitation announcements).[19,20]

## 3.2 Graphical evidence

### 3.2.1 French vaccination analysis

Figure 1 shows the reaction generated by the announcement on June $16^{th}$, 2017 relative to a mandatory vaccination policy announcement in France. We observe that the maximum number of Twitter users expressing themselves about the vaccination topic is reached the day of the announcement with a total of 2,997 users this day. The same day, 5,234 tweets relative to this topic were published. Consequently, the Twitter users published on average 1.75 tweets the day of the announcement. In accordance to the real-time microblogging design of Twitter, we also notice a non durable reaction after the event, the number of tweets by day is close to the number of the pre-event period six days after the announcement. A second peak of tweets appeared one day after the implementation of the policy of July $4^{th}$, 2017 with a number of tweets reaching 2,839 in the day and 1,826 users.

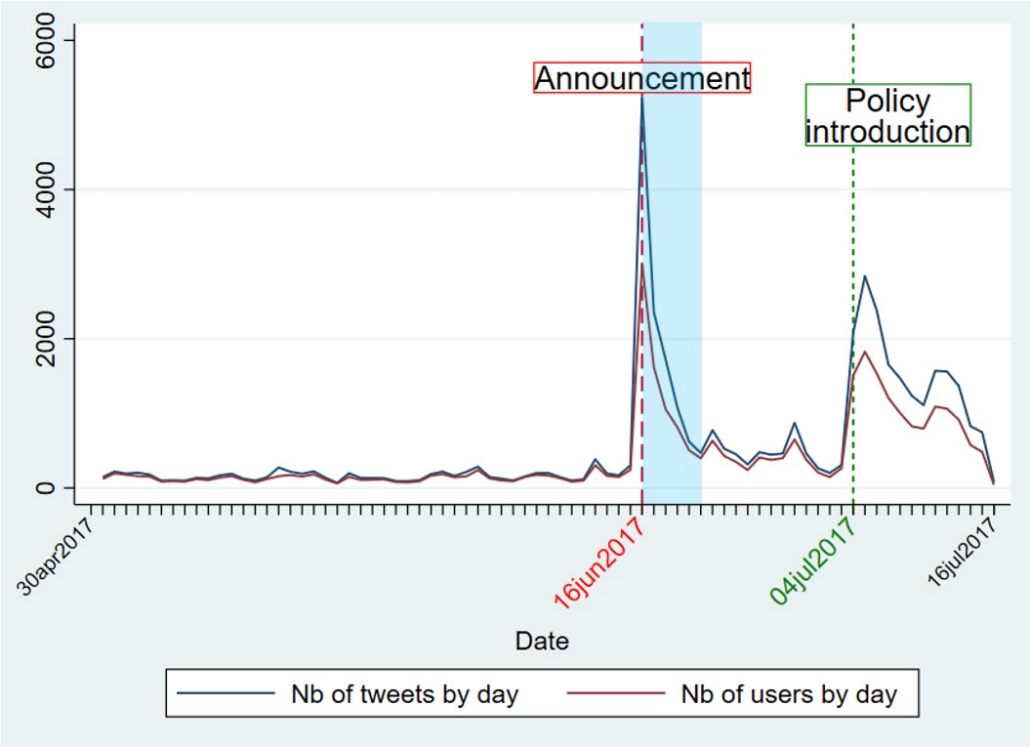
### 3.2.2 European vaccination announcement analysis

We now turn to the analysis of the reactions to vaccination policy announcements in other EU countries. Figure 2 shows the reactions on Twitter concerning the announcements relative to mandatory vaccination in Italy. We observe a peak of tweets the day after the announcement and this one does not correspond to the maximum number of tweets in a day on the studied period. This is in fact the event in Italy which generated the lower peak of tweets. While the announcement generated 3,252 tweets the day after, the policy generated 5,417 tweets on the day of its implementation.We note that the vaccination subject was particularly eventful in

[19] https://www.mediametrie.fr/sites/default/files/2019-01/2019%2001%2003%20-%20CP%20Audience%20Internet%20Global_Novembre2018.pdf

[20] https://www.journaldunet.com/media/publishers/1207513-audience-internet-octobre-2017/

Figure 1: French vaccination policy: Evolution over time of the number of tweets and Twitter users



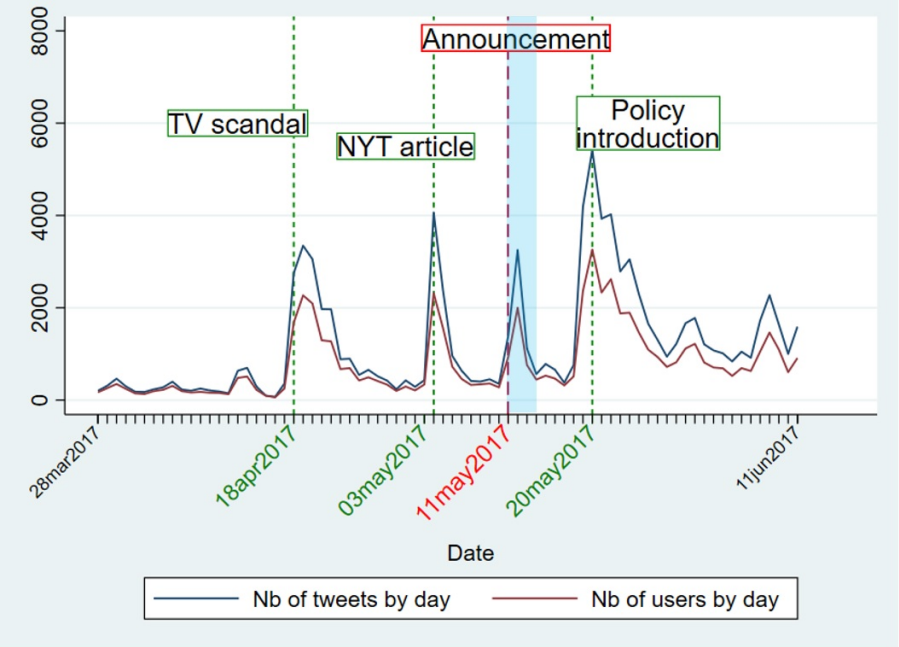

Italy. On April $18^{th}$, 2017 a scandal erupted following the broadcast of a television report about the papillomavirus vaccine.[21] After this scandal another one followed on May $3^{rd}$, 2017 because an article in the newspaper "New York Times" claimed that the Five Star movement in Italy was anti-vaccination.[22] The television scandal of April $18^{th}$ generated 3,345 tweets in the day of April $19^{th}$ and on its side the New York Times article created 4,062 tweets in the day at the exact date of the event. Considering all these close events it is more difficult to analyze what is the duration of the reactions the day of the announcement. However, we can distinguish that most of the reactions lasted four days. We find an average of 1.63 tweets published by users on the vaccination topic the day of the announcement with a total number of 2,000 users this day. This number indicates that the reaction pattern on Twitter is the same between France and Italy. Individuals react on average approximately the same number of times, although it is true that the speak in tweets is smaller in Italy.

In Figure 3 we observe the number of tweets and users over time in Germany. Apart from the announcement, we observe a controversial event before, on March $13^{th}$, 2019 in the form of an exclusion of students from school due to non-vaccination of the children.[23] Nevertheless, this decision remained a local one and should not impact the reactions the day of the announcement.

[21] https://www.davidemaggio.it/archives/146868/report-roberto-benigni-querela-vaccino-papilloma-virus
[22] https://www.nytimes.com/2017/05/02/opinion/vaccination-populism-politics-and-measles.html
[23] https://www.aerzteblatt.de/nachrichten/101610/Schueler-wegen-fehlender-Masernimpfung-von-Schule-ausgeschlossen

We find a lower number of tweets reached the day of the announcement in comparison to the same event in France and in Italy. It can possibly be due to the number of Twitter users in this country that is lower. We observe, however, a publication of 1,166 tweets the day of the announcement. The total number of twitter users is of 820 this day which gives an average of 1.42 tweets by individuals. In conclusion, we can say that even if the quantity of tweets is stronger in France than in Italy and Germany the pattern of reaction seems to be the same with individuals reacting on average more than one time on this theme. The order of magnitude of the reactions nevertheless remains to be studied using trend momentum in order to normalize the reactions to take into account the contexts of each country.

Figure 2: Italian vaccination policy: Evolution over time of the number of tweets and Twitter users

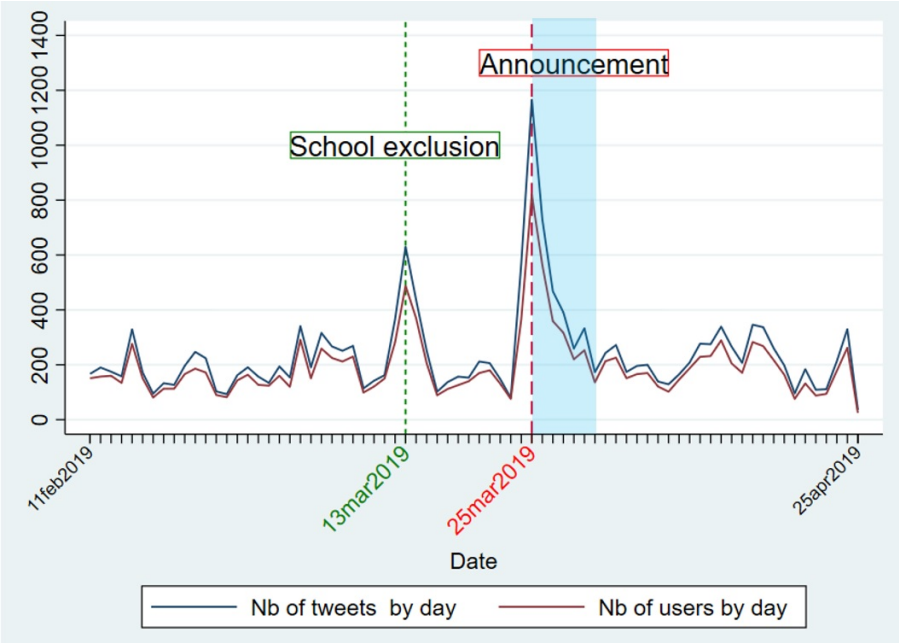



### 3.2.3 French policies announcement analysis

In Figure 4 we observe the evolution of reactions about the tobacco topic. We notice that the maximum number of tweets per day is reached at a different date than the announcement one. This peak of tweets (303 tweets) on October $4^{th}$, 2017, corresponds to a Tobacconists' demonstration. The peak of tweets following the announcement appeared the next day, on October $18^{th}$, 2017 with 299 tweets published by 248 users in the day. This gives an average of 1.20 tweets per user on that date. Individuals therefore seem to react less than with vaccination. We notice again an ephemeral reaction on Twitter after the events, which lasts for four days.

Concerning the carbon tax increase, we see in Figure 5 events before the announcement of the carbon tax increase. On August $30^{th}$, 2017, an article from "Le Monde" journal was

Figure 3: German vaccination policy: Evolution over time of the number of tweets and Twitter users



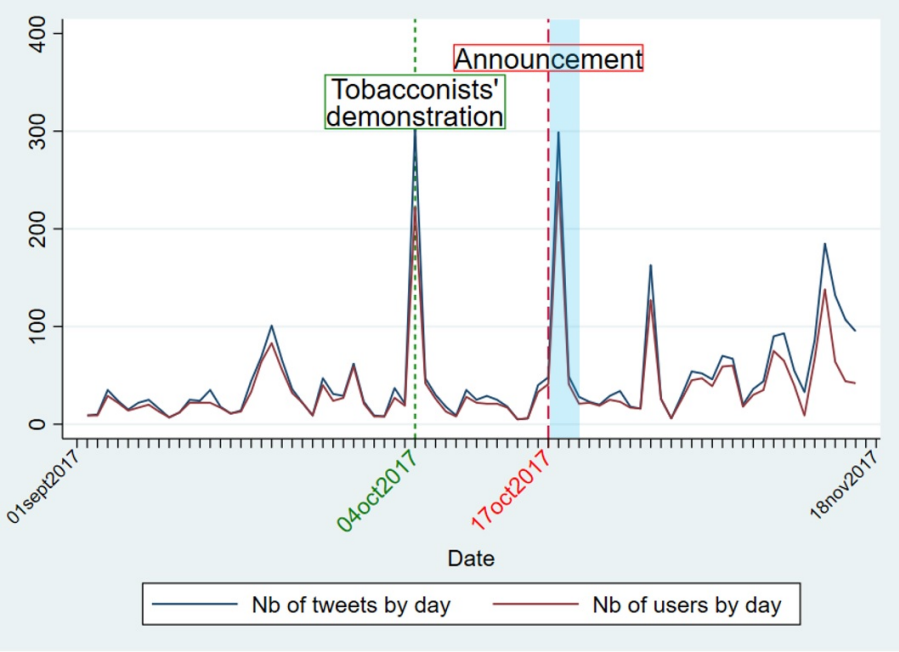

published treating the question of a carbon tax implementation for French and German energy companies in a note by the Terra Nova think tank. Another event that happened before the announcement is the verdict in the carbon tax fraud trial on September 13, 2017. This was a value added tax swindle on the market of pollution rights for which twelve people have been convicted. As these events were unrelated to the announcement of the policy, there could be no anticipation regarding this one. We observe that the announcement did not generate a huge reaction in comparison to the fraud trial event with only 60 tweets published by 58 users about this topic on September $27^{th}$, 2017 (against 148 for the trial fraud event). We note that the average number of tweets published per user is approximately 1.03. We additionally see that the reactions last three days. Hence, for both tobacco and carbon tax there is much less reaction, simultaneously because there are fewer people reacting and because they each tweet less times.

The last French announcement studied is the speed limitation. Besides the announcement of the implementation of this policy, we know that on December $1^{st}$, 2017 an experiment was conducted in two departments. The French media "Le point" consequently published an article about this experiment. We observe that this article did not create a reaction on Twitter. We only observe a huge peak of tweets the day of the announcement. This day, 3,100 individuals published 4,368 tweets relative to this topic. As a result, the average number of tweets published per user is approximately 1.41. For this announcement the reactions lasted approximately four days. Therefore, even if the quantity of tweets is approximately the same as for the vaccine

announcement, individuals react on average fewer times to this announcement.

Comparing the vaccination policy announcement to other constraining policy announcements, we find that individuals react a bit longer and that they will post on average more tweets related to vaccination than for other topics. The discrepancy in reaction between the different announcements can not be explained by the number of individuals affected by them because, as a reminder, vaccination concerns about 3.8 million people, while for tobacco 12 million people are affected and for the carbon tax and speed limit 40 million or more people. Nevertheless, we note that the announcement for which the pattern of reactions on Twitter seems the closest to the one on vaccination is the announcement on the speed limitation. These two policy announcements share common characteristics in terms of restriction of freedom.[24]

Figure 4: Increase of the tobacco price: Evolution over time of the number of tweets and Twitter users




### 3.3 Analysis of the magnitude of reactions

In Figures 7a and 8a we defined the peak of tweets as the day of the event in order to compare the trend momentum of all policies. In the same way, we represent the trend momentum values for Twitter users who reacted to the announcements in the Figures 7b and 8b. The concept of trend momentum normalizes reactions around zero outside of the announcement period because

[24]For the announcement on vaccination, we distinguish tweets of the following nature: "I signed the petition for freedom of vaccination in France...". For the announcement on speed limits we can quote for example this tweet: "Not convinced by those who defend a new diminution of the speed limit to 80km / h . Can the state indefinitely curb individual freedom in the name of risk?"

Figure 5: Increase of the carbon tax: Evolution over time of the number of tweets and Twitter users

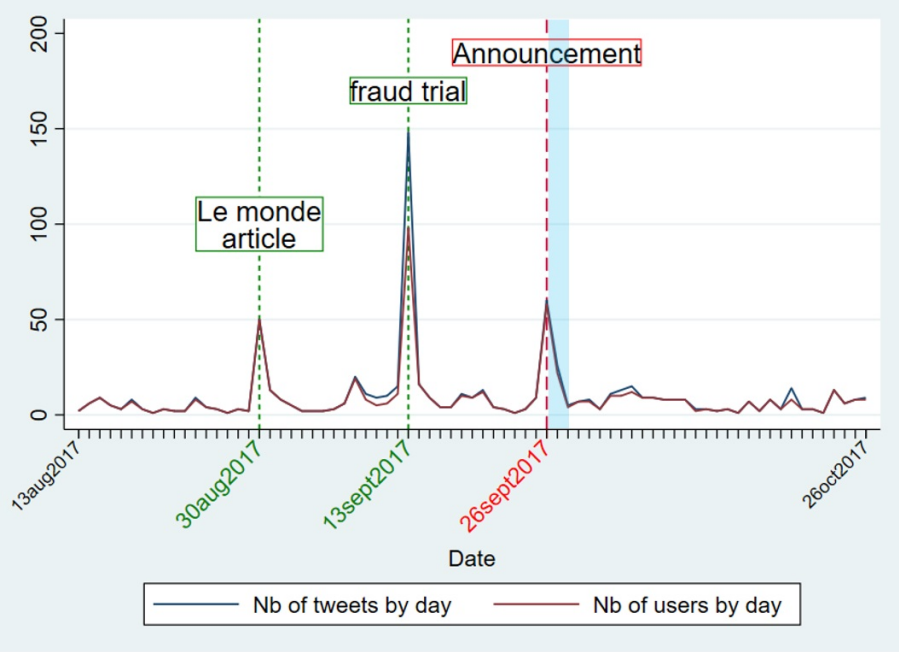
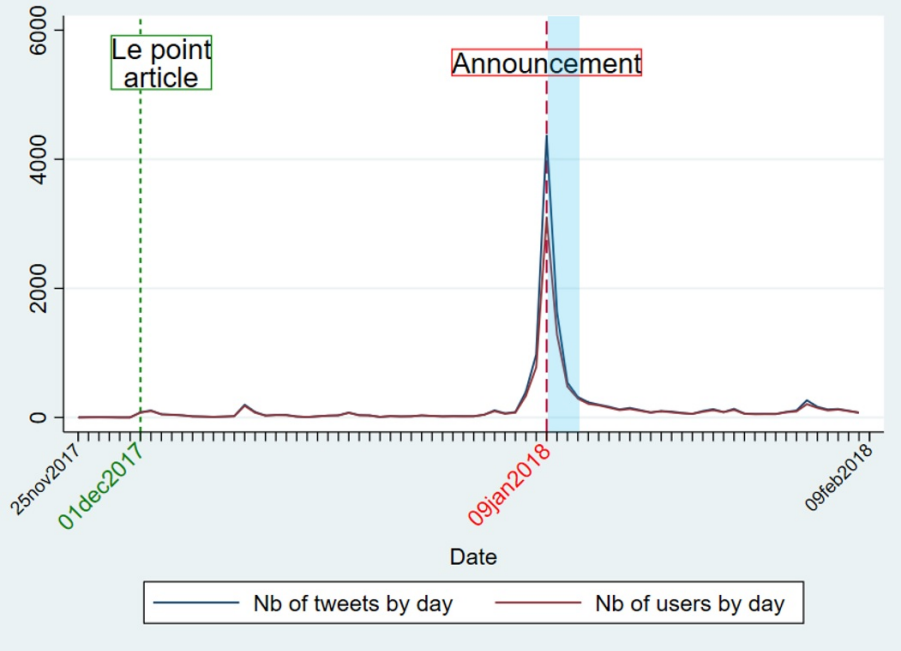



Figure 6: Speed limitation: Evolution over time of the number of tweets and Twitter users



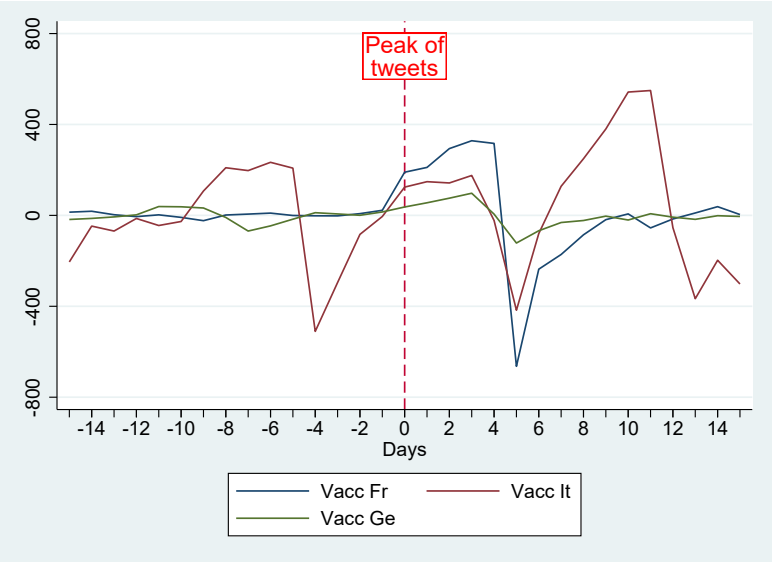
the moving average with a larger time window would then be close to the moving average with a shorter time window. Thus, we observe a variation of tweets and users relatively to the previous period level, for each policy. Consequently, it allows us to analyze the intensity of reactions according to each announcement context.

#### 3.3.1 Trend momentum analysis at the European level

Figures 7a and 7b show a greater intensity of reaction in France than in other countries with regards to vaccination. Whether it is Italy or Germany, the reaction intensity does not reach that of France. Indeed, the trend momentum on vaccination in France is higher than the other two. Note that in the case of Italy, there seems to be a strong reaction but for events related to the vaccination other than the announcement itself. We notice some disturbances on the momentum trend in Italy before the announcement because of the article published in the New York Times. It therefore appears that France is a particularly sensitive country with regard to the implementation of mandatory vaccination compared to other European countries that have made the same announcement.

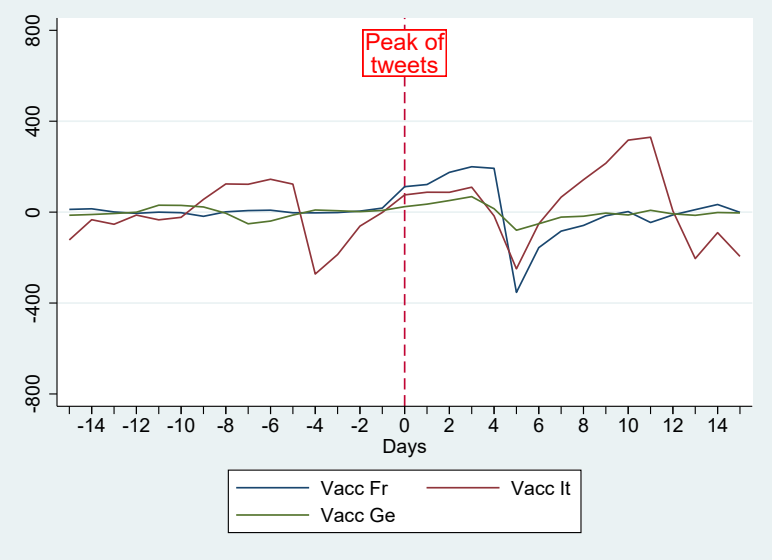
#### 3.3.2 Trend momentum analysis at the French level

Figure 8a shows the different magnitude of reactions on Twitter of French policy announcements. We find that the policy with the largest value of trend momentum is the French vaccination announcement. This result shows that reactions to vaccination are much stronger than for other policies. In figure 8b we distinguish again a higher magnitude for the number of users who tweeted about the mandatory vaccination announcement in France than for the other announcements. We can affirm that the intensity of the reactions, with regard to the vaccine announcement in France, is not only due to the sensitivity of this subject for certain individuals (who are then led to tweet repeatedly) but also to the number of people who feel concerned by it. However, when we consider the number of users, we also note a smaller difference of magnitude between the policies, especially the difference between the vaccination announcement in France and the speed limitation is tiny. Nevertheless, we note that the intensity of reaction to the speed limitation is also important. The common characteristic of these two announcements is the restriction of freedom for the individuals concerned by these policies. Thus, it seems that the intensity of reactions is due to this common factor. We therefore conclude that the restriction of freedom is a highly sensitive subject.




(a) Trend momentum of European policies calculated on the number of tweets

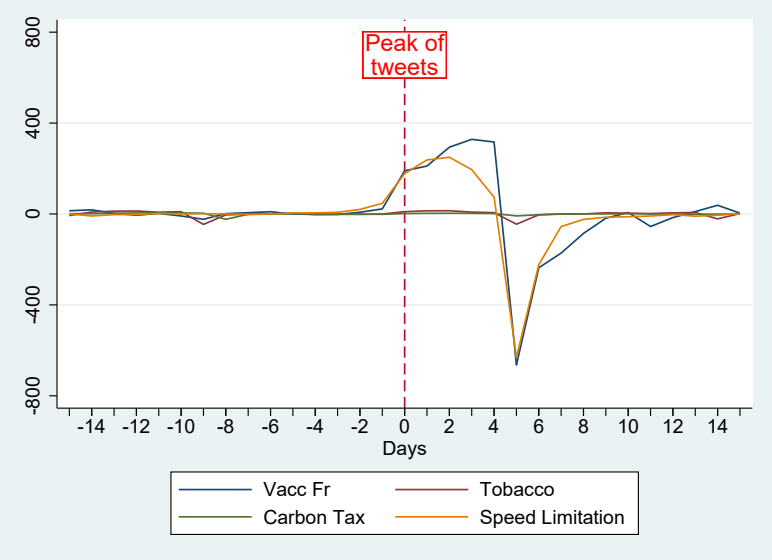
Note: $TM(1) = MA(1,4) - MA(1,5)$




(b) Trend momentum of European policies calculated on the number of Twitter users

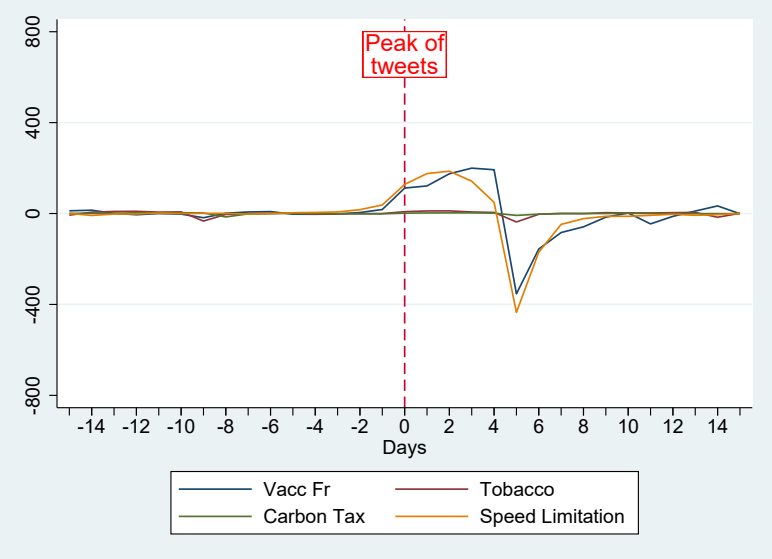
Note: $TM(1) = MA(1,4) - MA(1,5)$

Figure 7: Evolution of Trends Momentum over time in Europe




(a) Evolution over time of Trend Momentum of French policies calculated on the number of tweets

Note: $TM(1) = MA(1,4) - MA(1,5)$




(b) Evolution over time of Trend Momentum of French policies calculated on the number of Twitter users

Note: $TM(1) = MA(1,4) - MA(1,5)$

Figure 8: Evolution of Trends Momentum over time for French policy announcements

# 4 ROBUSTNESS TESTS

## 4.1 Trend Momentum with other time windows

We show in Figures 7b to 8b in the Appendix that we obtain consistent results using the TM concept by varying the time window between the two moving averages. Compared to similar announcements in Europe, France has TMs of higher magnitudes, both on the number of tweets and on the number of users. In the same vein, in France, we find that the magnitudes of reactions are greater for the vaccine policy and the speed limit, and that these magnitudes are very close.

## 4.2 Analysis on one key word

The number of words to express oneself on each of the topics being different we conducted a similar analysis using only one keyword per topic. This analysis allows us to control whether reactions observed the day of the announcement are overestimated or not for policies with a larger number of keywords. Therefore, we keep only the word "vaccine" in the singular and plural for the vaccination policies in Europe. For the different French policies we have kept the words: "vaccine", "tobacco", "carbon tax" and "80kmh". Our results are virtually unchanged (see Figures 13 to 16).

# 5 DISCUSSION

This paper investigates reactions to a new vaccination requirement in France on Twitter. We conduct a comparison with similar announcement in Europe and constraining policy announcements in France. We first observe that every policy announcement is followed by reactions on Twitter. In Italy and Germany, reactions seem to be of approximately the same duration than France with the common characteristic of a high volatility in the number of tweets and the number of users involved in the topic even several days after the announcement. In comparison to other policy announcements in France, we find that individuals react for a longer period for the compulsory vaccination announcement and we do not find as much volatility in the days following the announcement as in the comparison between vaccine announcements in Europe.

Regarding the magnitude of reactions on the vaccination topic between countries, we observe a magnitude much more important in France. This finding seems to indicate a greater sensitivity to this type of statement in France and is consistent with the rest of the literature (Larson et al., 2016). If we compare the French announcements, the magnitude of the reac-

tions about vaccination is the highest in terms of not only number of tweets but also number of individuals involved in this topic. The vaccination subject seems to be sensitive in comparison to other announcements. This result is particularly true if we put the magnitude of the reactions in perspective to the number of people directly concerned by the announcement, since the vaccination one directly affects far fewer individuals than the other policies. Consequently, we argue that the magnitude effect is not due to the volume of people affected by the policy but rather by people who feel concerned about it. We note, however, that the magnitude of the announcement having the most similar characteristics to that of vaccination is the announcement on the speed limitation which has a magnitude of reactions close to that one. One explanation for this is that the magnitude of the reactions to vaccination is due to the fact that French people seem to be particularly sensitive about the obligations imposed on them for their own good. Through comparison with other policies, this study brings to the literature a better understanding of the reasons for strong online reactions, reflecting the degree of controversy within society.

With this analysis on the social network, we conclude a high level of controversy provoked by the vaccination announcement in France. The French population seems particularly sensitive on this subject. If we consider the COVID-19 vaccination strategy adopted by the French government with a non mandatory vaccination, a fragile targeted population that can refuse the vaccine anytime (for a dependent person, one relative refusing the vaccine is enough), it then seems to be adapted to the population that constitutes the territory. Nevertheless, we must remember that the study was conducted on a single social network. In the future, further analysis should be conducted on other ones. It would also be relevant to know the impact of this controversy on the behavior of the population with the emergence of new vaccines.

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# Appendix

Data collection details:

- **French mandatory vaccination announcement:**
  - Date used: 16 June 2017
  - Date of tweets collection: from 2 May 2017 to 16 July 2017
  - Words used to collect the tweets : "vaccin", "vaccins", "vaccination" and "antivax"
- **Italian mandatory vaccination announcement:**
  - Date used: 11 May 2017
  - Date of tweets collection: from 28 March 2017 to 11 June 2017
  - Words used to collect the tweets : "vaccino", "vaccini", "vaccinazione", "vaccinazioni", "antivaccinismo" and "antivaccinisti"
- **German mandatory vaccination announcement:**
  - Date used: 25 March 2019
  - Date of tweets collection: from 11 February 2019 to 25 April 2019
  - Words used to collect the tweets : "impfstoff", "impfung", "vakzin", "schutzimpfung", "impfen", "impfgegner", "anti-impf", "impfkritiker" and "impfzwang"
- **Tobacco price increase policy in France:**
  - Date used: 17 October 2017
  - Date of tweets collection: from 2 September 2017 to 17 November 2017
  - Words used to collect the tweets : "hausse du prix du tabac", "hausse du prix des tabac", "hausse du tabac", "hausse du prix des cigarettes", "hausse du prix des clopes" et "tabac"
- **Tax carbon increase**
  - Date used: 26 September 2017
  - Date of tweets collection: from 13 August 2017 to 26 October 2017
  - Words used to collect the tweets : "taxe carbone"

- **80kmh speed limit on secondary roads:**
  - Date used: 1st December 2017
  - Date of tweets collection: from 25 November 2017 to 9 February 2018
  - Words used to collect the tweets : "80km/h" and "80kmh"

DESCRIPTIVE STATISTICS TABLES:

Table 1: Descriptive statistics of tweet databases by policy

| **Policies** | **Total nb of tweets over 76 days** | **Daily Mean** | **Daily Std. Dev.** | **Med nb of daily tweets** | **P5 nb of daily tweets** | **P95 nb of daily tweets** | **Min nb of daily tweets** | **Max nb of daily tweets** |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| French vacc. | 43,614 | 571.97 | 824.75 | 210 | 93 | 2354 | 69 | 5,234 |
| Italian vacc. | 91,422 | 1202.92 | 1186.14 | 770 | 176 | 4025 | 70 | 5417 |
| German vacc. | 17,733 | 239.63 | 164.33 | 196 | 95 | 569 | 36 | 1166 |
| Tobacco price | 3,559 | 46.83 | 54.39 | 29 | 7 | 163 | 5 | 303 |
| Carbon tax | 730 | 9.86 | 18.74 | 6 | 1 | 26 | 1 | 148 |
| Limitation speed | 12,882 | 169.50 | 536.69 | 56 | 3 | 540 | 1 | 4368 |

Note: Column 1 gives the total number of tweets collected over the considered period of 76 days. Column 2 to 8 provides descriptive statistics of the number of daily tweets on the 76 days. Column 2 shows the mean of daily tweets and column 3 the standard deviation (Std. Dev.). Column 4 to 8 provide information about the distribution. Column 4 gives the median while column 5 and 6 show respectively the $5^{th}$ percentile (P5) and the $95^{th}$ percentile (P95). Finally, column 7 and 8 show the minimum and the maximum value of daily tweets over the period.

Source: Twitter web-scrapping

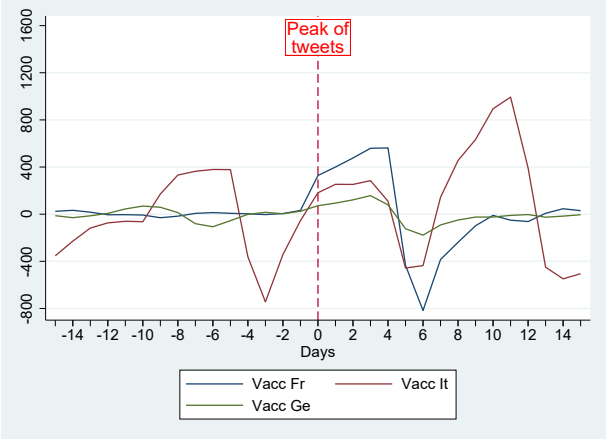
Table 2: Descriptive statistics of users who posted at least one tweet related to the policy

| **Policies** | **Total nb of users over 76 days** | **Daily Mean** | **Daily Std. Dev.** | **Med nb of daily users** | **P5 nb of daily users** | **P95 nb of daily users** | **Min nb of daily users** | **Max nb of daily users** |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| French vacc. | 18,861 | 407.37 | 510.69 | 170.5 | 76 | 1,537 | 43 | 2,997 |
| Italian vacc. | 24,686 | 796.052 | 714.83 | 518 | 131 | 2,330 | 60 | 3,262 |
| German vacc. | 9,391 | 194.70 | 118.14 | 165 | 81 | 370 | 25 | 820 |
| Tobacco price | 1,640 | 36.70 | 41.03 | 23.5 | 7 | 127 | 5 | 248 |
| Carbon tax | 538 | 8.61 | 13.80 | 6 | 1 | 22 | 1 | 98 |
| Limitation speed | 7,841 | 138.45 | 387.73 | 54.5 | 3 | 478 | 1 | 3,100 |

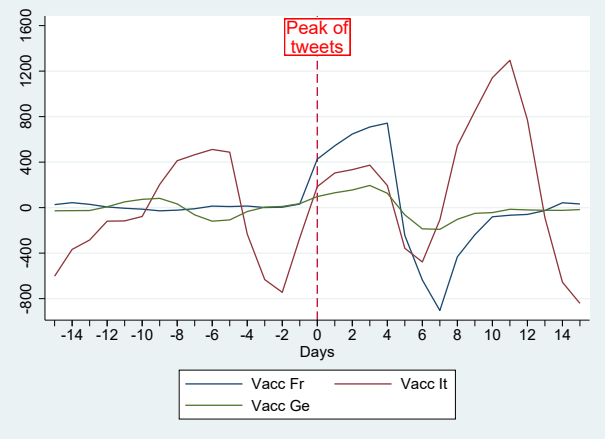
Note: Column 1 gives the total number of users who posted at least one tweet on the topic over the considered period of 76 days. Column 2 to 8 provides descriptive statistics of the number of daily users on the 76 days. Column 2 shows the mean of daily tweets and column 3 the standard deviation (Std. Dev.). Column 4 to 8 provide information about the distribution. Column 4 gives the median while column 5 and 6 show respectively the $5^{th}$ percentile (P5) and the $95^{th}$ percentile (P95). Finally, column 7 and 8 show the minimum and the maximum value of daily users over the period.

Source: Twitter web-scrapping

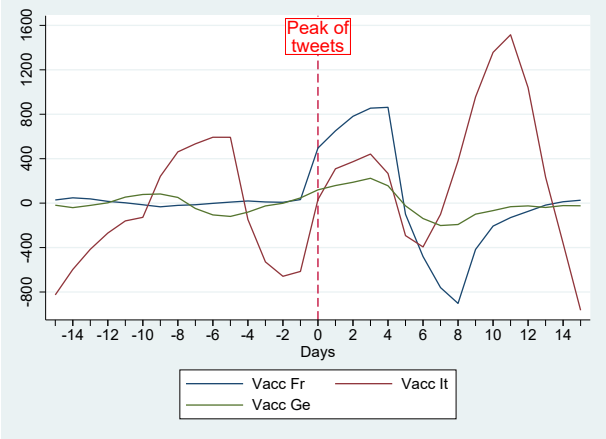
ROBUSTNESS TESTS:



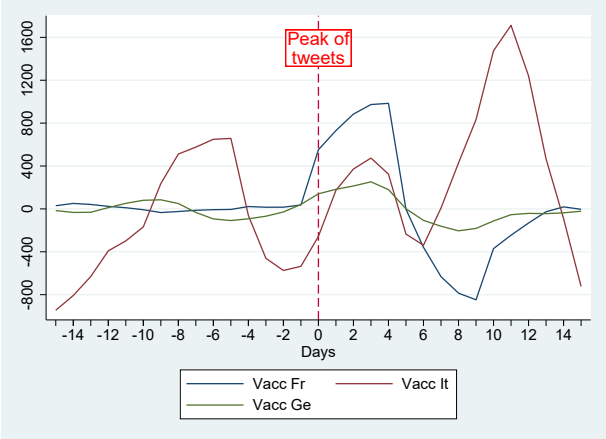

(a) Evolution over time of TM on the number of tweets in Europe. $TM(1) = MA(1,4) - MA(1,6)$




(b) Evolution over time of TM on the number of tweets in Europe. $TM(1) = MA(1,4) - MA(1,7)$

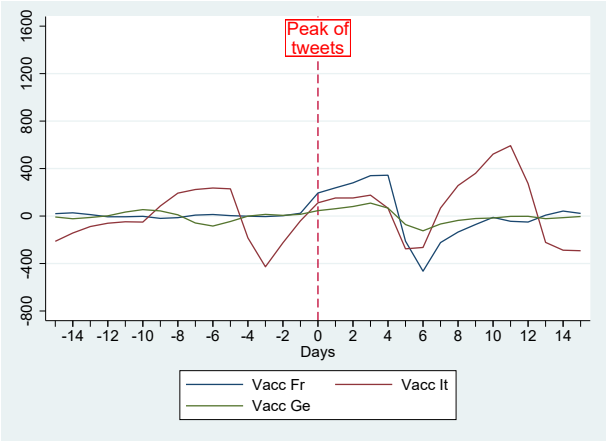



(c) Evolution over time of TM on the number of tweets in Europe. $TM(1) = MA(1,4) - MA(1,8)$

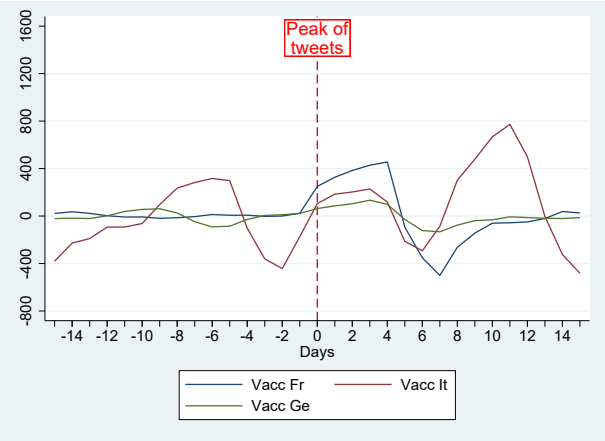



(d) Evolution over time of TM on the number of tweets in Europe. $TM(1) = MA(1,4) - MA(1,9)$

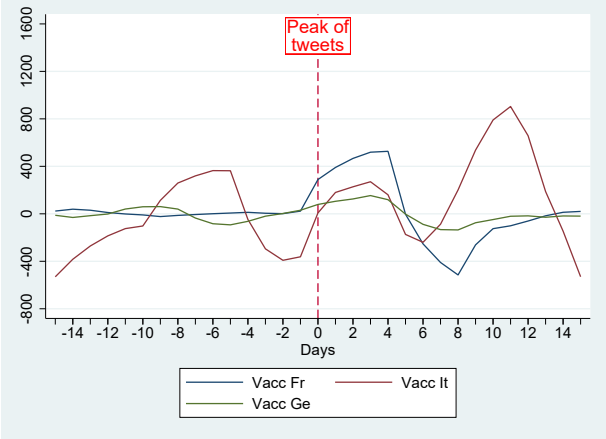
Figure 9: Evolution of Trends Momentum calculated on the number of tweets over time in Europe with different Moving Averages



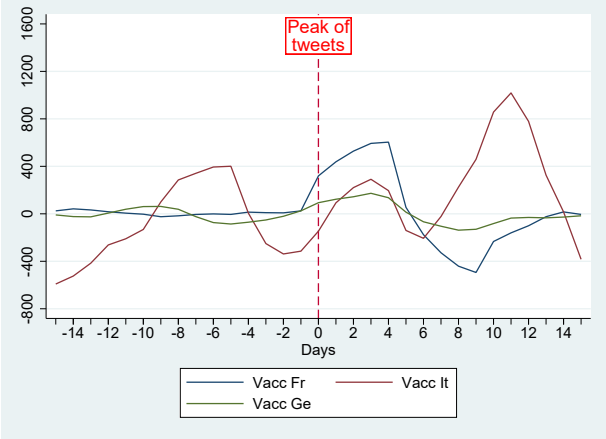

(a) Evolution over time of TM on the number of users in Europe. $TM(1) = MA(1,4) - MA(1,6)$




(b) Evolution over time of TM on the number of users in Europe. $TM(1) = MA(1,4) - MA(1,7)$

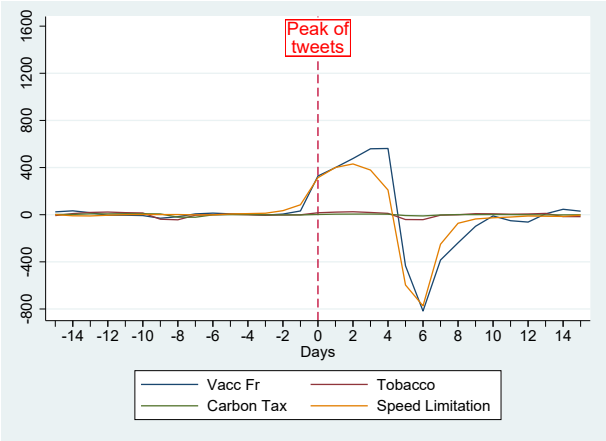



(c) Evolution over time of TM on the number of users in Europe. $TM(1) = MA(1,4) - MA(1,8)$

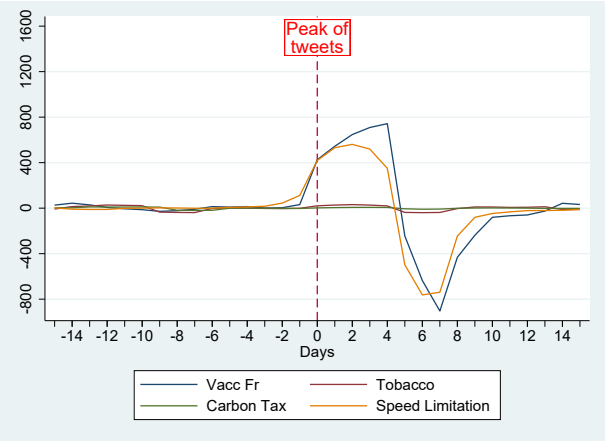



(d) Evolution over time of TM on the number of users in Europe. $TM(1) = MA(1,4) - MA(1,9)$

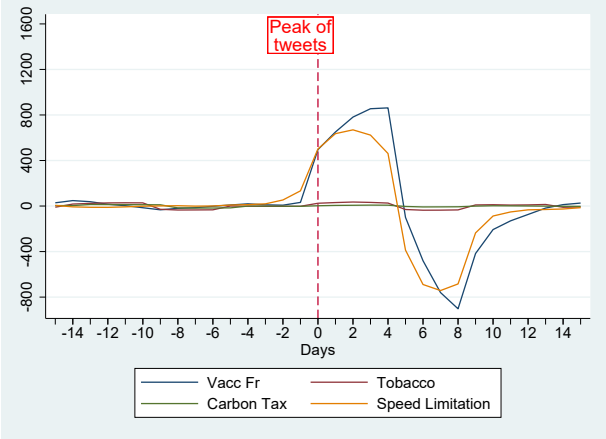
Figure 10: Evolution of Trends Momentum calculated on the number of users over time in Europe with different Moving Averages



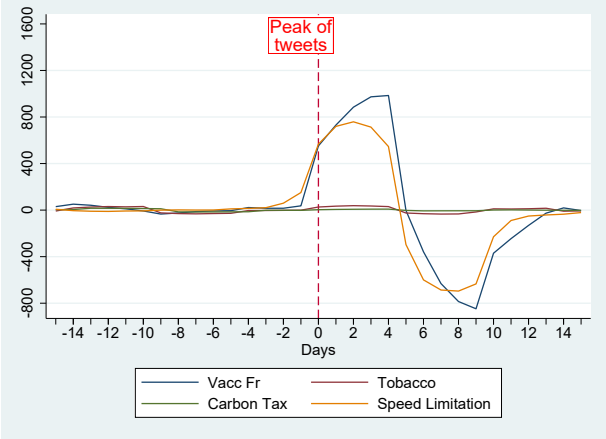

(a) Evolution over time of TM on the number of tweets in France. $TM(1) = MA(1,4) - MA(1,6)$




(b) Evolution over time of TM on the number of tweets in France. $TM(1) = MA(1,4) - MA(1,7)$

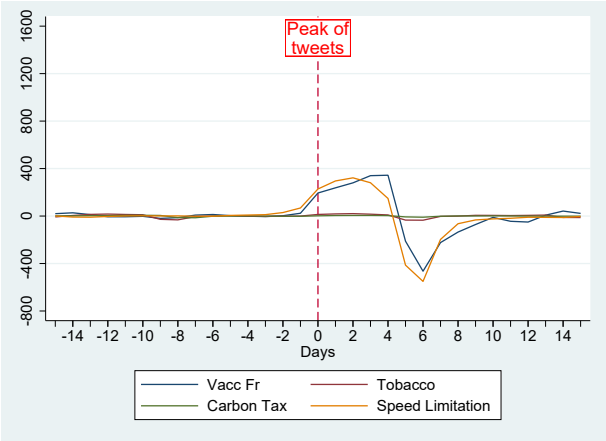



(c) Evolution over time of TM on the number of tweets in France. $TM(1) = MA(1,4) - MA(1,8)$

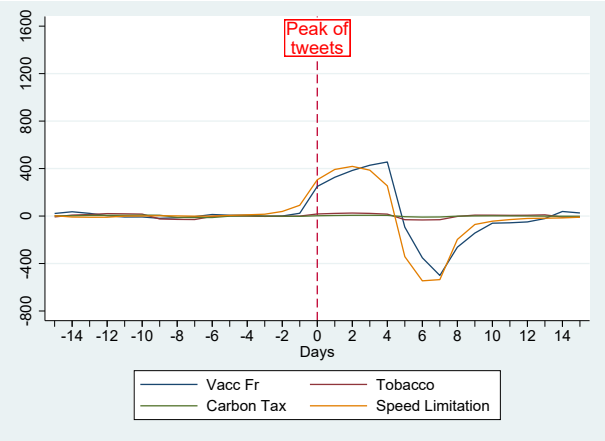



(d) Evolution over time of TM on the number of tweets in France. $TM(1) = MA(1,4) - MA(1,9)$

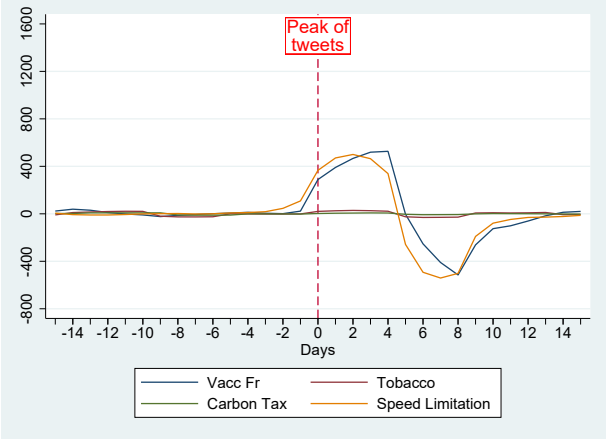
Figure 11: Evolution of Trends Momentum calculated on the number of tweets over time in France with different Moving Averages



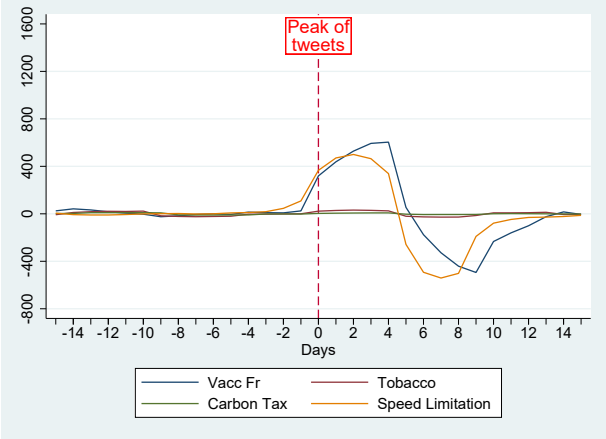

(a) Evolution over time of TM on the number of users in France. $TM(1) = MA(1,4) - MA(1,6)$




(b) Evolution over time of TM on the number of users in France. $TM(1) = MA(1,4) - MA(1,7)$

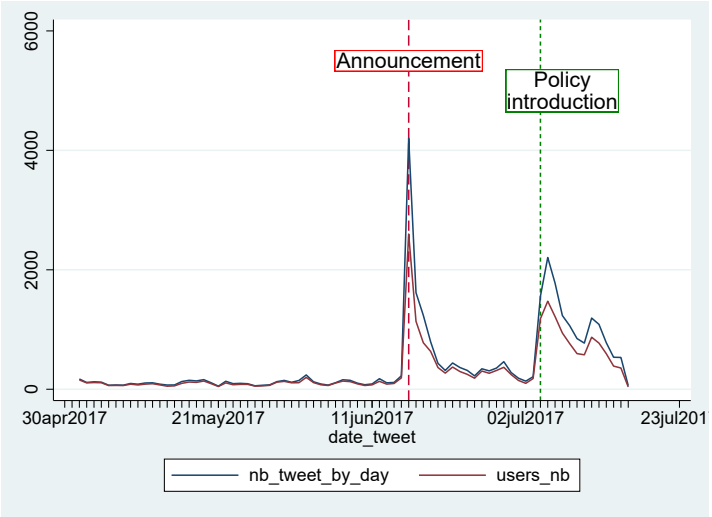



(c) Evolution over time of TM on the number of users in France. $TM(1) = MA(1,4) - MA(1,8)$

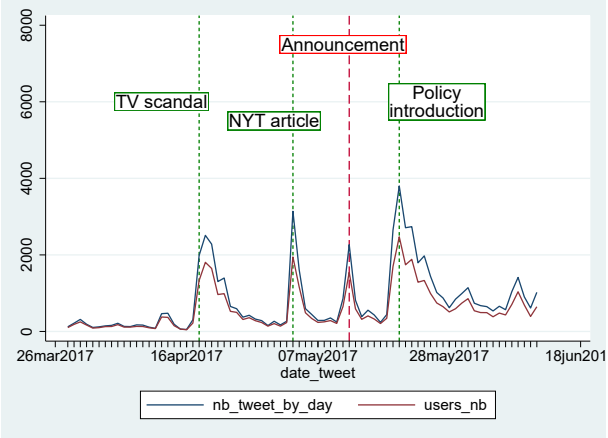



(d) Evolution over time of TM on the number of users in France. $TM(1) = MA(1,4) - MA(1,9)$

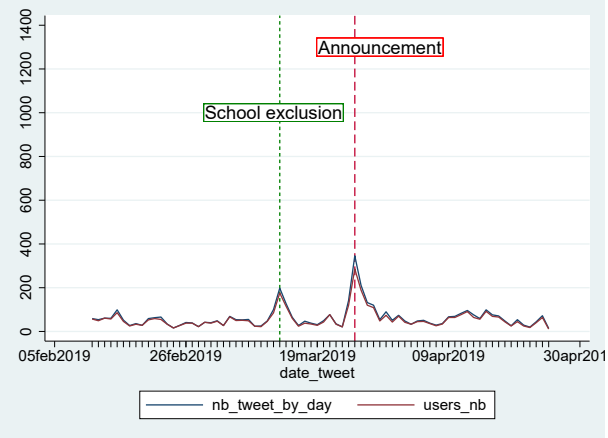
Figure 12: Evolution of Trends Momentum calculated on the number of users over time in France with different Moving Averages




(a) French vaccination policy: Evolution over time of the number of tweets and Twitter users with one key word



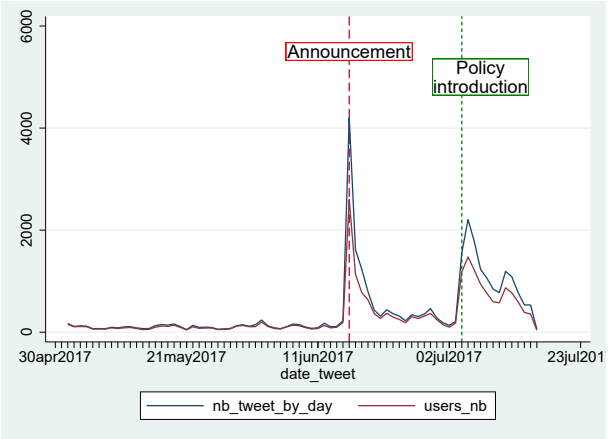

(b) Italian vaccination policy: Evolution over time of the number of tweets and Twitter users with one key word



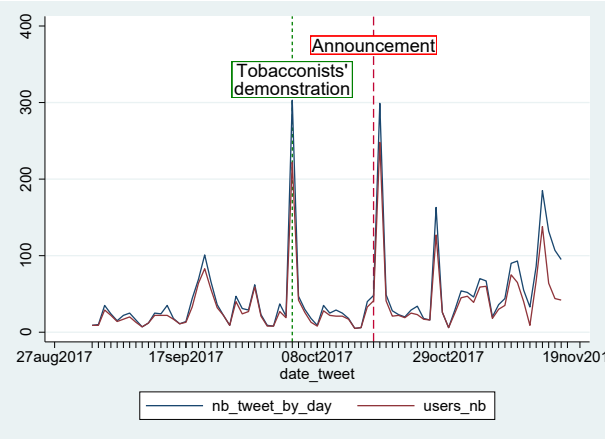

(c) German vaccination policy: Evolution over time of the number of tweets and Twitter users with one key word

Note: The key word used is "vaccine", singular or plural.

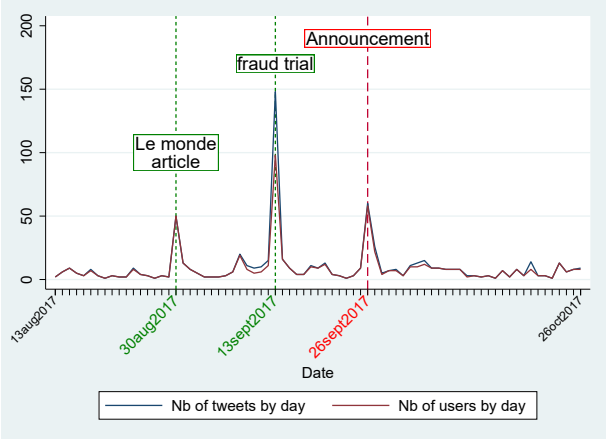
Figure 13: Evolution over time of the number of tweets and Twitter users with one key word in Europe



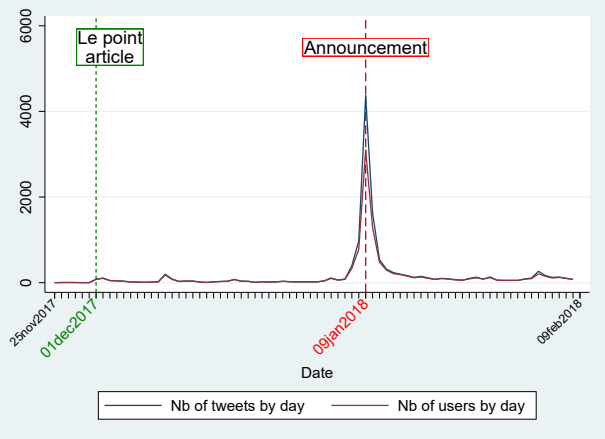

(a) French vaccination policy: Evolution over time of the number of tweets and Twitter users with one key word




(b) Tobacco price policy: Evolution over time of the number of tweets and Twitter users with one key word



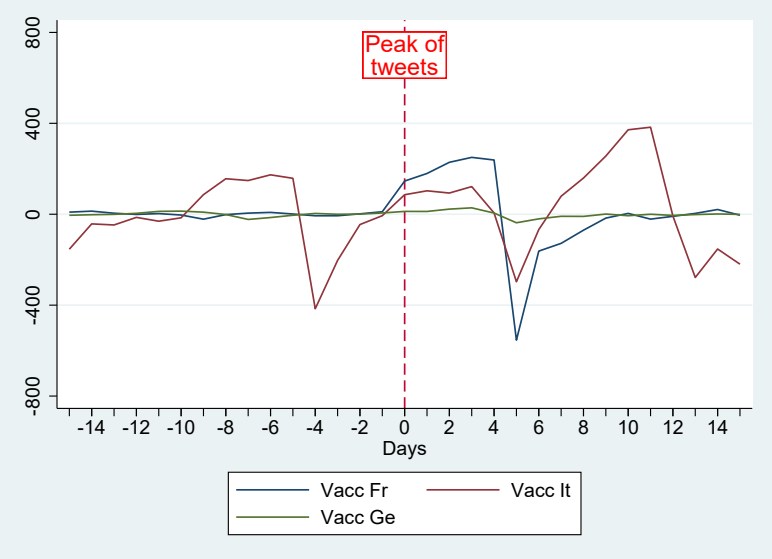

(c) Carbon tax policy: Evolution over time of the number of tweets and Twitter users with one key word




(d) Speed limitation policy: Evolution over time of the number of tweets and Twitter users with one key word

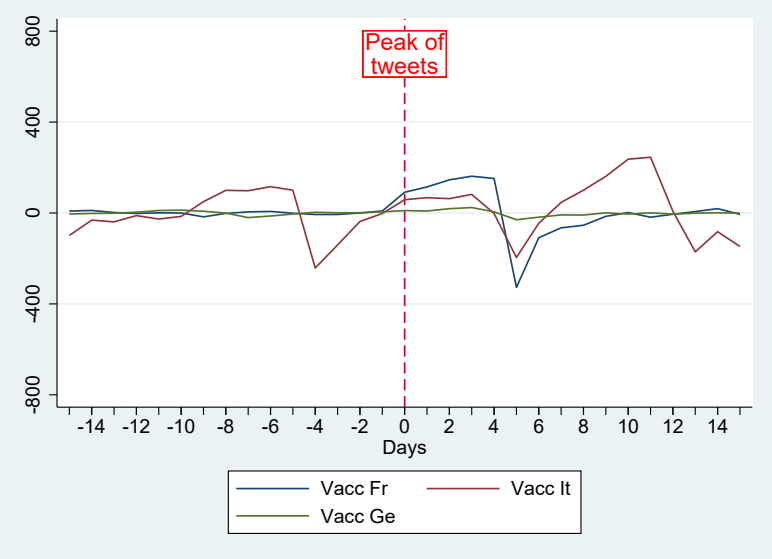
Note: The key words used is "vaccine","tobacco", "carbon tax", "80kmh".

Figure 14: Evolution over time of the number of tweets and Twitter users with one key word in France




(a) Trend momentum of European policies calculated on the number of tweets

Note: $TM(1) = MA(1,4) - MA(1,5)$

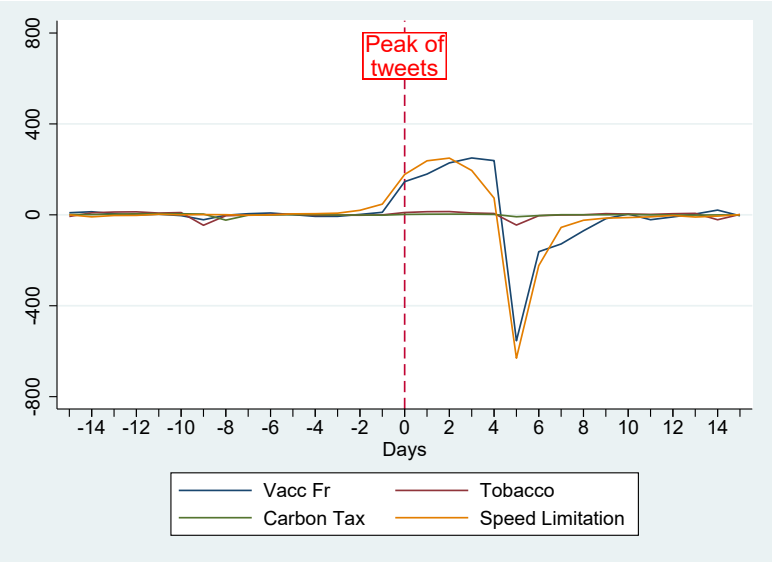



(b) Trend momentum of European policies calculated on the number of Twitter users

Note: $TM(1) = MA(1,4) - MA(1,5)$

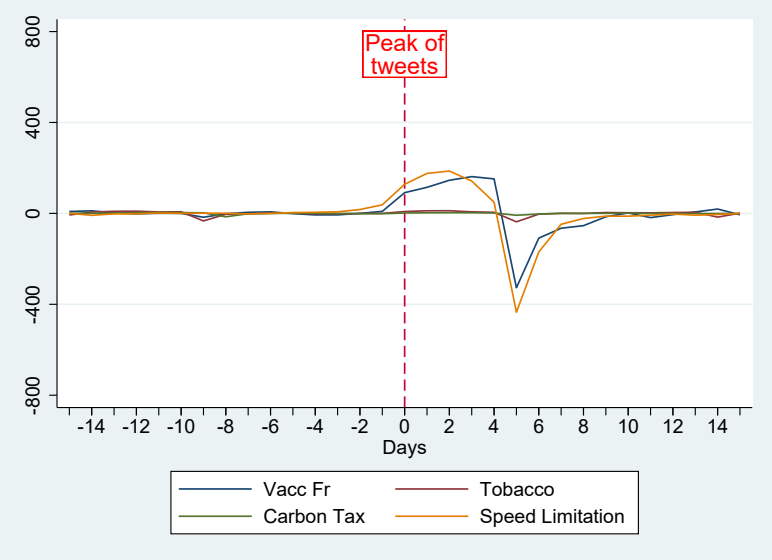
Note: The key word used is "vaccine", singular or plural.

Figure 15: Evolution of Trends Momentum over time in Europe with one key word




(a) Evolution over time of Trend Momentum of French policies calculated on the number of tweets

Note: $TM(1) = MA(1,4) - MA(1,5)$




(b) Evolution over time of Trend Momentum of French policies calculated on the number of Twitter users

Note: $TM(1) = MA(1,4) - MA(1,5)$

Note: The key words used is "vaccine","tobacco", "carbon tax", "80kmh".

Figure 16: Evolution of Trends Momentum on one key word over time for French policy announcements