#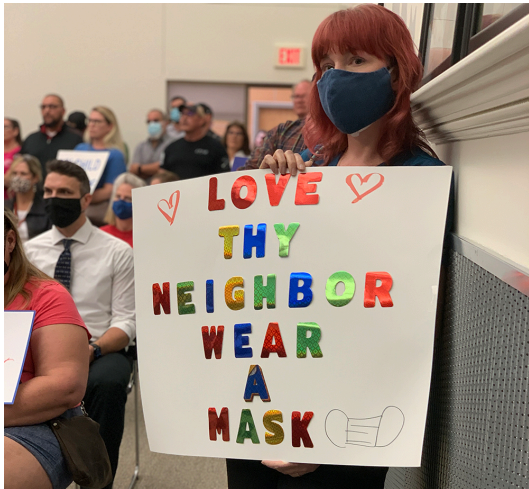 Statistically Evaluating Social Media Sentiment Trends towards COVID-19 Non-Pharmaceutical Interventions with Event Studies

Jingcheng Niu[1,2,3], Erin E. Rees[1], Victoria Ng[1], Gerald Penn[2,3]

[1]Public Health Agency of Canada

[2]University of Toronto, [3]Vector Institute

Sentiment towards
Non-Pharmaceutical Interventions

Social Media Sentiment towards NPIs

- Neural sentiment analysis is a powerful tool to understand the public's opinion on NPIs.

- Studies often plot out the daily average sentiment to understand sentiment trends.

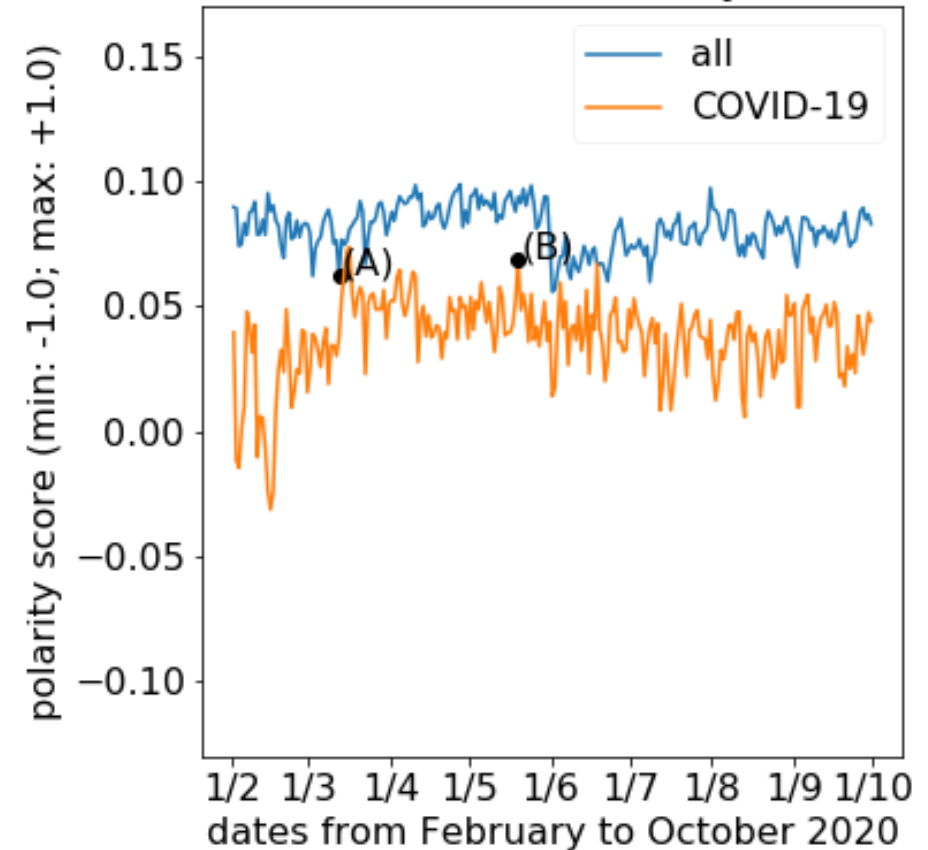- *However, there are several issues with the current approaches.*
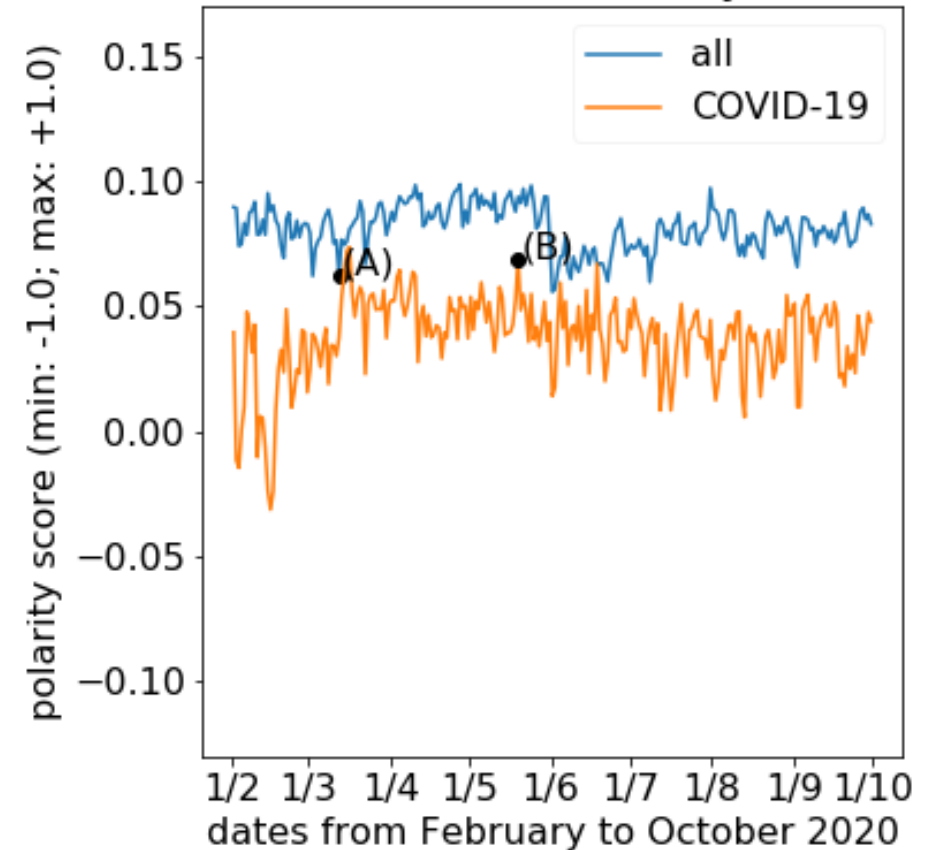
Wang et al. (2020a) found that:
- The **overall** valence reached a **minimum** when the government announced a "lock-down" (A);
- The **COVID-19** valence reached a **maximum** when Amsterdam announced release measures (B).

Issues

- Why event A caused a minimum in the **overall** trend but event B caused a maximum in the **COVID-19** trend?

- The data are very noisy, there are other peaks and valleys.

- NO **statistical analysis** available to verify their findings!

- The sentiments are not independent: overall sentiment can affect each NPI sentiment.

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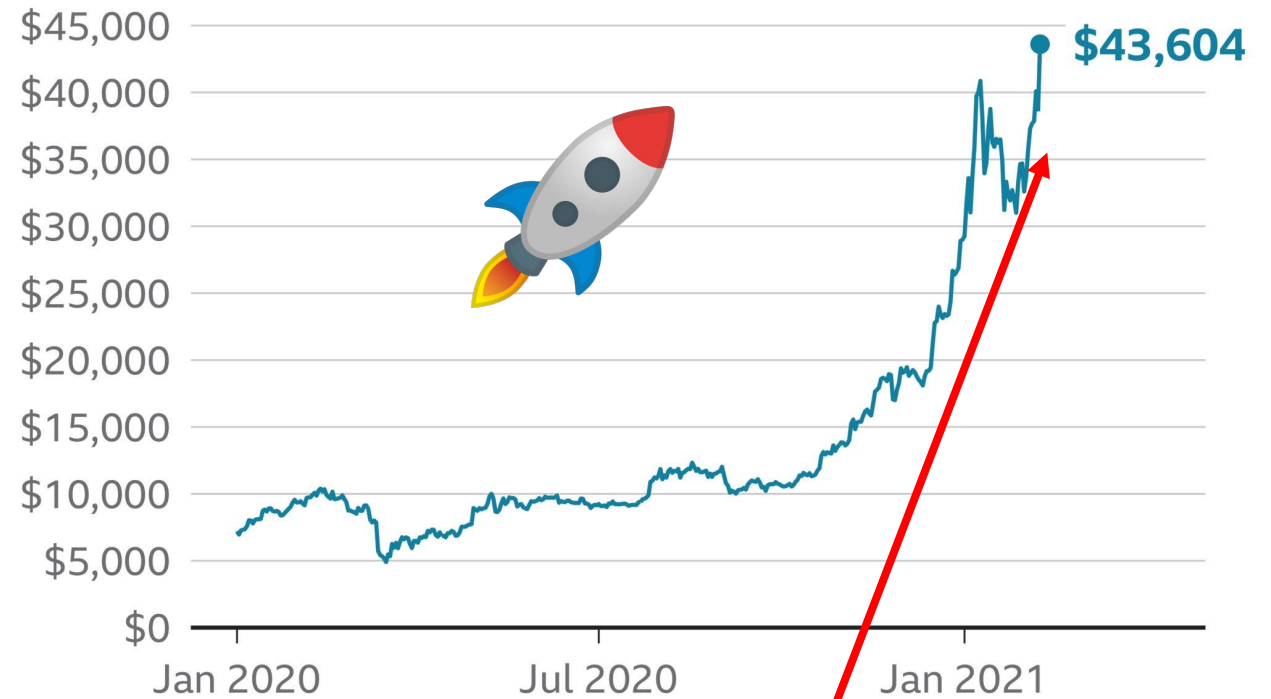
Similar Problem in finance

I bought a lot of bitcoins!

Bitcoin jumps as Tesla buys currency

Tesla purchased $1.5bn of Bitcoin and announced it will start accepting the cryptocurrency as payment

$43,604

Source: Bloomerg. Last update 08 February 2021, 15:00 GMT

BBC

"The news caused the price of Bitcoin to jump **17%** to $44,220, a record high."

BBC business: https://www.bbc.com/news/business-55939972

However, does the news really **cause** the price jump?

- The price of bitcoin was going up before the news.
- How much of the jump is caused by the news?
- Statistical test?

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Jul 2020   Jan 2021

date 08 February 2021, 15:00 GMT   **BBC**

Event Study

(Brown and Warner, 1980, 1985)

However, does the [...] really **cause** the price jump[...]
- The price of bitcoin was going up before the news.
- How much of the jump is caused by the news?
- Statistical test?

[...]e news **caused** the price of Bitcoin to jump **17%** to $44,220, a record high."

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Event Study Method: In Finance

- The "Event Study" method is widely used in the finance industry to examine the return behaviour of a security after the market experiences an unexpected event (such as a stock split or an earnings release).

- Basic Idea:
  - If there are **no unexpected events**, the return of a stock should reflect the **overall trend of the market**,
  - Therefore, the expected return of a stock can be estimated,
  - The difference between the estimation and the real value is caused by the event.

Event Study: In Finance

- At time t, the actual return R_t:

$$R_t = \mathbb{E}[R_t] + \xi_t$$

- We can estimate the expected return with a Market Model:

$$\mathbb{E}[R_t] = \alpha + \beta \cdot R_{market}\,(t)$$

- We can analyze the effect of unexpected events by observing the abnormal return (cumulative average residual):

$$\mathrm{CAR}(t_1, t_2) = \sum_{t=t1}^{t_2} \xi_t$$

Event Study: In Public Health

NPI Sentiment

- Overall Sentiment
  - An aggregation of discussion on all aspects of the pandemic.
- NPI Sentiment
  - An aggregation of people's reaction towards the NPI.
  - Different people have different perspective of the NPI.

Finance

- Market Return (Index)
  - An aggregation of the majority of stocks traded on the market.
- Individual Stock Return
  - An aggregation of the stock traders' reaction.
  - Different traders have different judgement.

Event Study: In Public Health

- The actual sentiment:

$$S_t = \mathbb{E}[S_t] + \xi_t$$

- We can estimate the expected sentiment with the "market model" in the context of public health:

$$\mathbb{E}[S_t] = \alpha + \beta \cdot S_{overall}(t)$$

- We can analyze the effect of public health events by observing the CAR:

$$\mathrm{CAR}(t_1, t_2) = \sum_{t=t1}^{t_2} \xi_t$$

Experimental Setup

- Gilbert et al. (2020) collected 5,979,759 English Twitter samples from Canada from January 21, 2020 to August 23, 2020.

- NPI related tweets were extracted using NPI related keywords.

- NTUA-SLP (Baziotis et al., 2018) Valence Regression Model.

Wearing a mask

(i)

- Analysis of tweets containing a mask related keyword.

- Event 1: On April 6th, 2020, the advisory for mask wearing was revised: mask wearing was encouraged.

(ii)

- Event 2: On May 20th, 2020, a recommendation for the general public to wear masks in public was formally issued.

(iii)

event 1   event 2

Canadian valence index
wearing a mask valence
wearing a mask valence-moving average
model predicted valence

abnormal returns
CAR
tweet volume
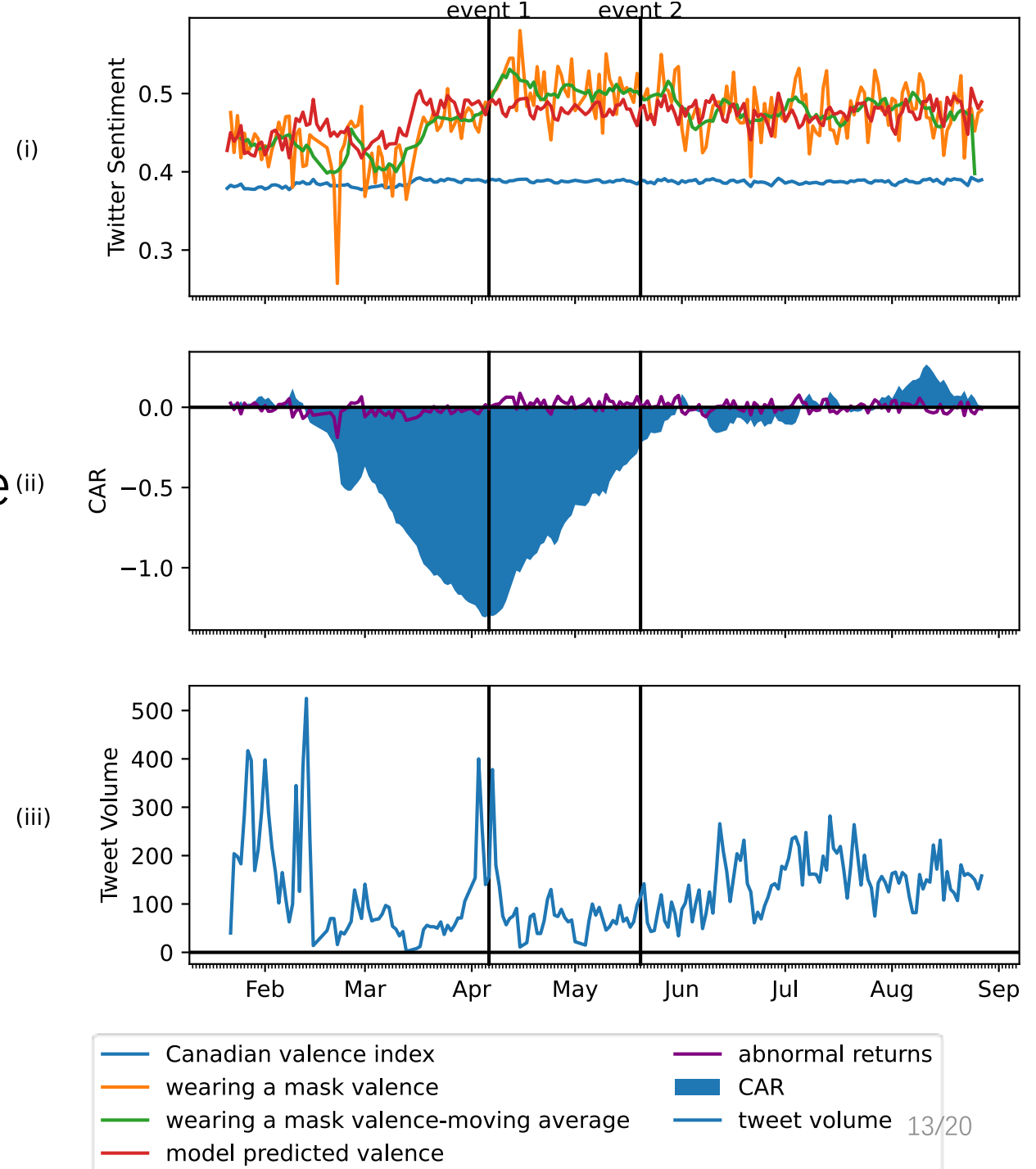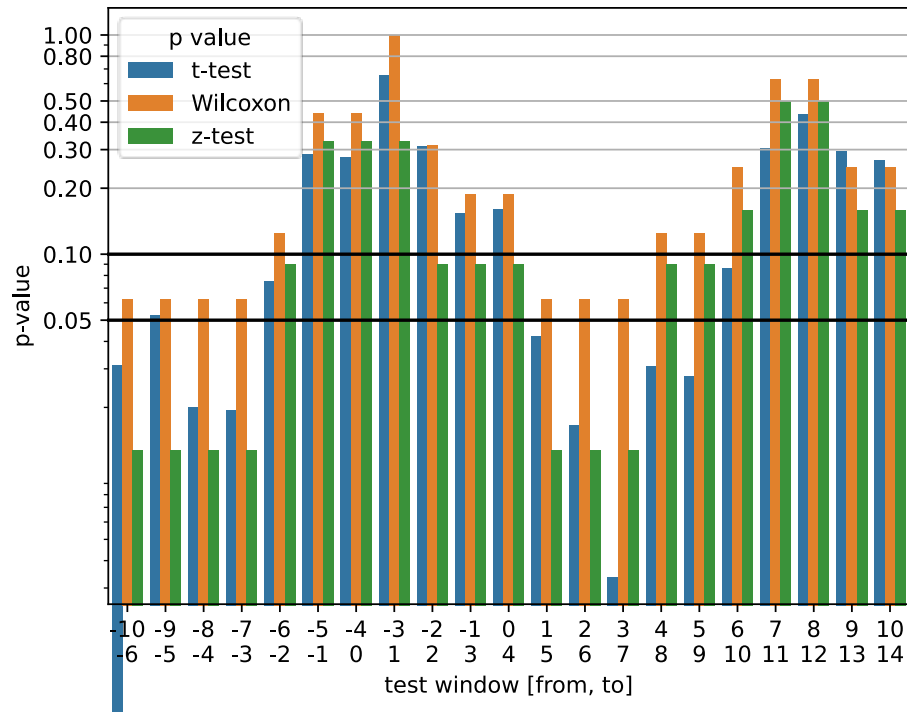
Statistical Tests
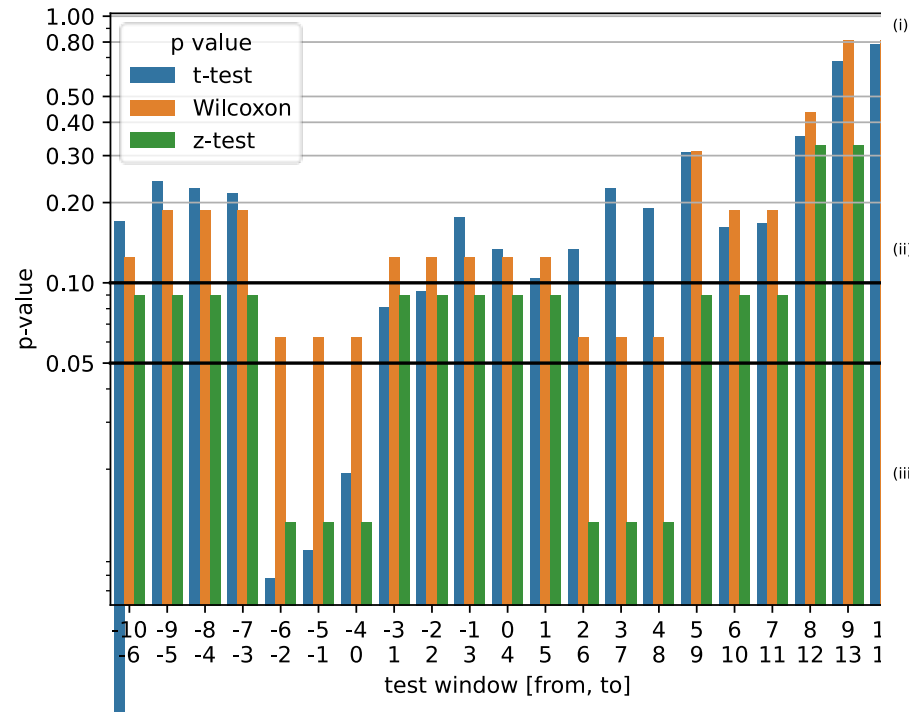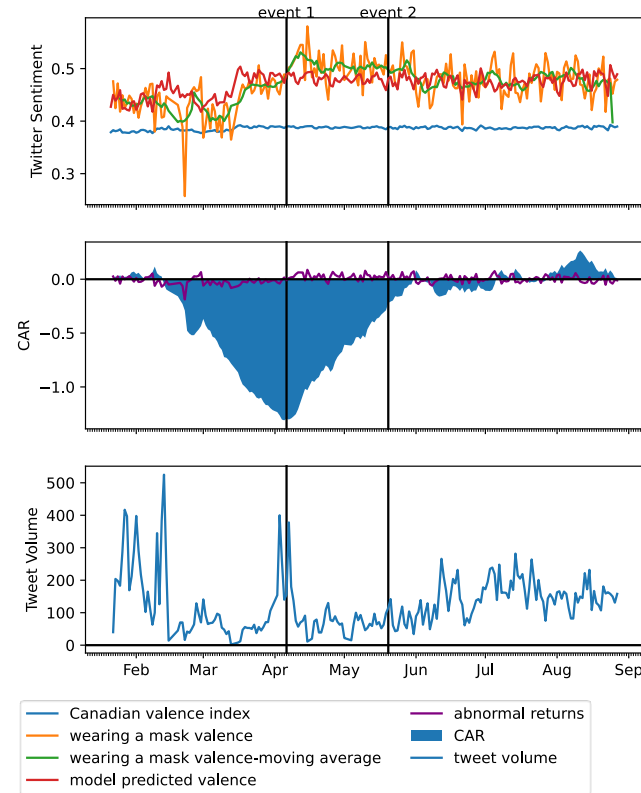
Event 1

Event 2

Observation: Mask advisory changes cause a positive sentiment boost.

- One-sample t-test
- One-sample Wilcoxon signed rank test
- Binomial proportionality z-test

Statistical Tests
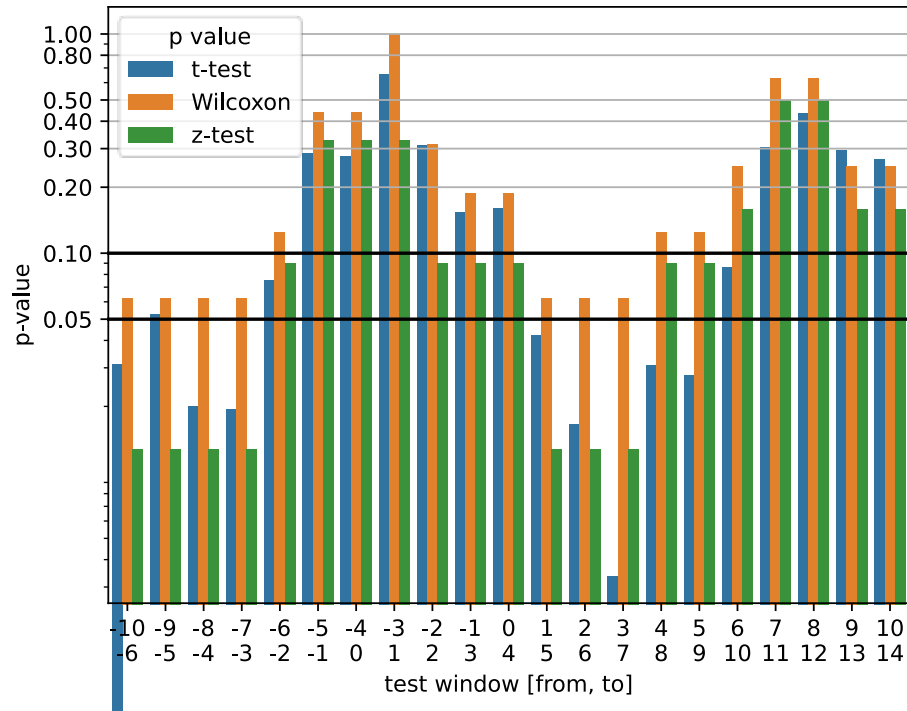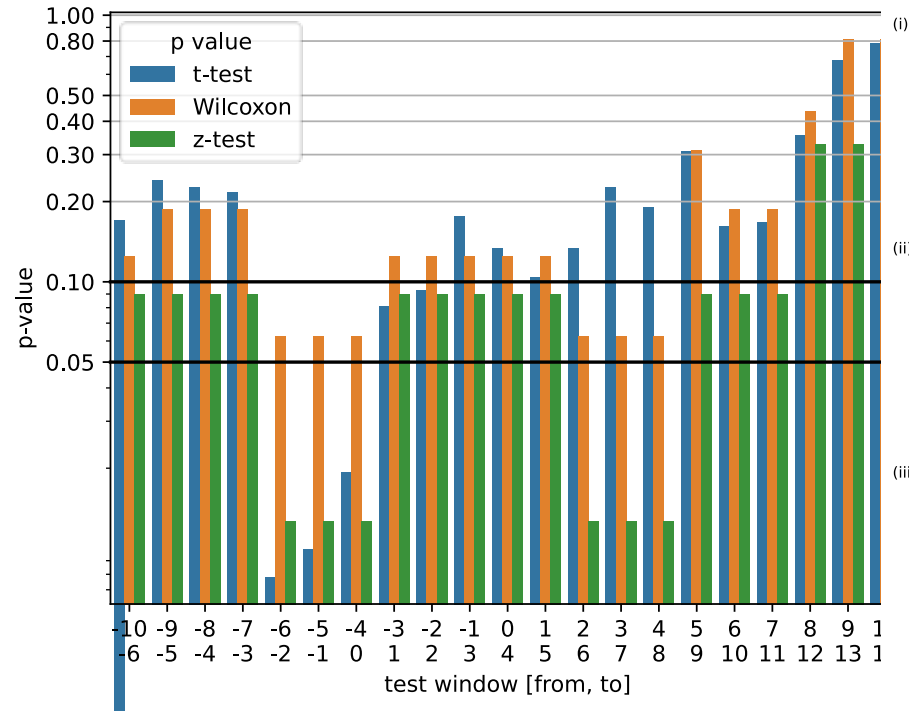
Event 1

Event 2

Statistically significant positive impact.

[+1, +9]

Also a period of significance right before the event occurred.

[-6, 0]   [+2; +8]
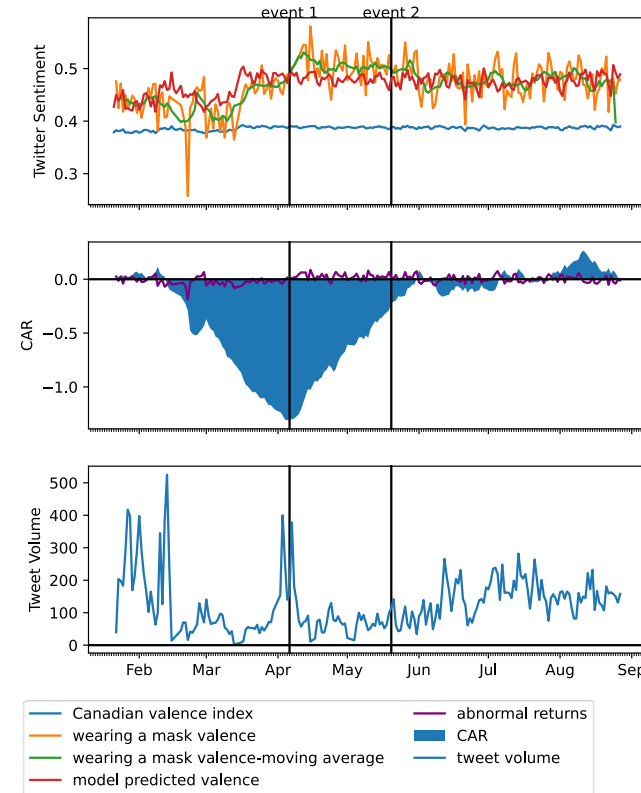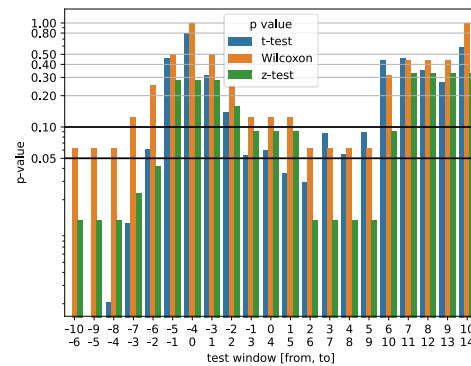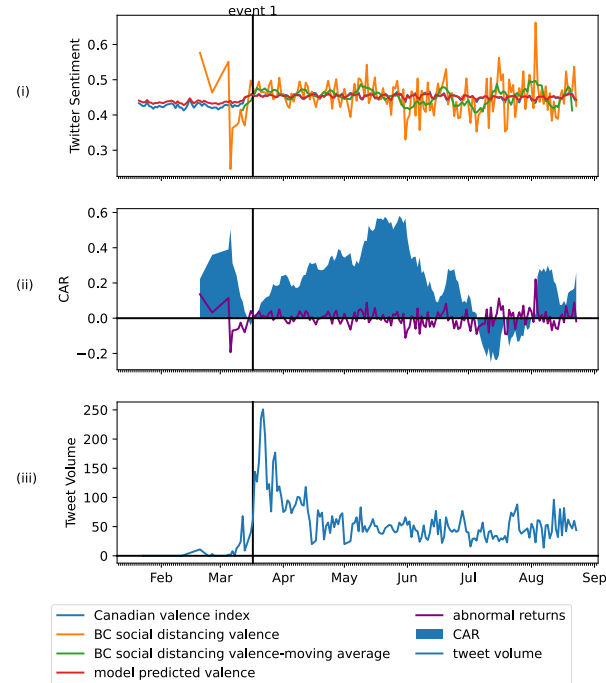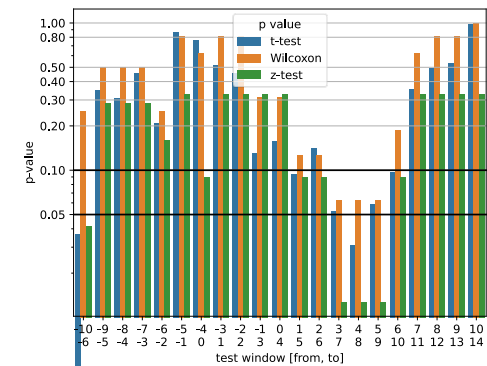
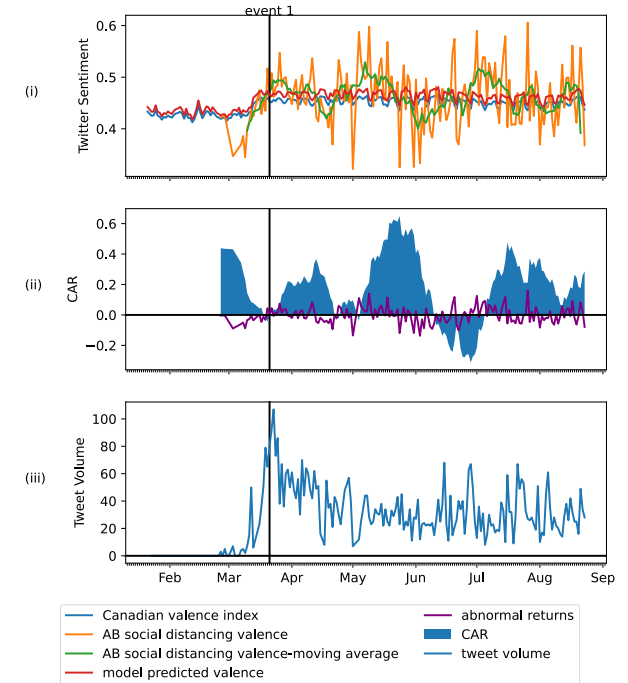# Social Distancing

Ontario (event on Mar 16)
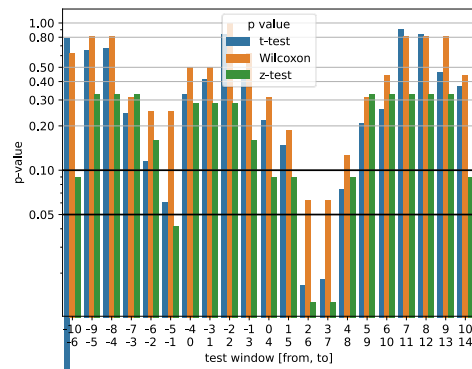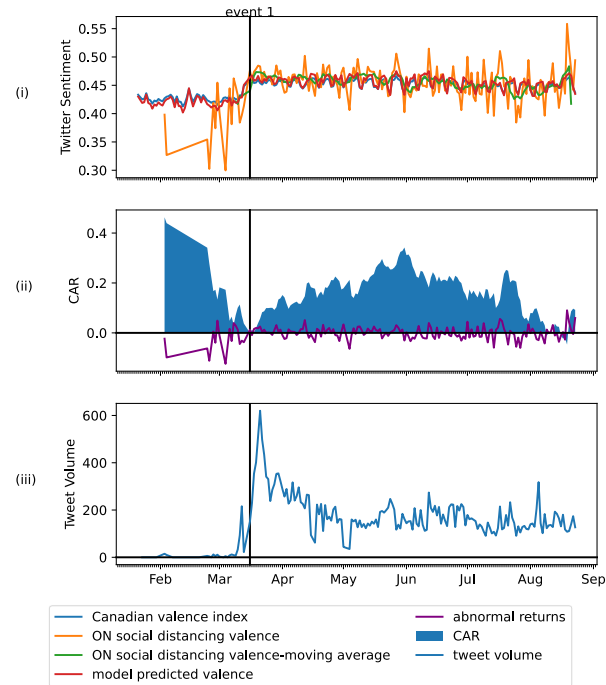
British Columbia (event on Mar 17)

Alberta (event on Mar 21)

Significant Period: [+2; +7]   [+1; +9]   [+3; +9]

Evaluation CAR against Survey Data

- The Twitter valence event study method can be used as a cheap and instant proxy to infer compliance.

- COVID-19 Monitor (Mohammed et al., 2020) includes a traditional survey of Canadian's compliance level of:
  - Wearing a mask
  - Social distancing

PRECAUTIONS

Proportion of the population taking specified actions in response to the COVID-19 pandemic
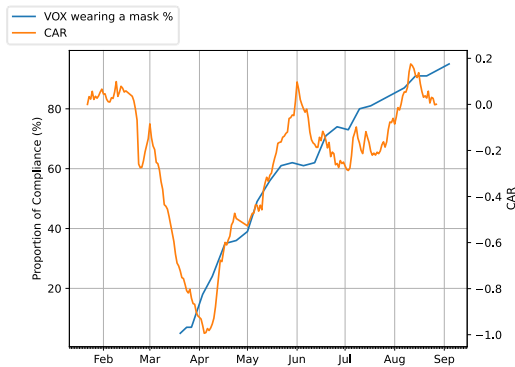
DISPLAY: Time series
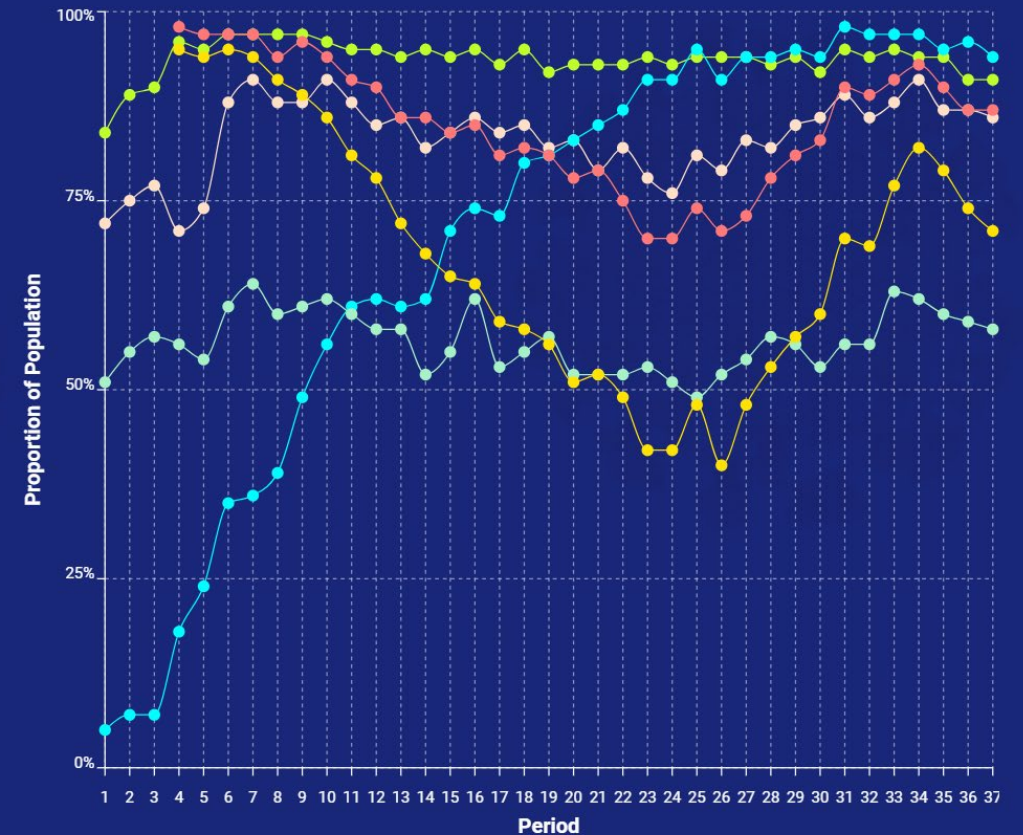
- Physical distancing
- Avoiding domestic travel
- Wearing a mask
- Working from home
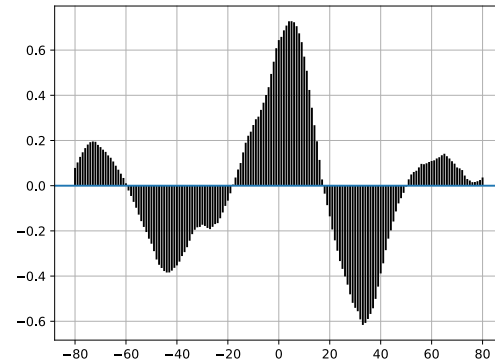- Avoiding gatherings (5+)
- Avoiding gatherings (10+)

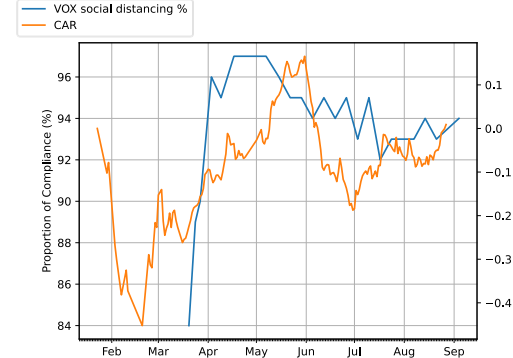# Evaluation CAR against Survey Data

Pearson's Correlation **Cross-correlation**

Pearson r = 0.807

Cross correlation: 0.710
Lag: +5 days

Wearing a mask

Pearson's Correlation **Cross-correlation**

Pearson r = 0.439
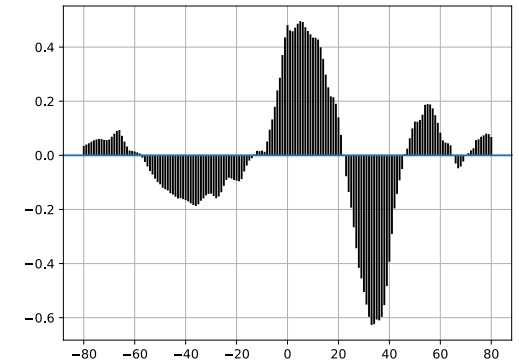
Cross correlation: 0.492
Lag: +5 days

Social distancing

Conclusion

- Applying Event Study for understanding public health sentiment trends.

- Two case studies:
  - Wearing a mask
  - Social distancing

- Promising Correlation between event study results and compliance survey.

Acknowledgements

- Code and Data: https://github.com/frankniujc/covid_sentiment_analysis

- Contact:

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