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

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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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• The COVID-19 valence reached a maximum when Amsterdam announced release measures (B).
Similar Problem in finance

I bought a lot of bitcoins!

“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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Event Study
(Brown and Warner, 1980, 1985)
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):

\[ \text{CAR}(t_1, t_2) = \sum_{t=t_1}^{t_2} \xi_t \]
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:
  \[ \text{CAR}(t_1, t_2) = \sum_{t=t_1}^{t_2} \xi_t \]
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

• 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.

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

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

Observation: Mask advisory changes cause a positive sentiment boost.
Statistical Tests

Event 1

Statistically significant positive impact.

[+1, +9]

Event 2

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
Evaluation CAR against Survey Data

Pearson’s Correlation
- Wearing a mask
  - Pearson $r = 0.807$
  - Cross-correlation: 0.710
  - Lag: +5 days

Cross-correlation

Pearson’s Correlation
- Social distancing
  - Pearson $r = 0.439$
  - Cross-correlation: 0.492
  - Lag: +5 days
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

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