

Appendix C: VAR analysis with global Google Trends data

In this version of the analysis, we perform the same analysis without restricting the Google Trends data to the United States. While the US-restricted data was stationary, the global Google Trends data was non-stationary. In the time series dataset, there were two non-stationary variables, i.e., Google trends and mid-rated media. Therefore, instead of dropping the mid-rated media data as done previously in the paper, we carried out cointegration tests for the data. If two or more variables are not stationary, then the standard practice is to check if they are cointegrated. For the analysis, the coint function from the statsmodel package in Python was used. This package uses the augmented Engle-Granger two-step cointegration test. If the variables are cointegrated, then running a Vector Error Correction Model (VECM) is more efficient than opting for the VAR model. If they are not cointegrated, then we can fit a VAR; however, we need to convert the non-stationary time series into stationary. One way to do so is by taking the first difference of the non-stationary variable. We did not find cointegration between Google Trends data and mid-reliability media, our non-stationary variables and so fitting the VAR model over the VECM model was appropriate in our scenario after taking the first difference of these variables to make them stationary. The results are different than when using a VAR model with US-specific Google Trends data, i.e., we find that both mentions of anti-vaccine keywords in both high and low-rated media appear to influence search activity on Bing. However, as described in the paper, the results of VAR with stationary data without taking the first difference of variables to make them stationary are more robust.

Table 1. Granger causality test results (media and search engine).

| Media Reliability | test stat | critical value | p-value | df | Direction of Granger Causality |
|-------------------|-----------|----------------|---------|----------|--------------------------------|
| Unrated | 1.739 | 2.052 | 0.101 | (7, 216) | Bing Search to Media |
| Unrated | 2.291 | 2.052 | 0.029 | (7, 216) | Media to Bing Search |
| Unrated | 0.9834 | 2.052 | 0.444 | (7, 126) | Google Search to Media |
| Unrated | 1.600 | 2.052 | 0.137 | (7, 126) | Media to Google Search |
| High | 1.511 | 2.052 | 0.165 | (7, 126) | Bing Search to Media |
| High | 2.399 | 2.052 | 0.022 | (7, 126) | Media to Bing Search |
| High | 0.8938 | 2.052 | 0.512 | (7, 126) | Google Search to Media |
| High | 1.059 | 2.052 | 0.391 | (7, 126) | Media to Google Search |
| Mid | 1.374 | 2.052 | 0.217 | (7, 126) | Bing Search to Media |
| Mid | 0.8896 | 2.052 | 0.515 | (7, 126) | Media to Bing Search |
| Mid | 0.9455 | 2.052 | 0.472 | (7, 126) | Google Search to Media |
| Mid | 1.017 | 2.052 | 0.420 | (7, 126) | Media to Google Search |
| Low | 1.586 | 2.052 | 0.141 | (7, 126) | Bing Search to Media |
| Low | 0.9086 | 2.052 | 0.501 | (7, 126) | Media to Bing Search |
| Low | 0.6706 | 2.052 | 0.697 | (7, 126) | Google Search to Media |
| Low | 0.5715 | 2.052 | 0.779 | (7, 126) | Media to Google Search |
| Unreliable | 1.341 | 2.052 | 0.232 | (7, 126) | Bing Search to Media |
| Unreliable | 2.261 | 2.052 | 0.031 | (7, 126) | Media to Bing Search |
| Unreliable | 1.091 | 2.052 | 0.370 | (7, 126) | Google Search to Media |
| Unreliable | 0.5645 | 2.052 | 0.784 | (7, 126) | Media to Google Search |

Table 2. Granger causality test results (media and social media.)

| Media Reliability | test stat | critical value | p-value | df | Direction of Granger Causality |
|-------------------|-----------|----------------|---------|----------|--------------------------------|
| Unrated | 0.7972 | 2.052 | 0.590 | (7, 216) | Twitter to Media |
| Unrated | 0.9624 | 2.052 | 0.460 | (7, 216) | Media to Twitter |
| High | 0.3418 | 2.052 | 0.934 | (7, 216) | Twitter to Media |
| High | 0.7045 | 2.052 | 0.668 | (7, 216) | Media to Twitter |
| Mid | 0.4909 | 2.052 | 0.841 | (7, 216) | Twitter to Media |
| Mid | 0.3946 | 2.052 | 0.905 | (7, 216) | Media to Twitter |
| Low | 0.9401 | 2.052 | 0.476 | (7, 126) | Twitter to Media |
| Low | 0.7151 | 2.052 | 0.659 | (7, 126) | Media to Twitter |
| Unreliable | 0.5605 | 2.052 | 0.787 | (7, 126) | Twitter to Media |
| Unreliable | 0.3834 | 2.052 | 0.911 | (7, 126) | Media to Twitter |

Table 3. Granger causality test results (search engine and social media).

| test stat | critical value | p-value | df | Direction of Granger Causality |
|-----------|----------------|---------|----------|--------------------------------|
| 1.497 | 2.052 | 0.170 | (7, 126) | Twitter to Bing Search |
| 0.2116 | 2.052 | 0.983 | (7, 126) | Bing Search to Twitter |
| 0.5670 | 2.052 | 0.782 | (7, 126) | Twitter to Google Search |
| 1.058 | 2.052 | 0.392 | (7, 126) | Google Search to Twitter |