Algorithms and digital traces: The case of Google trends

Max Pellert

University of Konstanz

Social Media Data Analysis

Announcements & info

- Course GitHub Classroom: https://github.com/SMDA-2024
  - All class materials in this public repo: https://github.com/SMDA-2024/SMDA-2024
- Course Discord Server: https://discord.gg/t8Dv4gZd
  - Ideal for sharing and discussing code and/or python issues
- Tutorial session this Thursday to give some guidance about projects and for your questions concerning methods/concepts for exercise 1
  - In person D431, 10:00 as usual
- Clarification about course grade: Only lecture or only exercise is not possible

Outline

1. Search data: Google trends

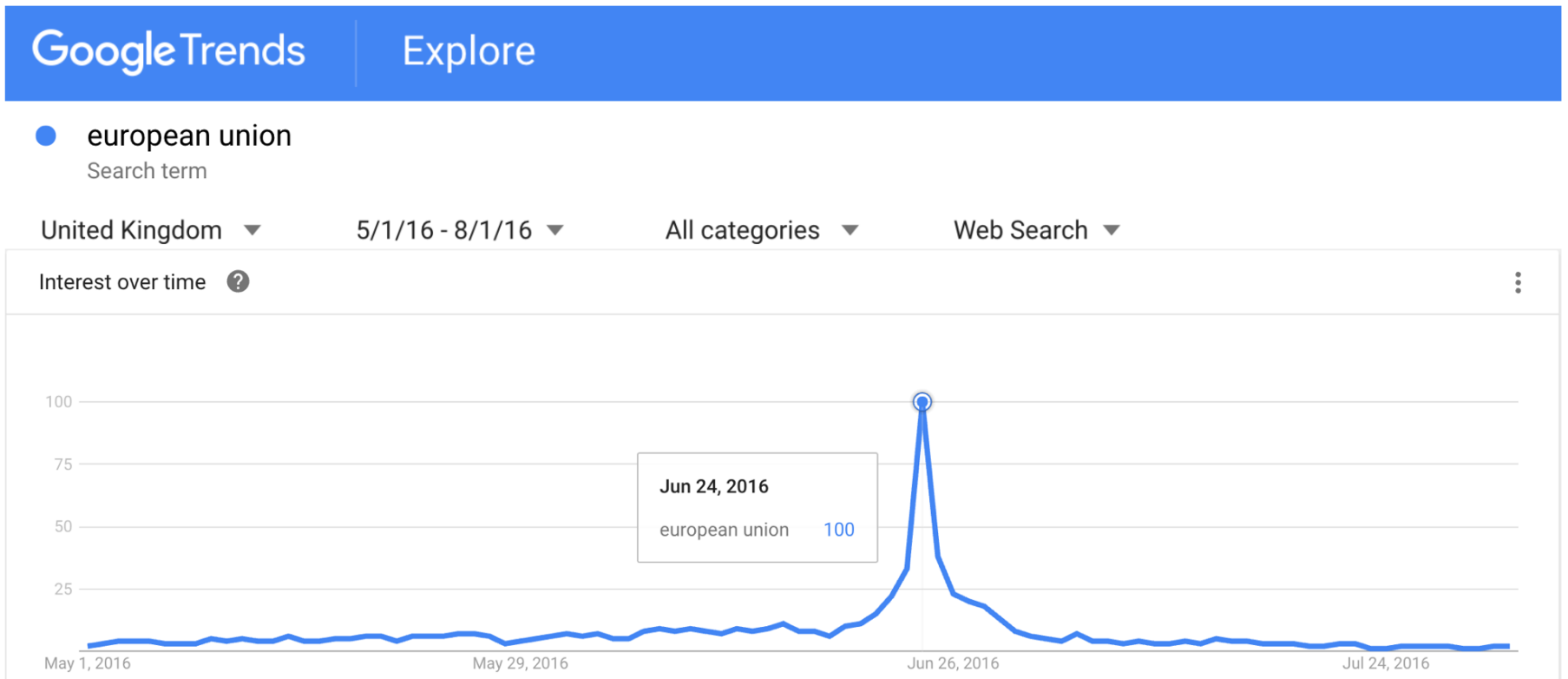
2. Measuring temporal orientation with Google trends

3. Correlating economic development and temporal orientation

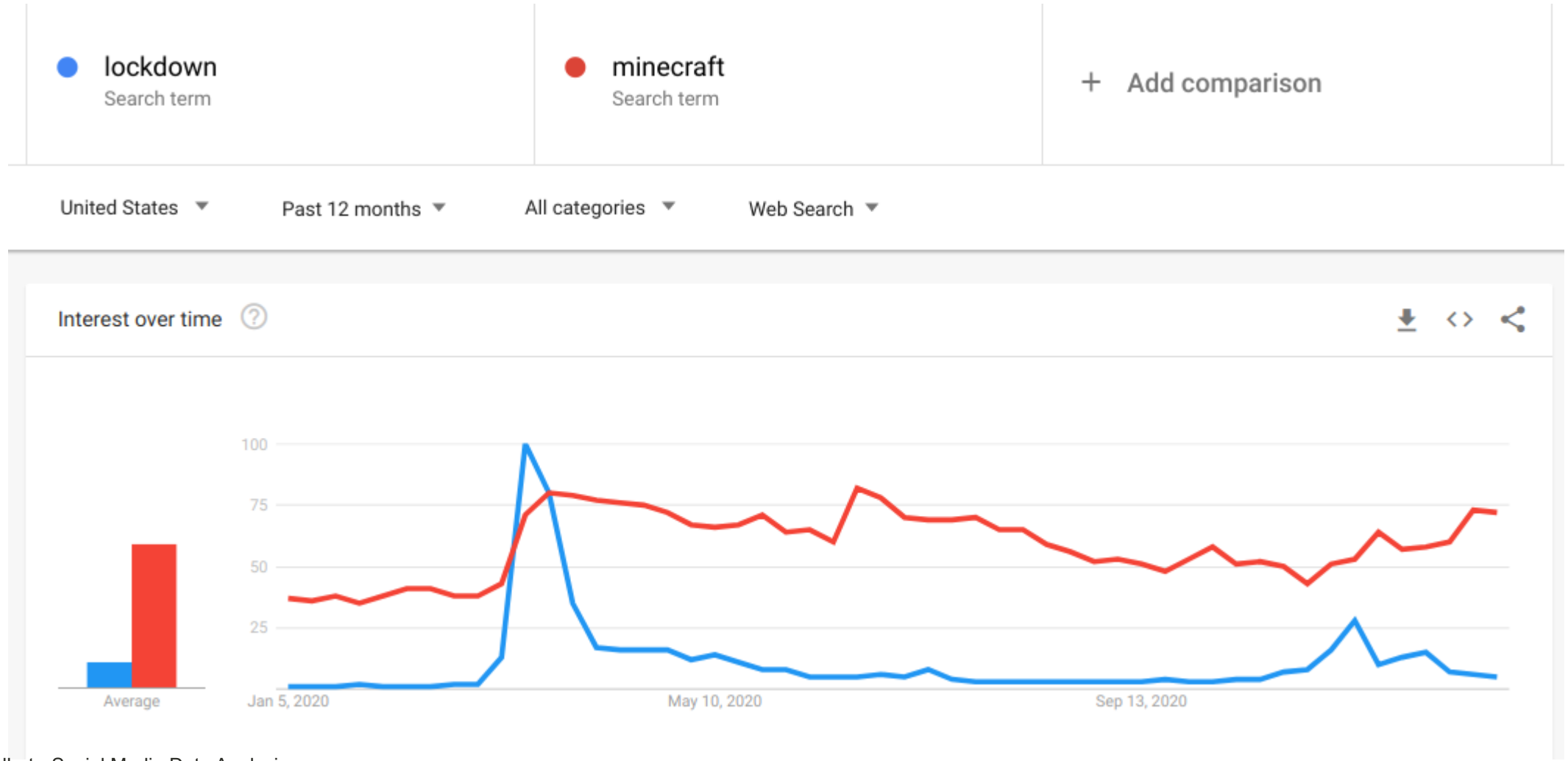
4. The parable of Google Flu trends

Google Trends

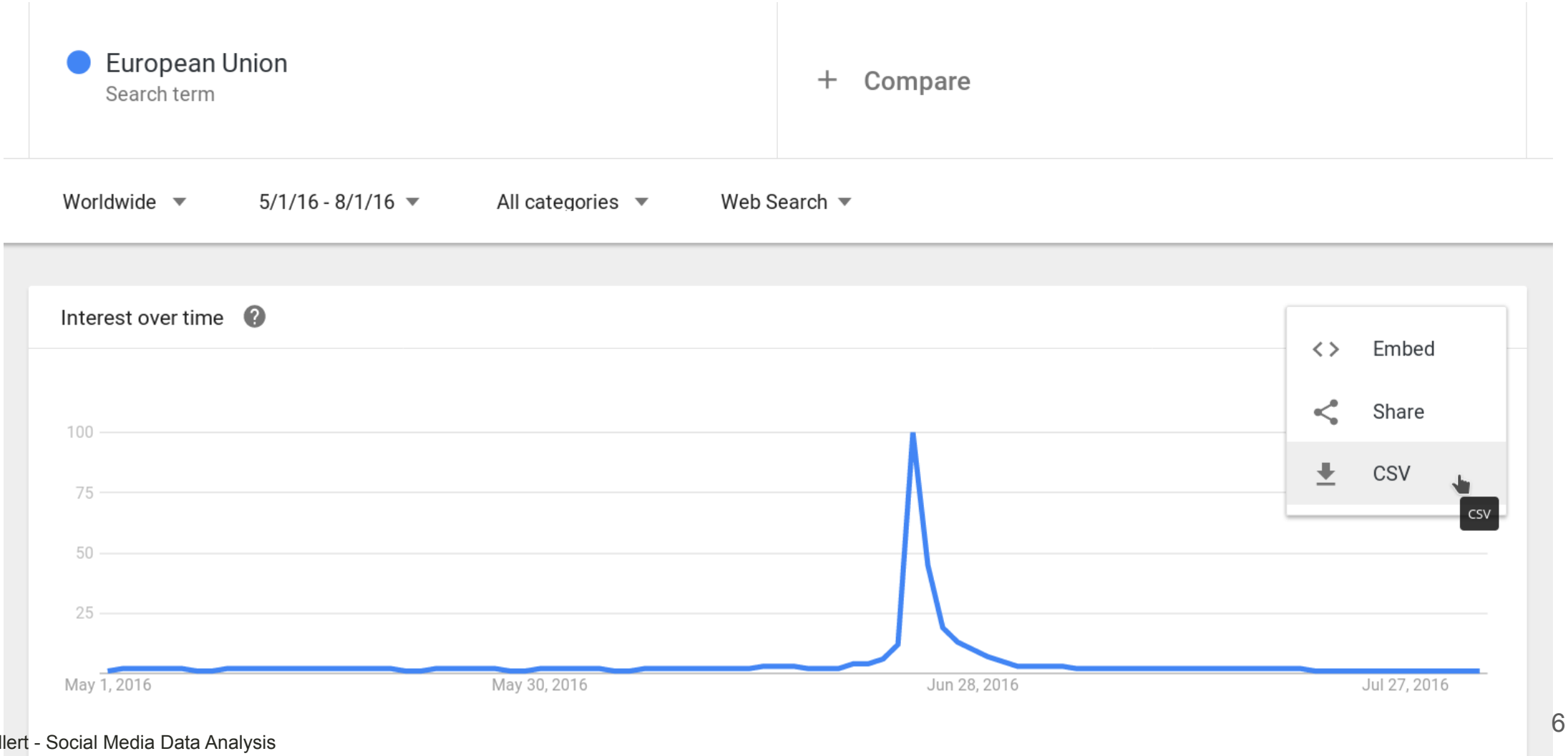
Google Trends is a website hosted by Google that allows you to get a measurement of Google search volume for a term



Searching for various trends



Exporting data

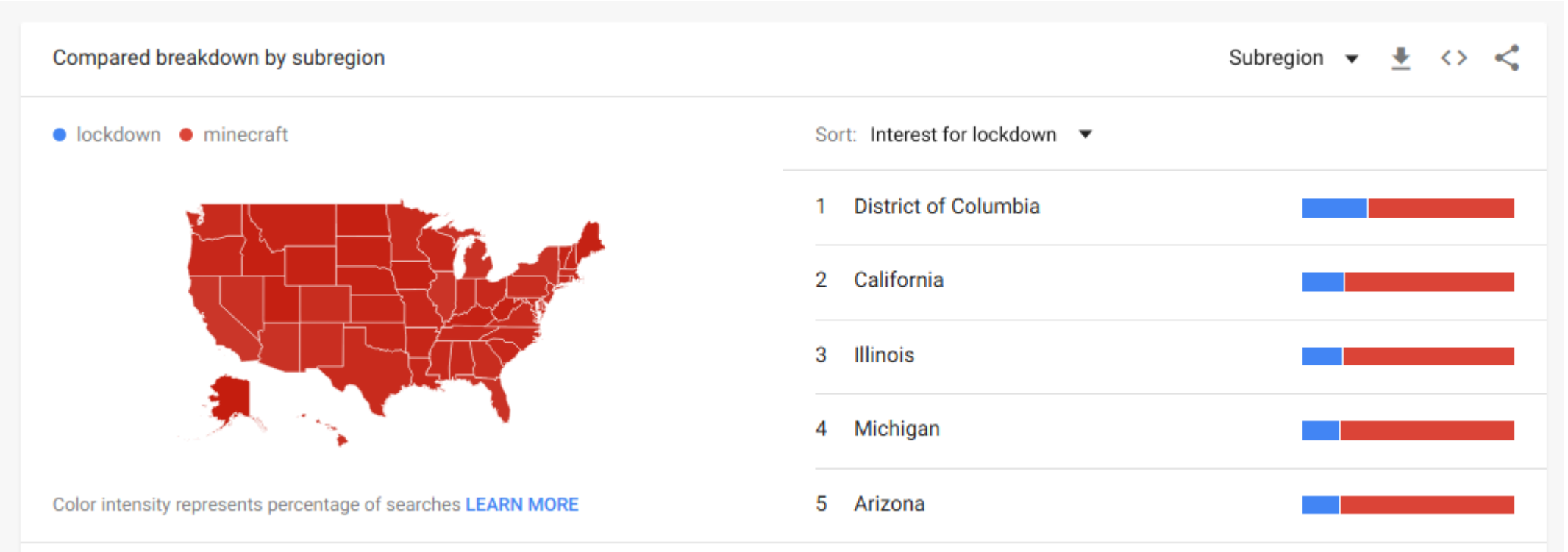


Export file format

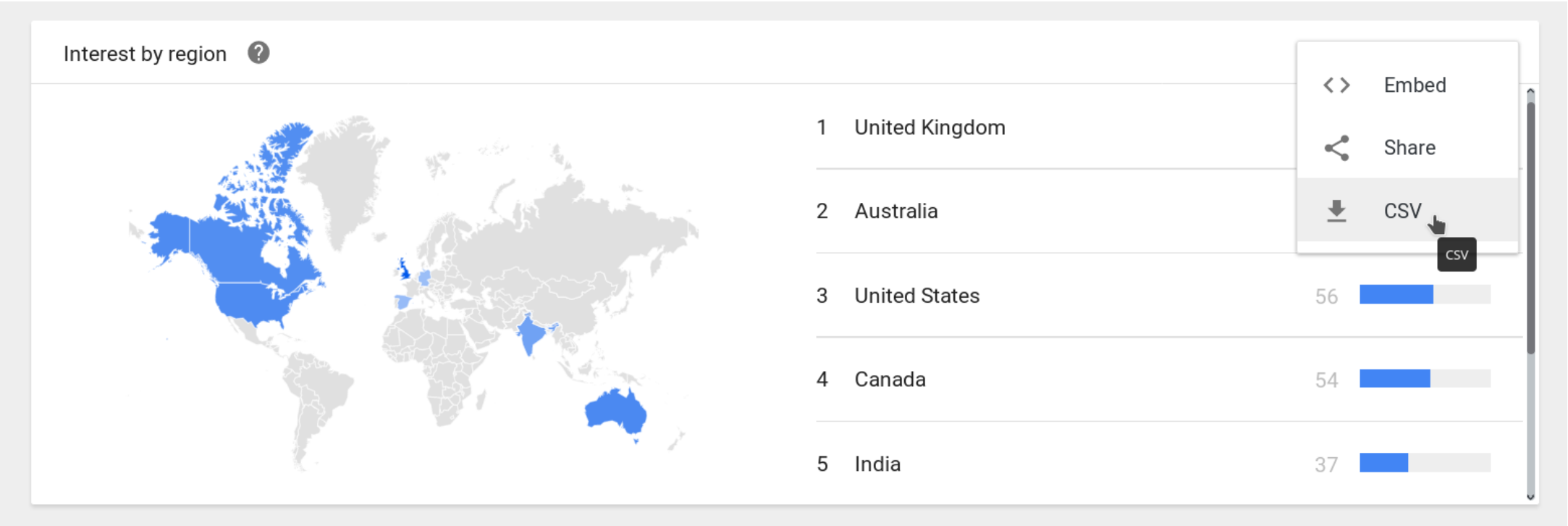
Category: All categories		
Day	minecraft: (United States)	lockdown: (United States)
2021-07-20	79	6
2021-07-21	72	5
2021-07-22	76	7
2021-07-23	70	6
2021-07-24	84	5
2021-07-25	81	6
2021-07-26	77	7
2021-07-27	74	7

Comparing regions

A lower panel shows a comparison between countries or between regions within the country you filtered for.



Exporting map data

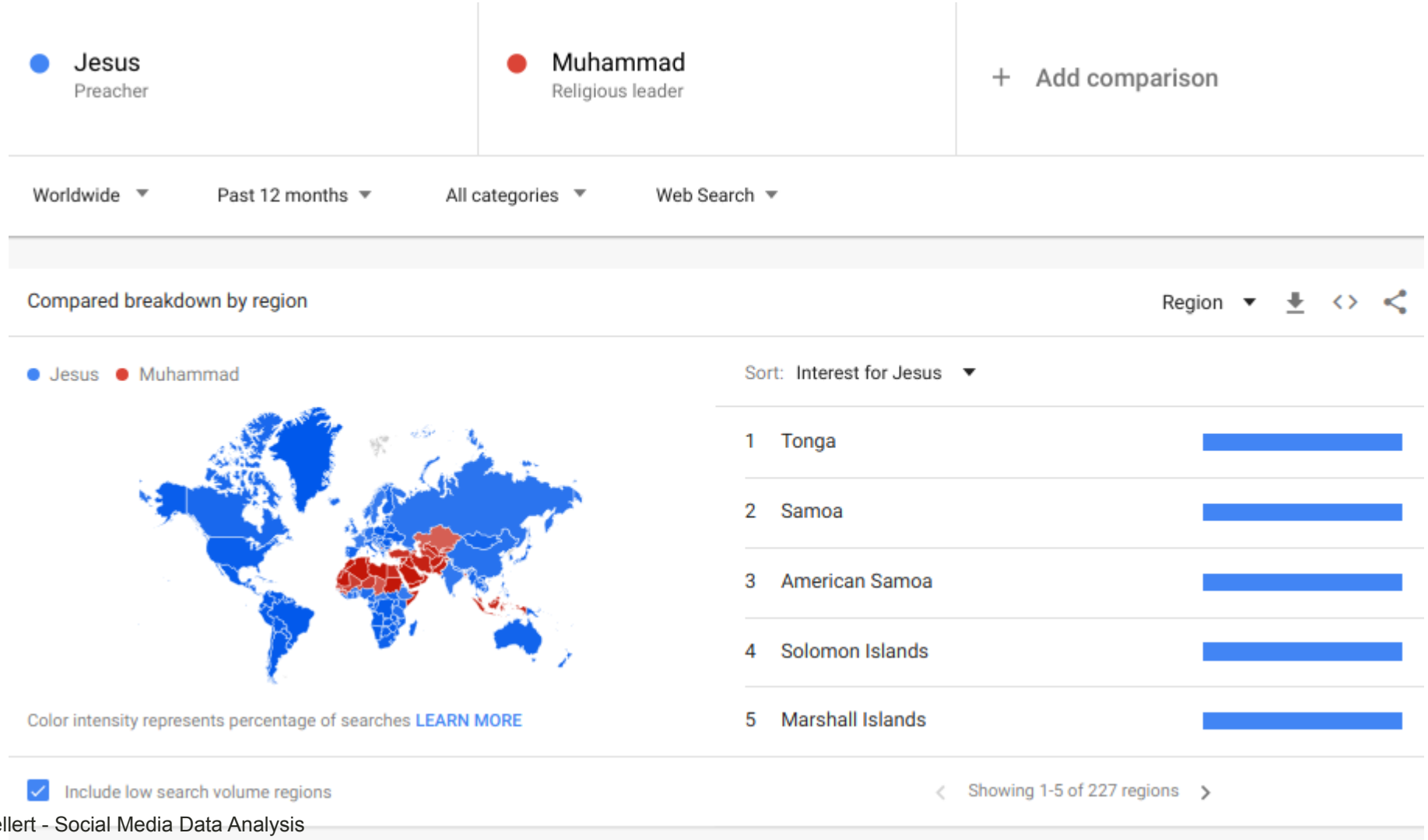


- Check "Include low search volume regions"

Export file format for maps

Category: All categories		
Country	minecraft: (7/20/21 - 10/20/21)	lockdown: (7/20/21 - 10/20/21)
Myanmar (Burma)	100%	<1%
Mongolia	100%	<1%
Australia	25%	75%
Cuba	100%	
Philippines	89%	11%
New Zealand	35%	65%
Seychelles	100%	
Nepal	92%	8%
São Tomé & Príncipe	100%	
Brunei	89%	11%
Bolivia	100%	<1%

Disambiguating queries across languages



Outline

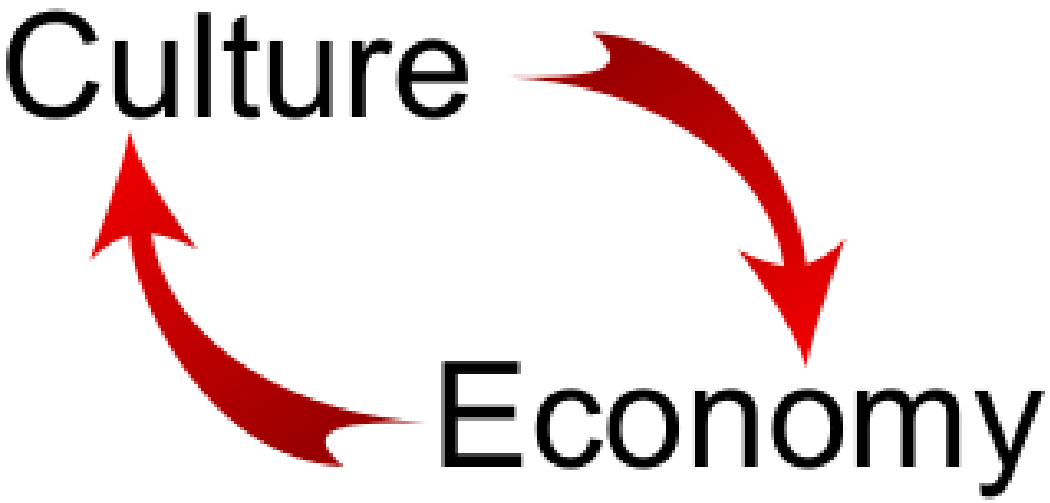
1. Search data: Google trends

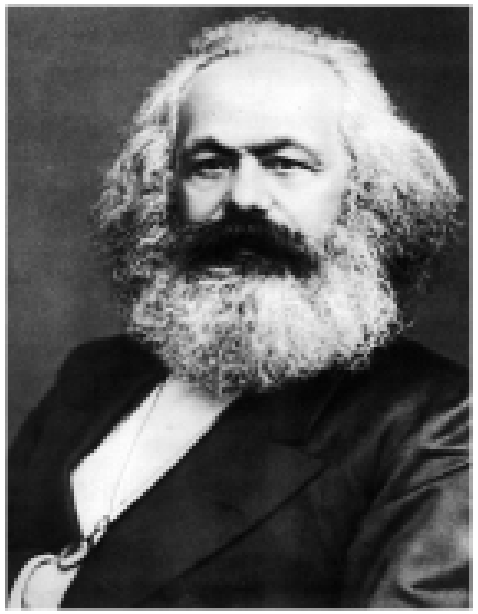
2. Measuring temporal orientation with Google trends

Time, culture, and the economy

What is the relationship between culture and the economy?

Max Weber

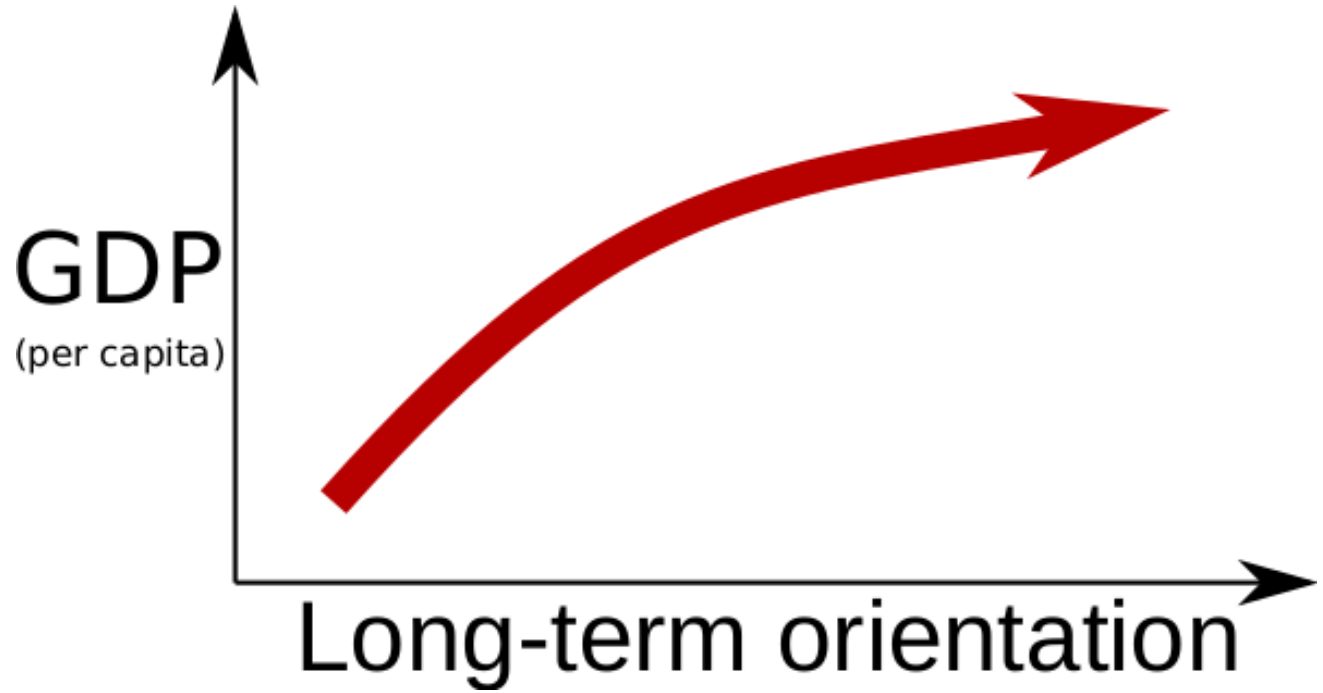




Karl Marx

Long-term orientation and economic development

> **Long-Term Orientation (Geert Hofstede)**
> Long-term oriented societies believe that the most important events in life will occur in the future; short-term oriented societies believe that those events occurred in the past or take place now.



Temporal orientation and Google Trends

SUBJECT AREAS:
GENERAL PHYSICS
STATISTICAL PHYSICS, THERMODYNAMICS AND NONLINEAR DYNAMICS
INFORMATION THEORY AND COMPUTATION
STATISTICS

Quantifying the Advantage of Looking Forward

Tobias Preis[1,2,3]*, Helen Susannah Moat[4,5]*, H. Eugene Stanley[1]* & Steven R. Bishop[4]*

We introduce a *future orientation index* to quantify the degree to which Internet users worldwide seek more information about years in the future than years in the past. We analyse *Google* logs and find a striking correlation between the country's GDP and the predisposition of its inhabitants to look forward.

Quantifying the Advantage of Looking Forward. T. Preis, S. Moat, E. Stanley, S. Bishop. Scientific Reports (2012)

Measuring the Future Orientation Index

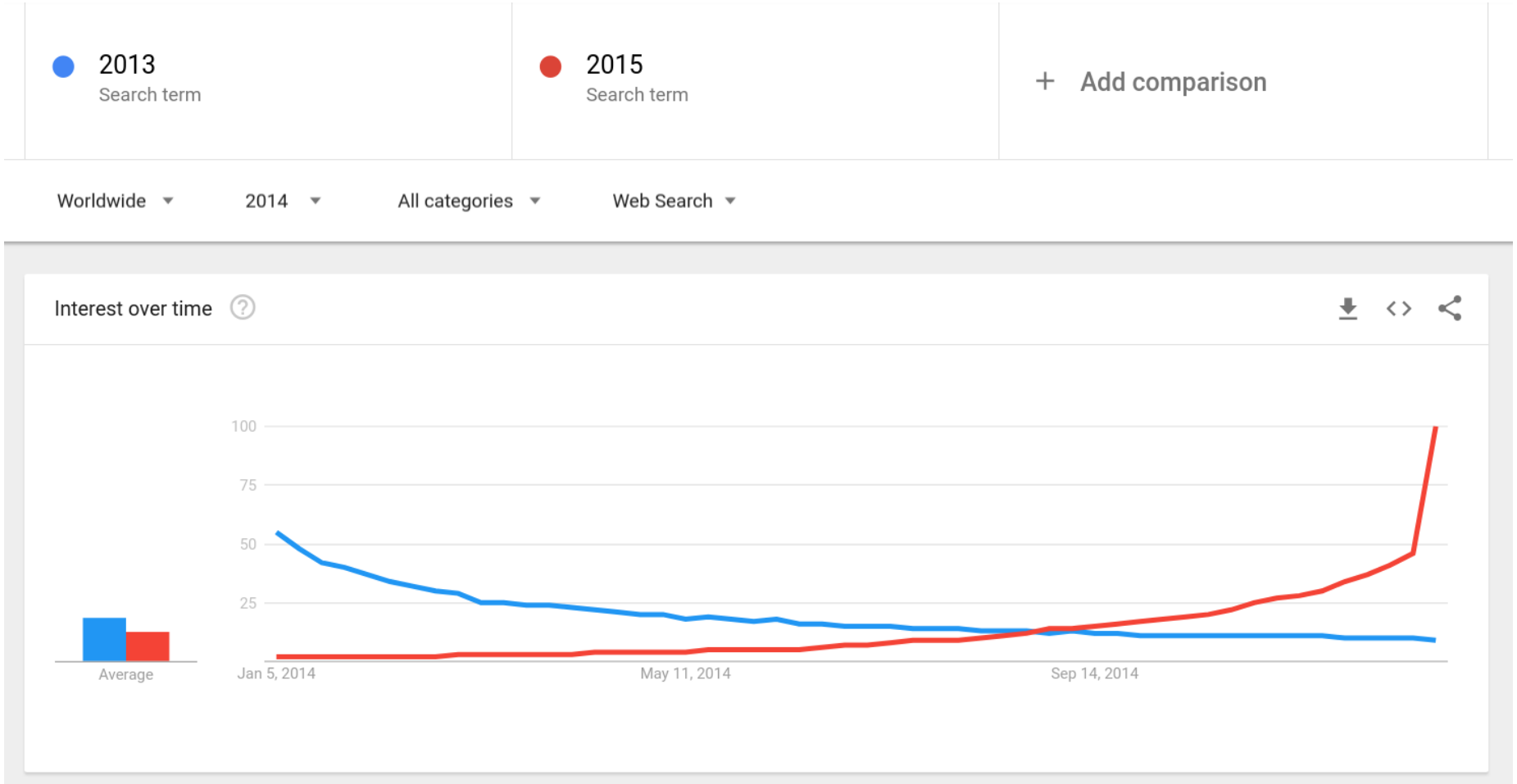
Pres et al. 2012 proposed a way to measure how much a society looks towards the future with Google Trends, the Future Orientation Index (FOI). The FOI for a country *c* on year *y* is calculated as:

$$FOI_{c,y} = \frac{G(y+1,y,c)}{G(y-1,y,c)}$$

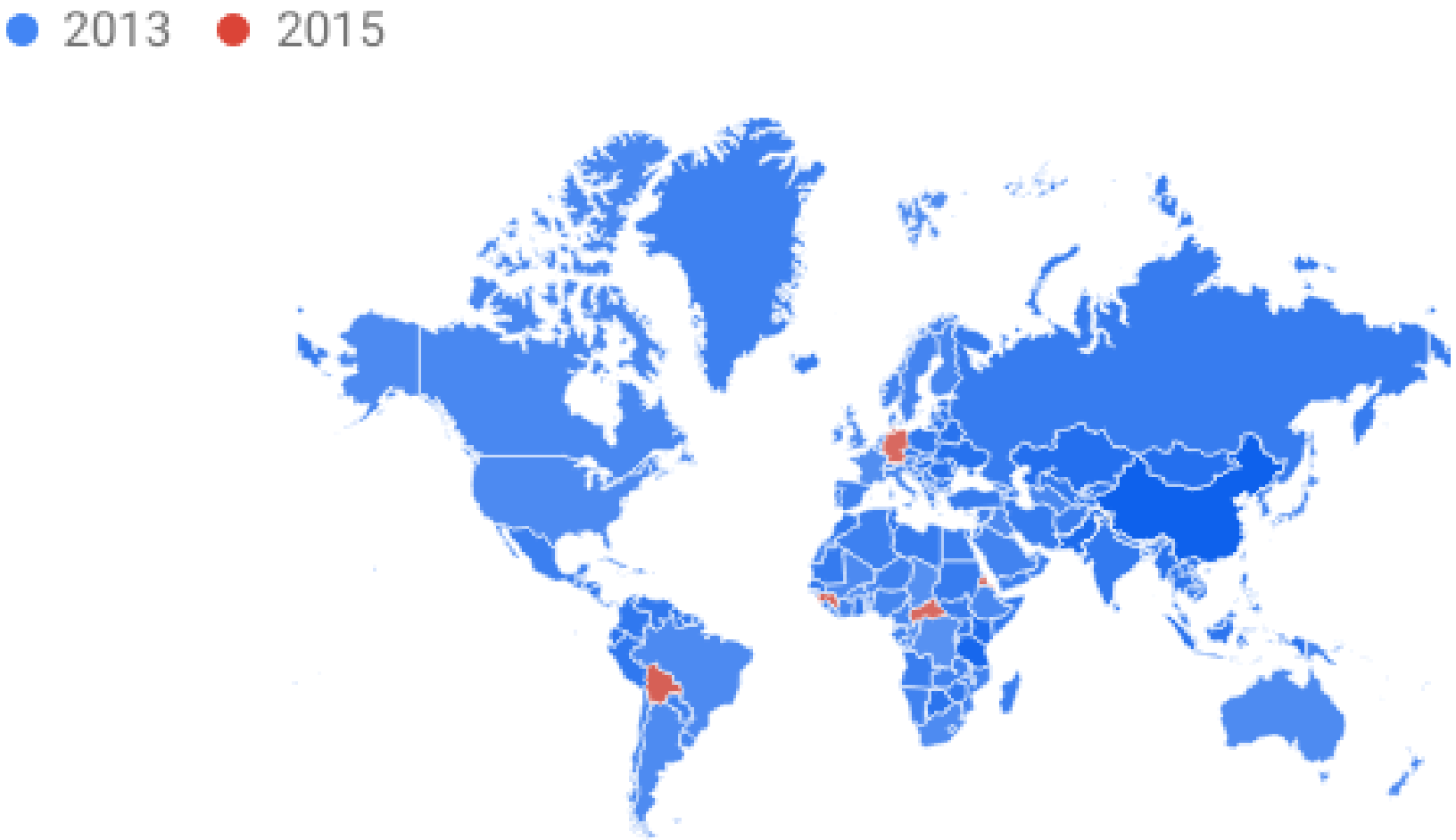
where $G(y_1, y_2, c)$ is the Google Trends volume for searches for year y_1 during year y_2 from country c.

The FOI measures the ratio of search volume from a country for next year divided by the search volume for the previous year in the same country.

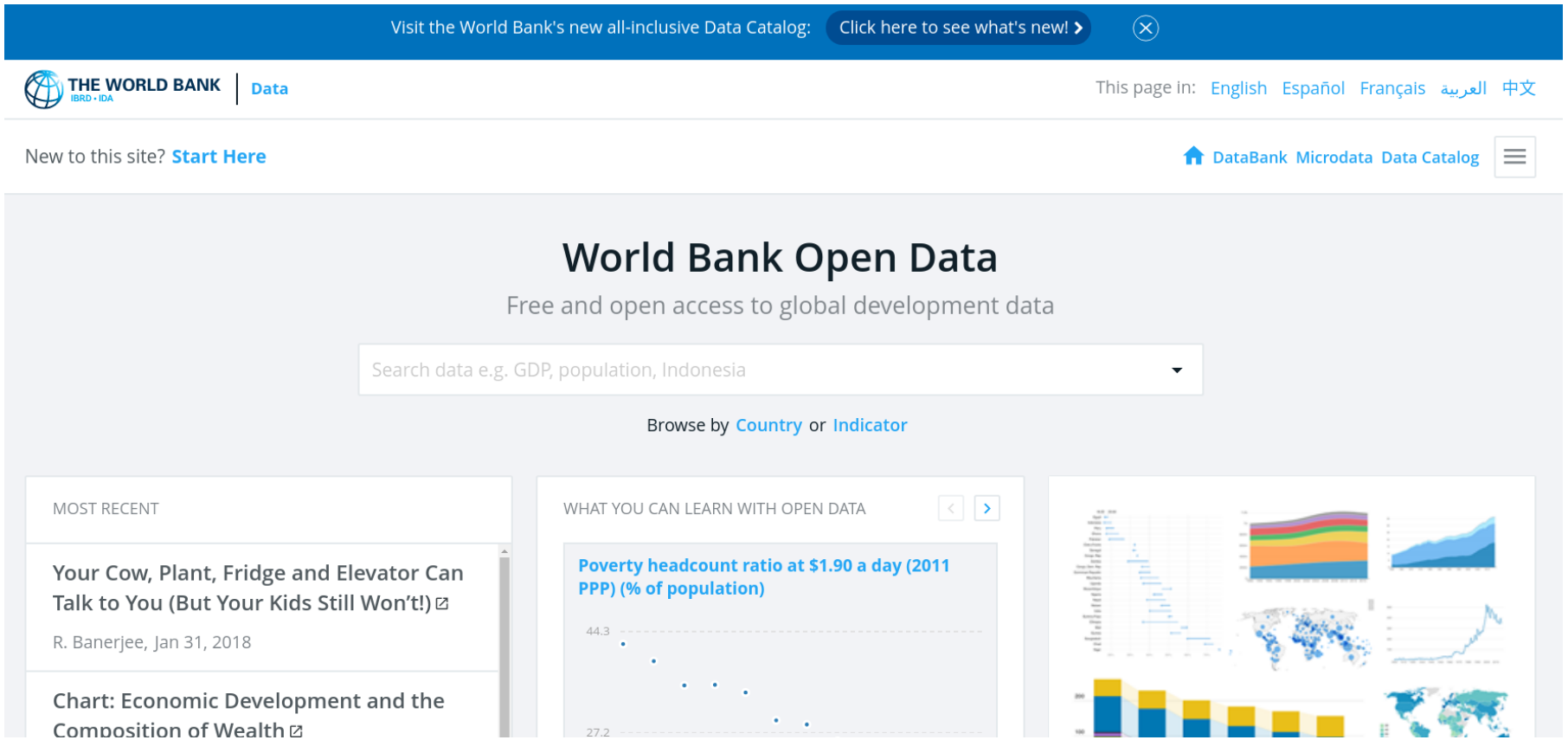
Example of trends for FOI



Example of trends for FOI

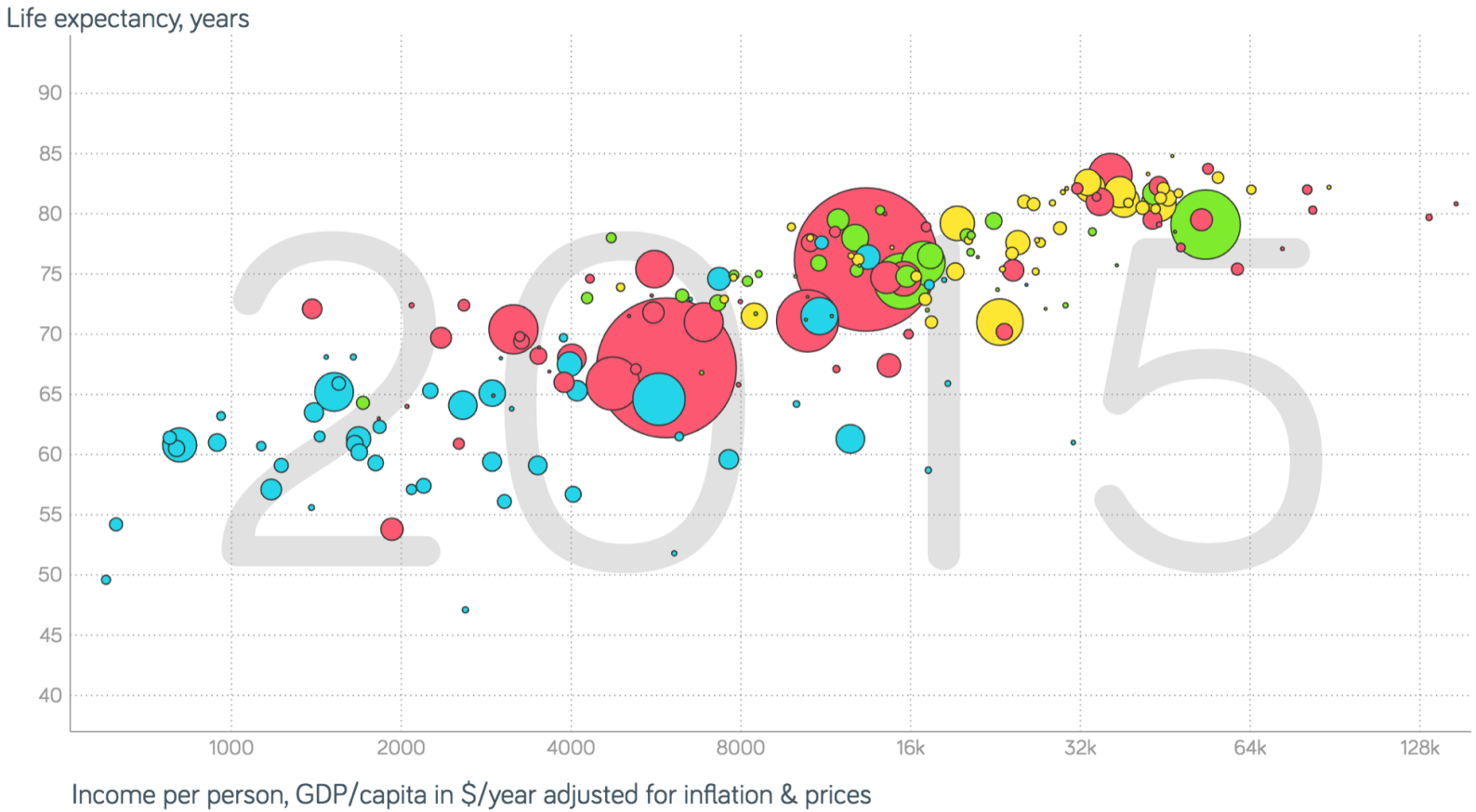


The World Bank Development Indicators



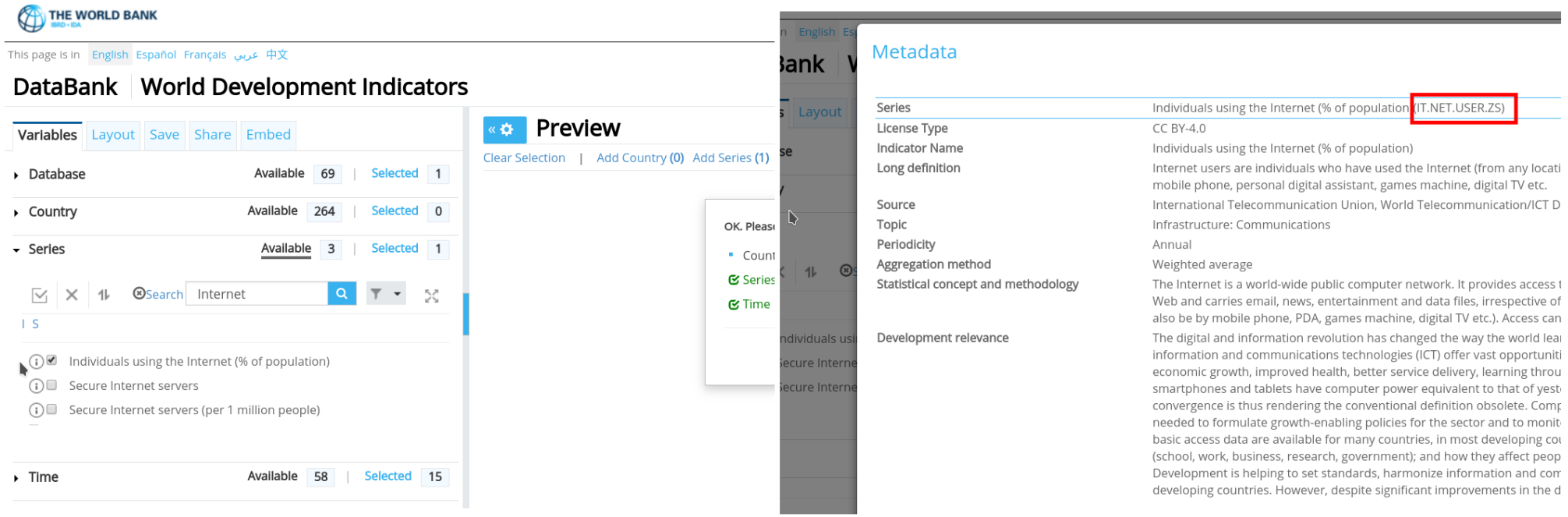
http://data.worldbank.org/

Example: Life expectancy and economic development



https://www.gapminder.org/

Searching for WDI Indicators



- You can search for indicators at http://databank.worldbank.org/wdi
- Go to the left panel and to the "Series" tab to search
- Press the "i" button to get more information, including the standard name

Outline

1. Search data: Google trends

2. Measuring temporal orientation with Google trends

3. Correlating economic development and temporal orientation

Some univariate statistics notation

- X is a random variable
  - In data: X_i is the value of the variable for entry i
  - For example the GDP of a country
- $E[X]$ is the expected value of X
  - We estimate the expected value as the mean of X:

$$\mu_X = \frac{1}{N} \sum_i X_i$$

  - N is the number of data points, for example the number of countries

Some more univariate statistics notation

- $V[X]$ is the variance of X
  - We calculate it as the expected squared difference to the mean X:

$$V[X] = \frac{1}{N}\sum_i (X_i - \mu_X)^2$$

  - It is measured in squared units of X
- σ_X is the standard deviation of X
  - $\sigma_X = \sqrt{V[X]}$, which is convenient because it measures dispersion in the same units as X
  - in R you can calculate it with the function sd()

Pearson's Correlation Coefficient $\rho(X, Y)$

> **Correlation:** Linear association or dependence between the values of variables X and Y

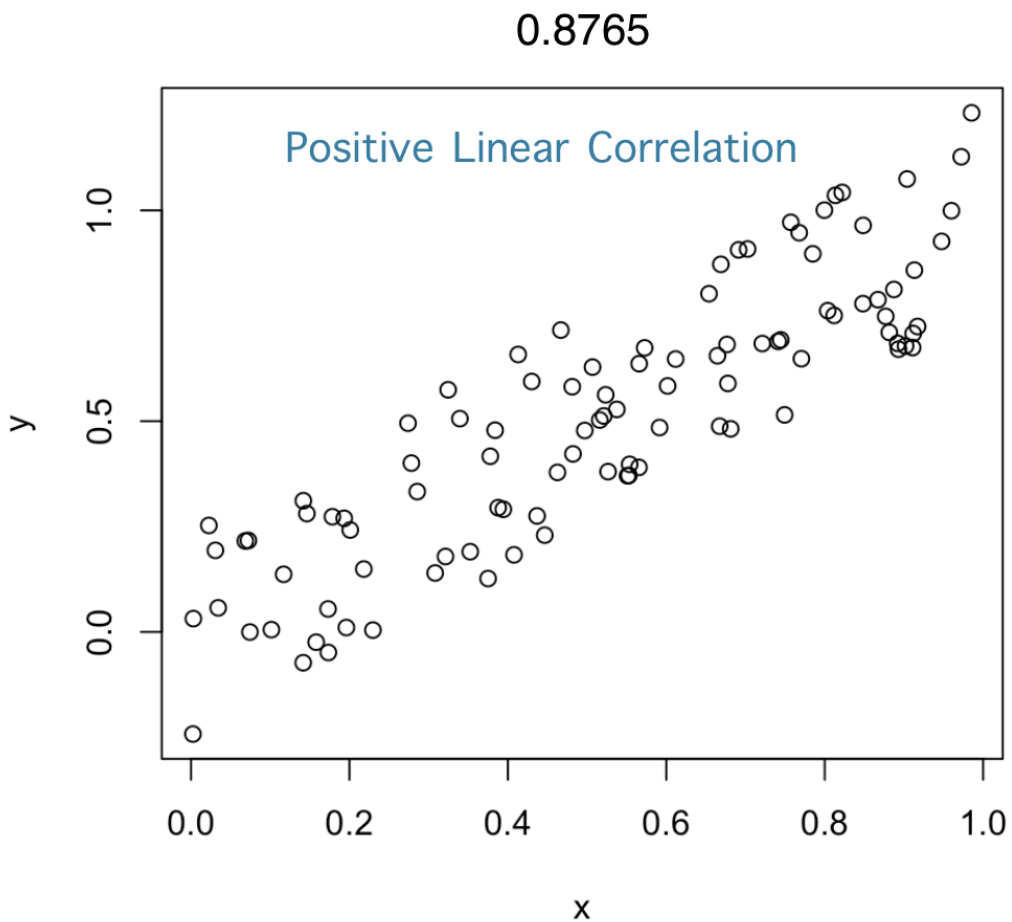
- If X and Y are independent, they satisfy that the expectation of the product equals the product of expectations:

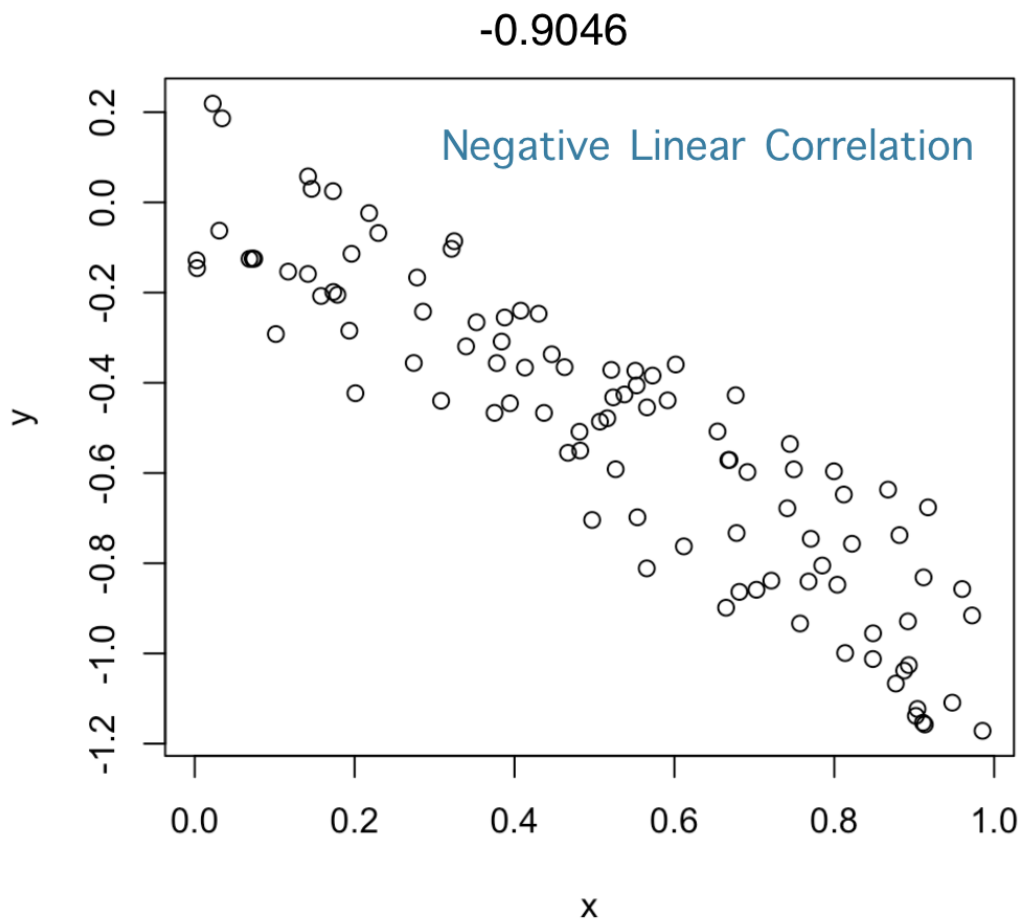
$$E[XY] = E[X]E[Y]$$

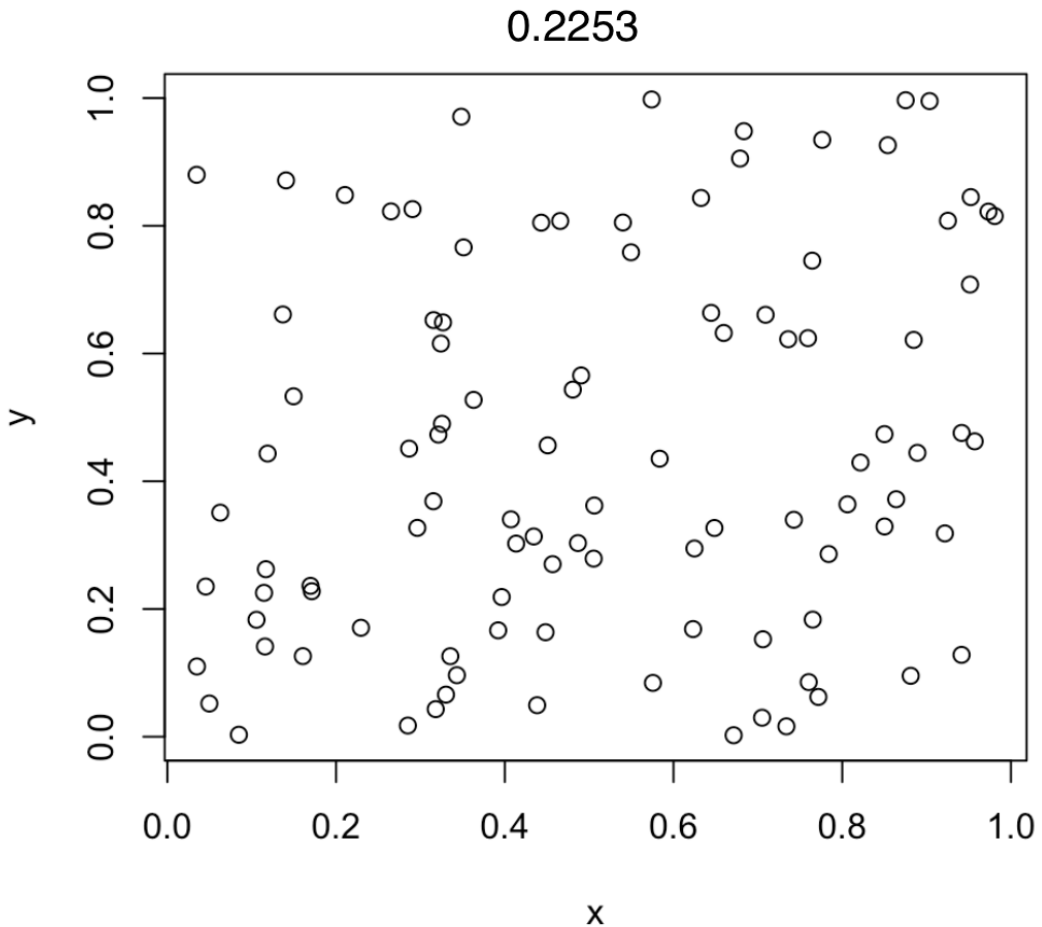
- The principle: correlation as the deviation from $E[XY] - E[X]E[Y] = 0$
- The absolute value of this difference can be at most $\sigma_X \sigma_Y$
- $\rho(X, Y)$ rescales the difference to be between −1 and 1

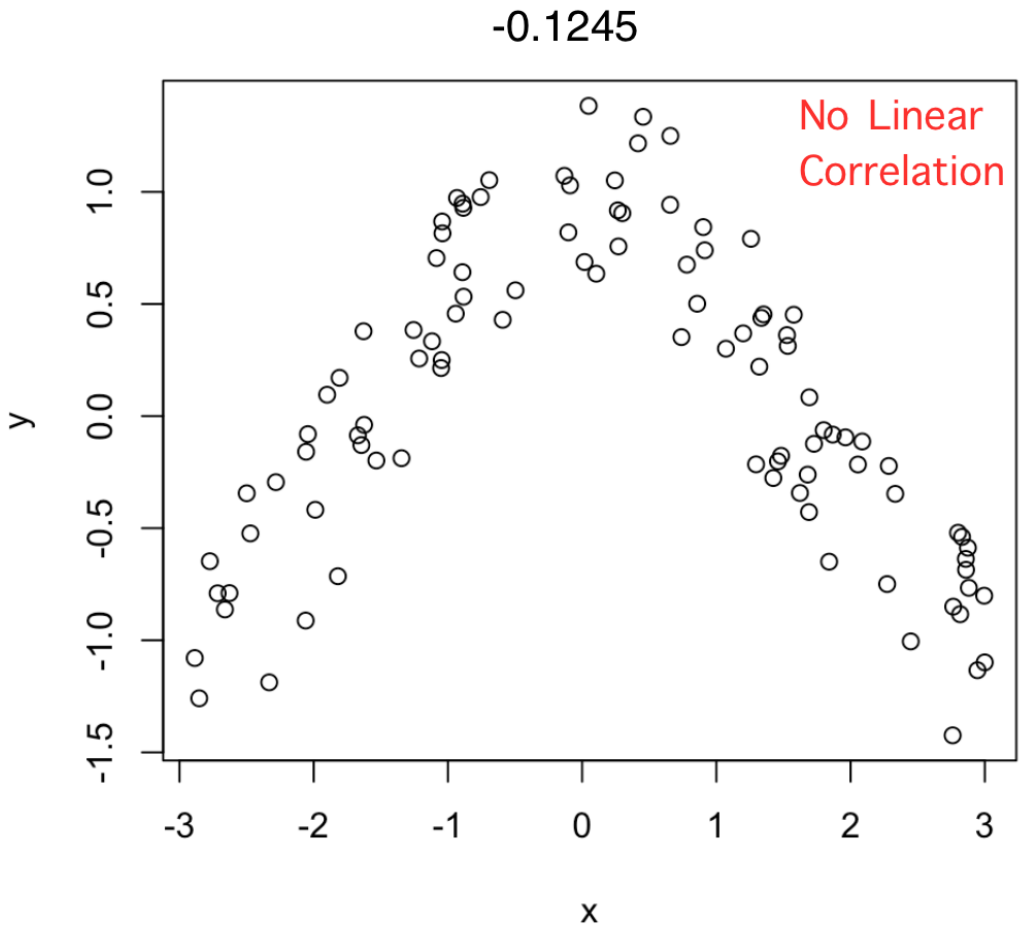
$$\rho(X, Y) = \frac{E[XY] - E[X]E[Y]}{\sigma_X \sigma_Y}$$

Some examples of Pearson's Correlation Coefficient



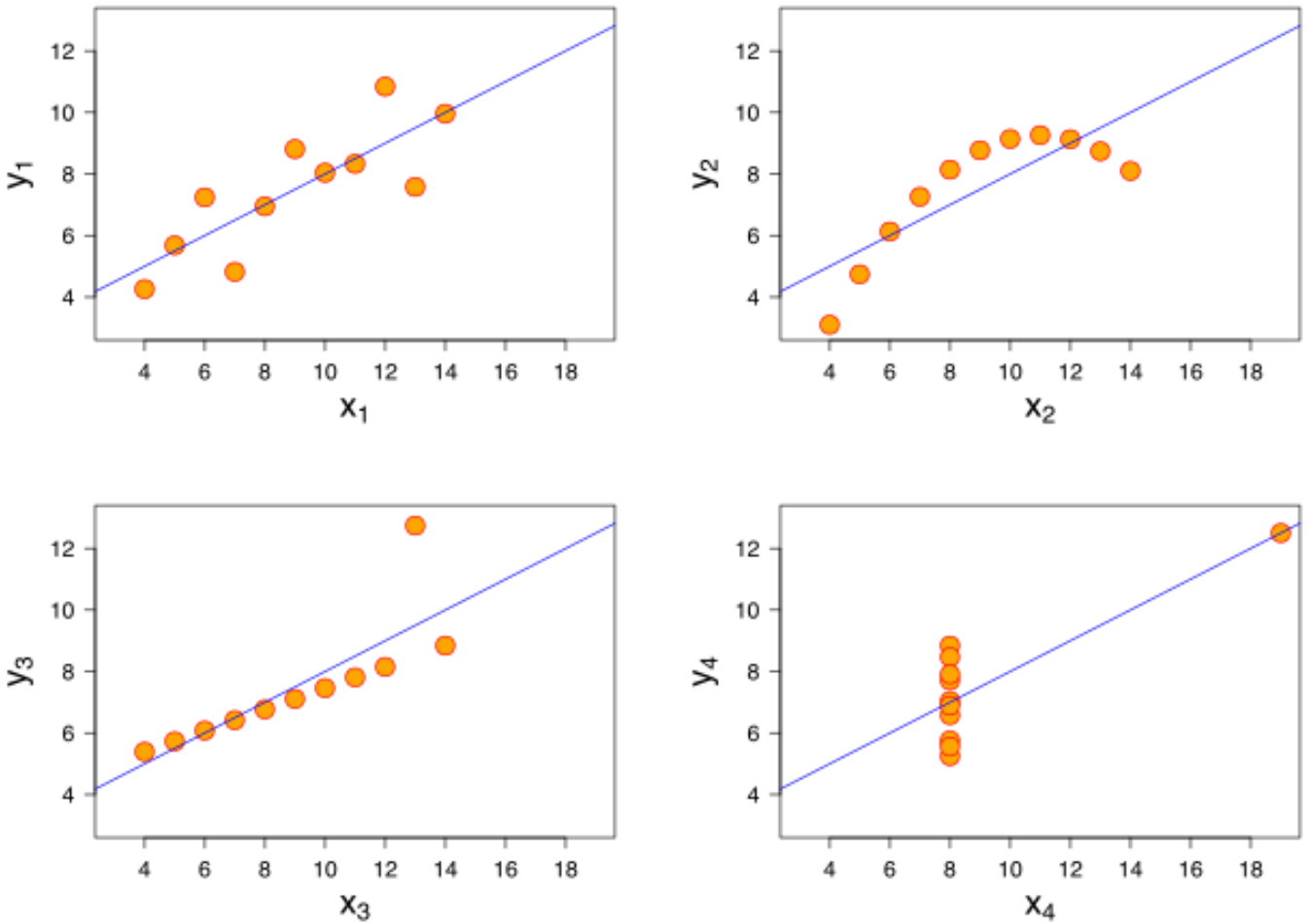




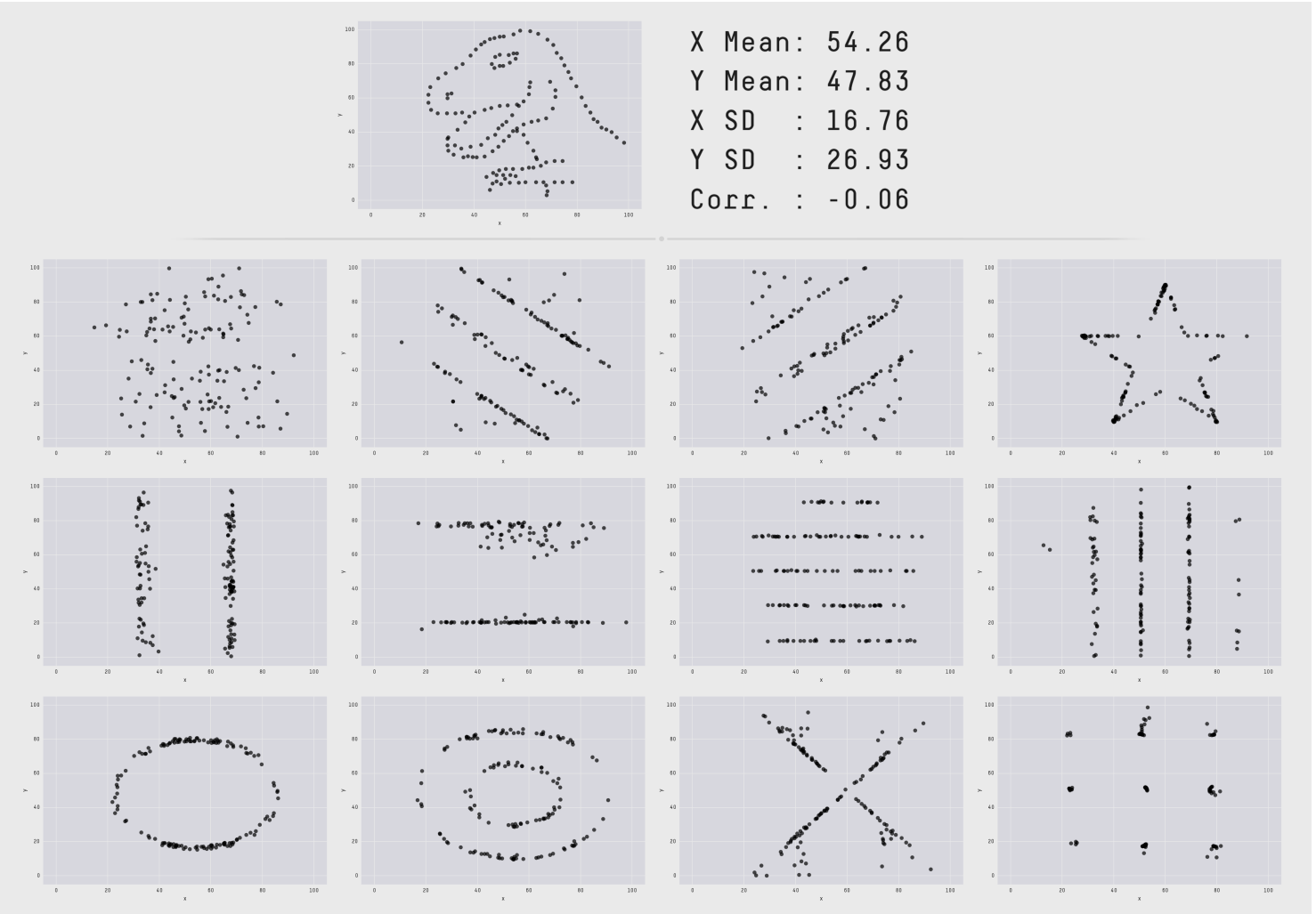


Independent variables will have a correlation close to zero, but a correlation close to zero does not mean independence

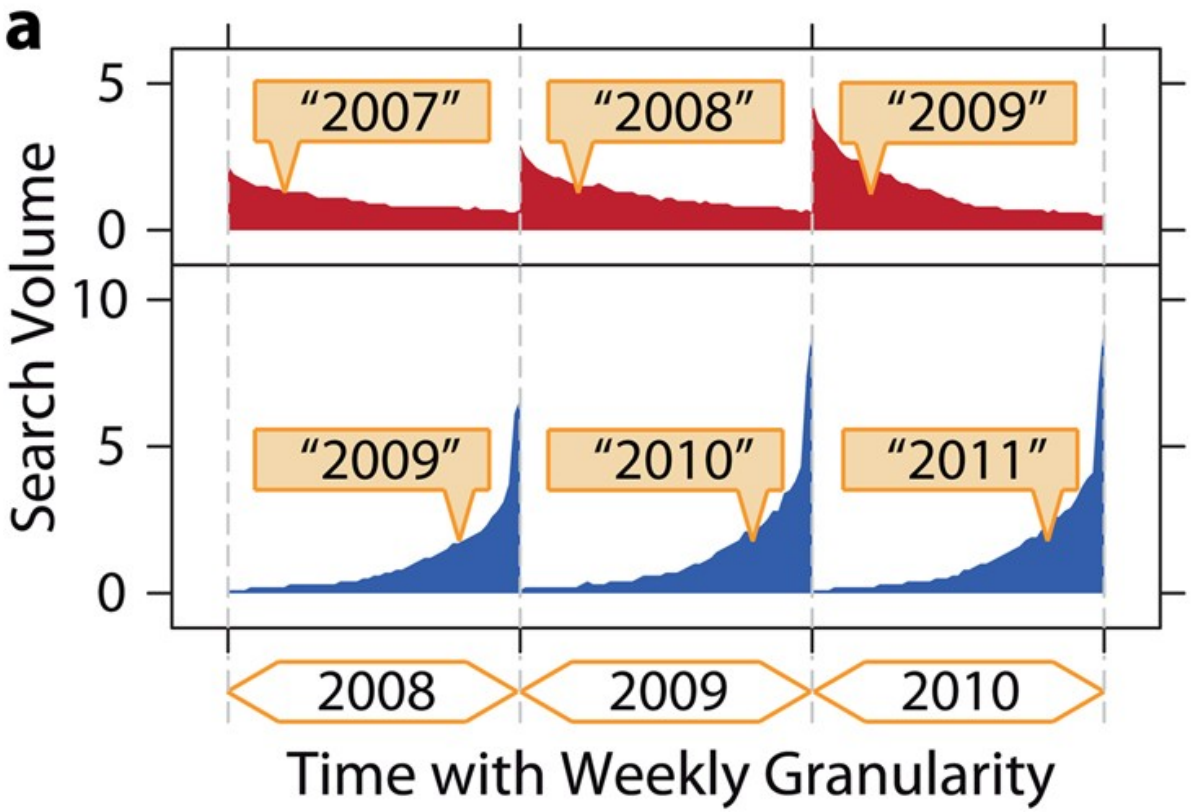
Anscombe's quartet ($\rho = 0.816$)

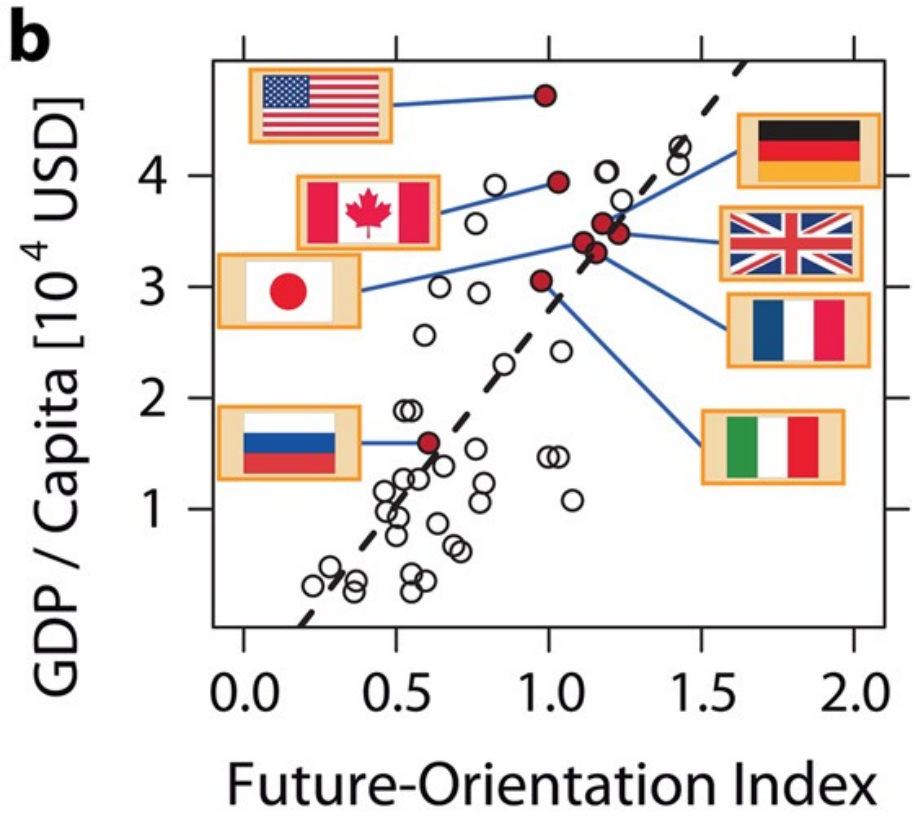


The Datasaurus dozen



Correlating the FOI and GDP per capita





Pearson correlation coefficient = 0.78

Outline

1. Search data: Google trends

2. Measuring temporal orientation with Google trends

3. Correlating economic development and temporal orientation

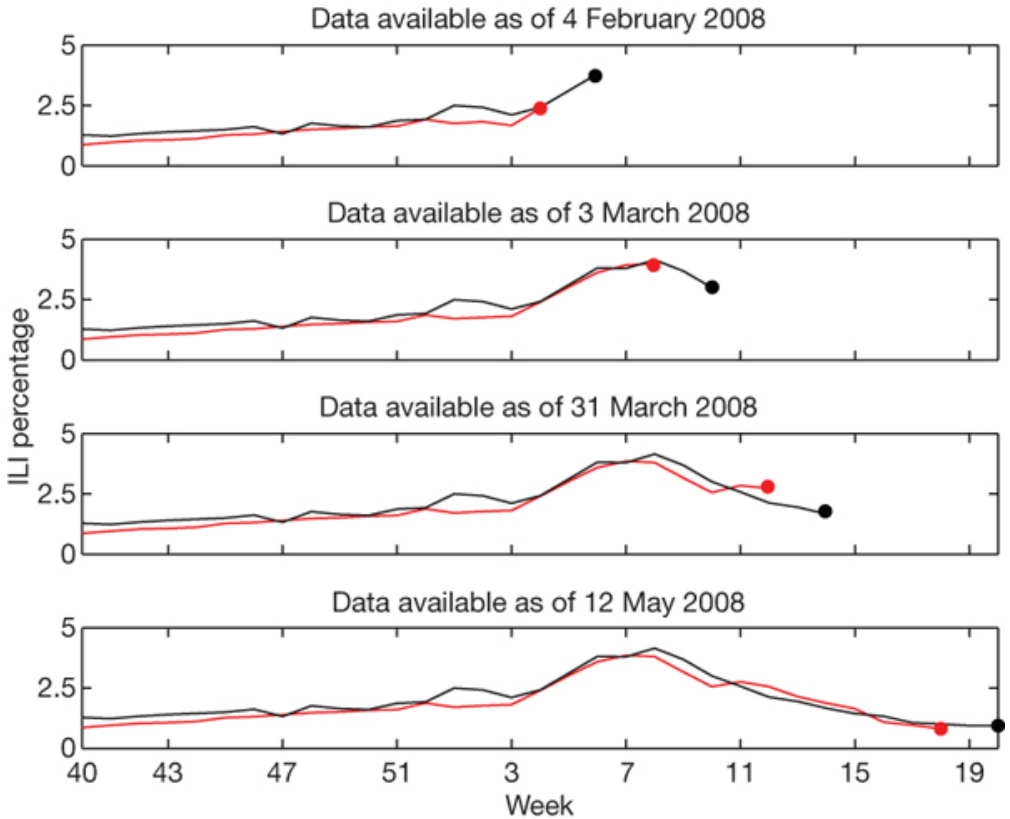
4. The parable of Google Flu trends

Nowcasting flu incidence with Google Trends

Nowcasting is predicting the present. It provides an estimation of the value of a quantity based on signals that appear at the same time.

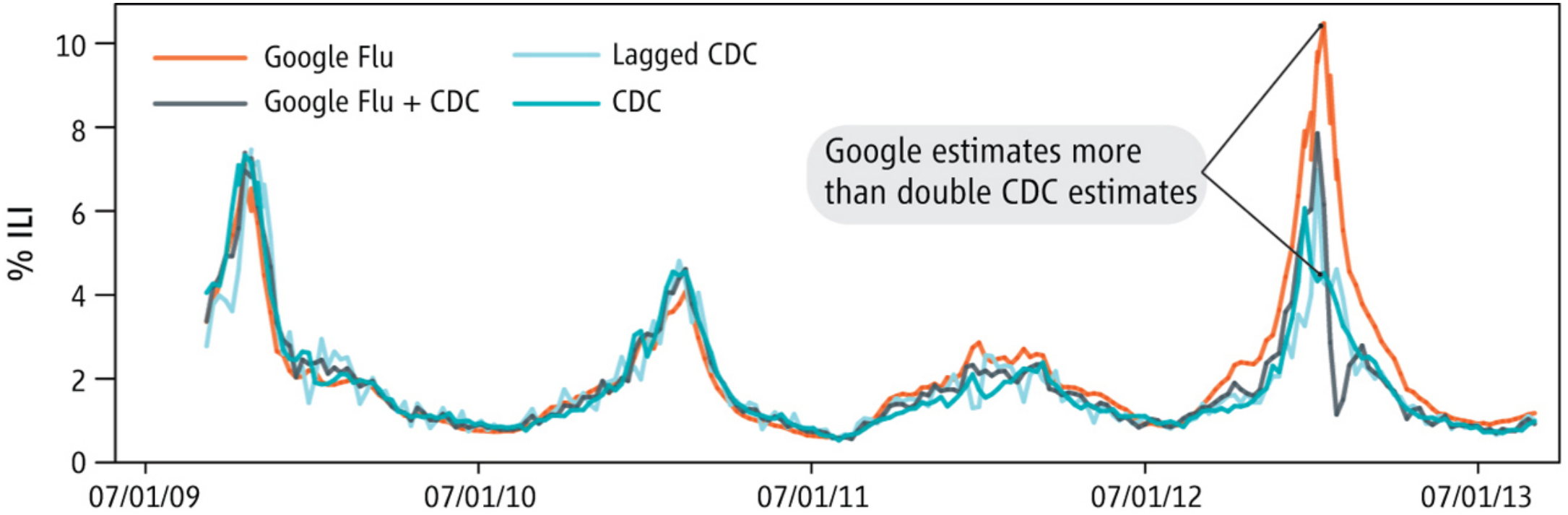
Google Flu Trends aimed at nowcasting influenza-related physician visits based on Google search volumes.

As reported in the Nature paper, Google Flu Trends achieved a high weekly accuracy between 2003 and 2008.



The figure shows the nowcasting result of Google flu trends. CDC data is published with a delay of two weeks.

When Google Flu Trends Stopped working



During the flu season of 2012/2013 Google Flu trends started overestimating the number of cases.

The Parable of Google Flu: Traps in Big Data Analysis. D. Lazer, R. Kennedy, G. King, A. Vespignani. Science (2014)

Comparing GFT with autoregression

Google flu:

$$flu_t = gft_t$$

Autoregressive model:

$$flu_t = \beta_0 + \beta_1 flu_{t-2} + \beta_2 flu_{t-3} + \epsilon$$

Combined model:

$$flu_t = \beta_0 + \alpha gft_t + \beta_1 flu_{t-2} + \beta_2 flu_{t-3} + \epsilon$$

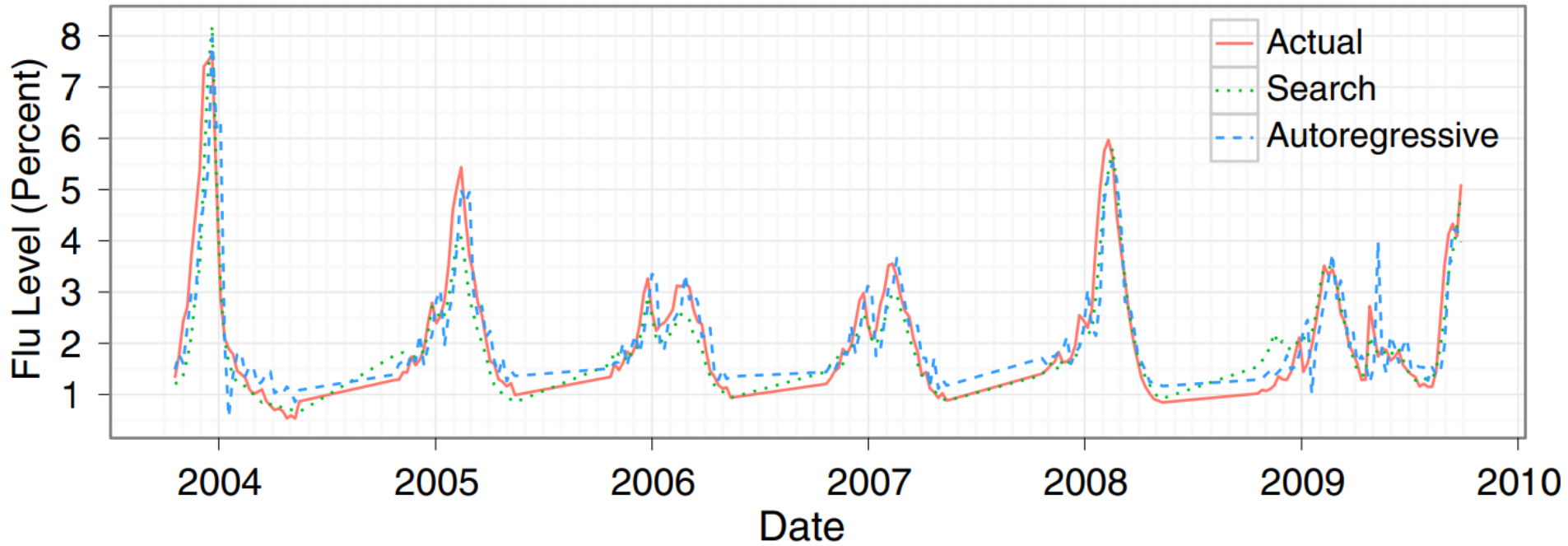
(note: More details on regression models in the next lectures)

Which model is better?

- Approach 1: explained variance
  - Correlation coefficient between predictions and empirical values
  - Coefficient of determination $R^2 = 1 - \frac{\sum_i \epsilon_i^2}{\sum_i (y_i - \overline{y})^2}$
- Approach 2: likelihood-based metrics
  - Likelihood $\hat{L}$, probability of the observed data (x) given the model and its parameter values: $\hat{L} = p(x|\hat{\Theta}, M)$
  - Bayesian Information Criterion: $k * ln(N) - 2 * ln(L)$, where N is the number of data points and k the number of parameters of the model

(note: More details on regression models in the next lectures)

GFT versus autoregression



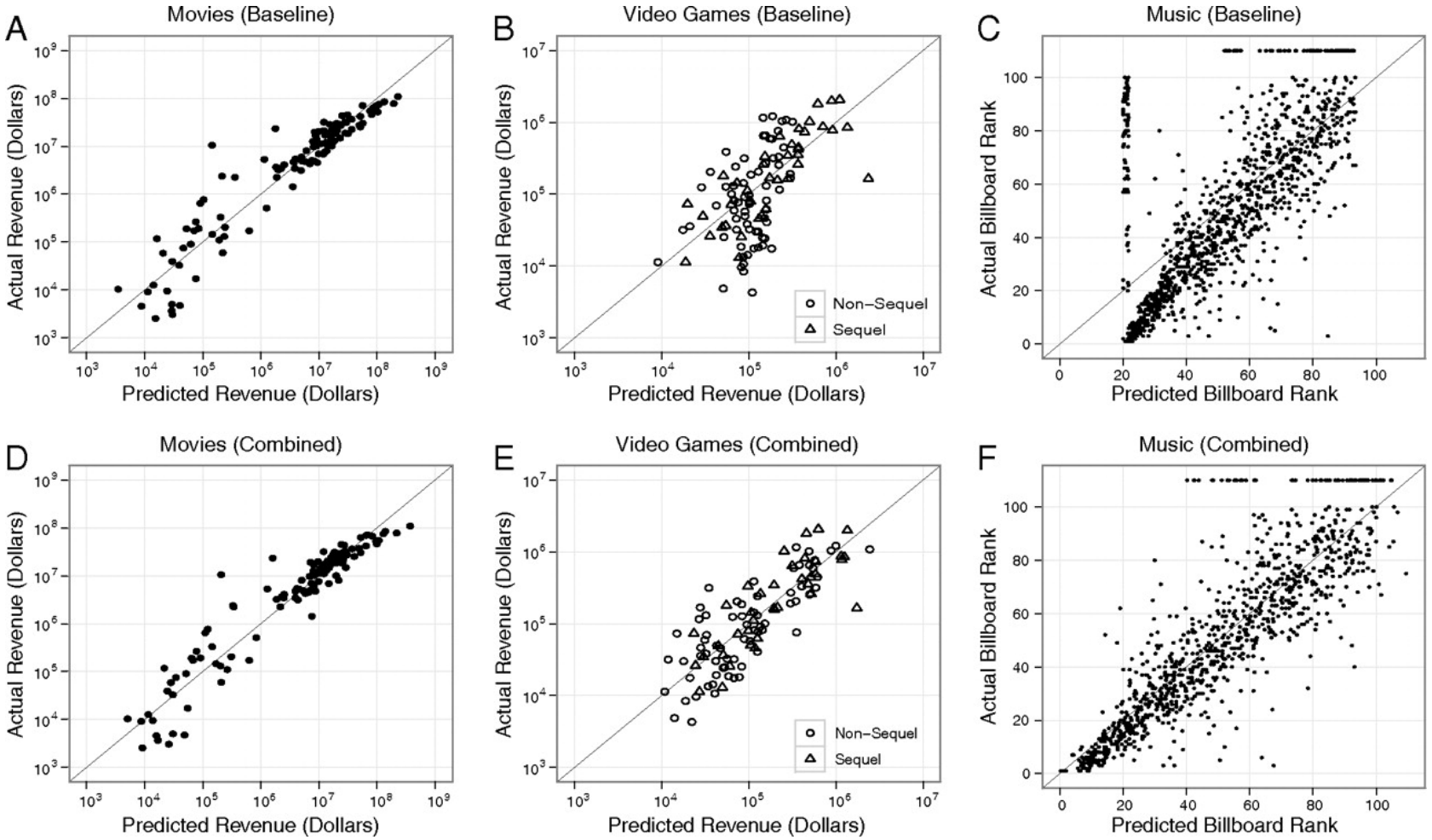
- Autoregressive model with two-week old data has correlation 0.86
- GFT had 0.94, Autoregressive model with last week data has 0.95
- Predicting consumer behavior with Web search. S. Goel, et al. PNAS (2010)

Algorithms and interfaces in digital traces

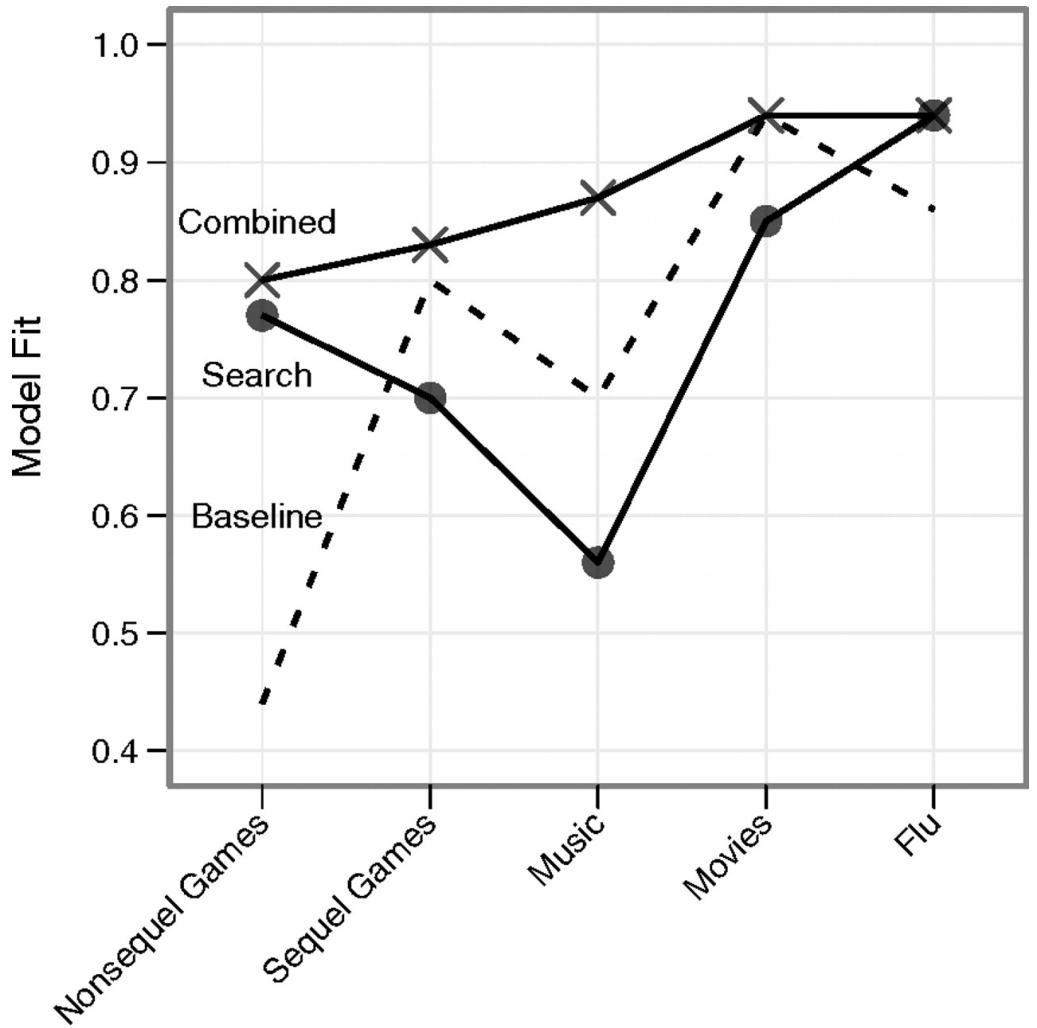
Algorithmic suggestions (terms to search, people to friend), shape the data and might not be possible to identify in the traces

Bit By Bit: Social Research in the Digital Age - Algorithmically Confounded. Matt Salganik (2018)

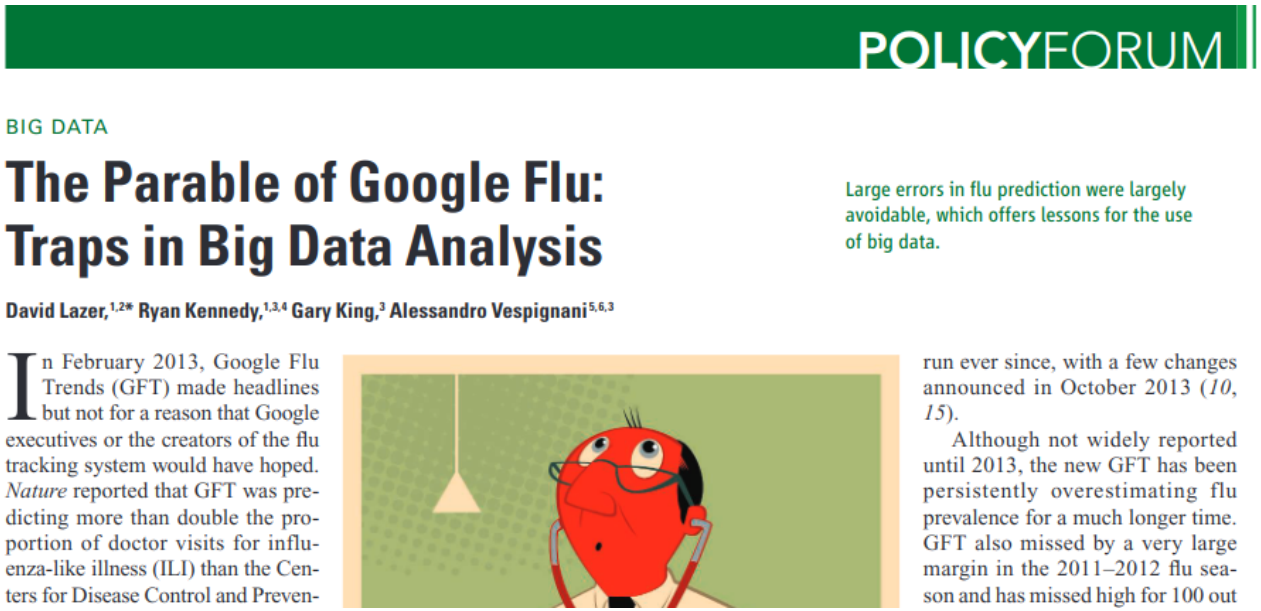
Where Google trends works: consumer trends



Comparing models in various cases



Big Data Hubris



POLICYFORUM

BIG DATA

The Parable of Google Flu: Traps in Big Data Analysis

Large errors in flu prediction were largely avoidable, which offers lessons for the use of big data.

David Lazer,[1,2*] Ryan Kennedy,[1,3,4] Gary King,[3] Alessandro Vespignani[5,6,3]

In February 2013, Google Flu Trends (GFT) made headlines but not for a reason that Google executives or the creators of the flu tracking system would have hoped. *Nature* reported that GFT was predicting more than double the proportion of doctor visits for influenza-like illness (ILI) than the Centers for Disease Control and Preven-

run ever since, with a few changes announced in October 2013 (*10*, *15*).

Although not widely reported until 2013, the new GFT has been persistently overestimating flu prevalence for a much longer time. GFT also missed by a very large margin in the 2011–2012 flu season and has missed high for 100 out

Google Flu Trends is an example of **Big Data Hubris**: ”The often implicit assumption that big data are a substitute for, rather than a supplement to, traditional data collection and analysis” (Lazer et al, Science, 2014)

> Take home message: **All data is better than Big Data**

Summary

- **Introduction to Google trends**
  - Searching trends across time and regions in a comparative way
  - A black box with lots of known unknowns

- **Temporal orientation and Google trends**
  - The interplay between culture and the economy
  - The Future Orientation Index
  - Correlating the FOI with GDP

- **Google Flu trends**
  - When Google trends started overestimating flu incidence
  - Big data models need to be compared with standard social science models
  - Digital traces are not made for research: algorithmic distortions