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Hurst's R/S-Analysis of Time Series

Enriching the Sociologist's Toolkit?

One morning, Norman wondered…

1. Sociologists are interested in long-term movements of social indicators (e.g. fertility, crime, church attendance, quality of life).
2. Yet, sociologists only rarely analyze time series.

Calling me at the office, he explained…

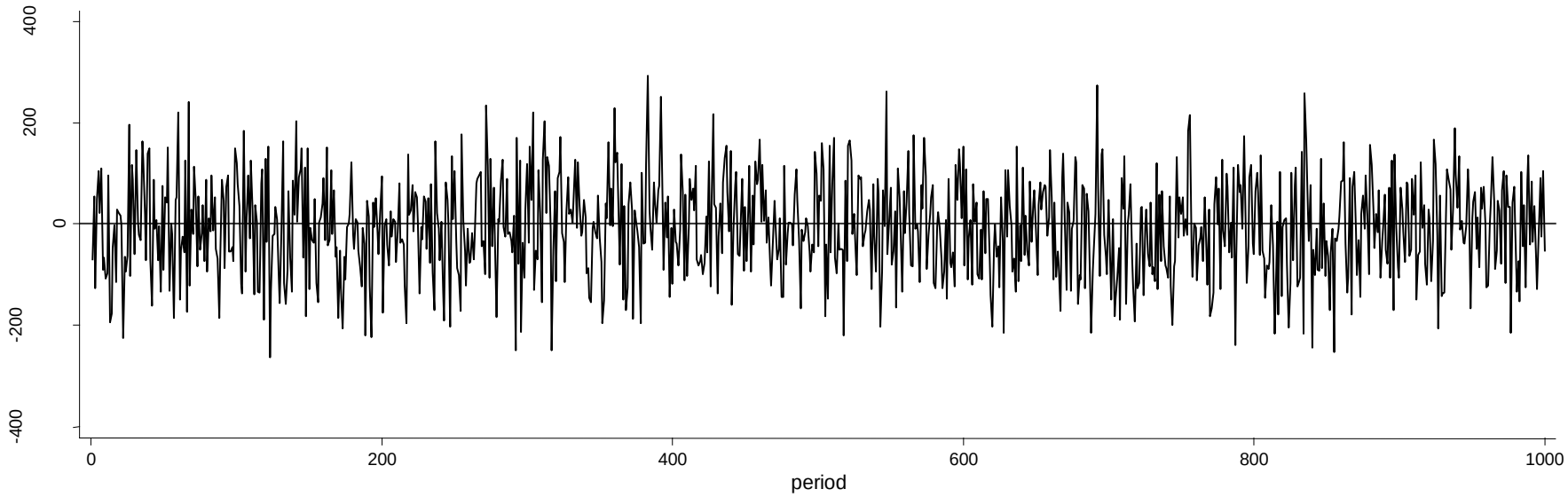
- Being stuck in Egypt, Hydrologist Harold Hurst developed a non-parametric statistic to identify systematic fluctuations of river heights.
  Its an ancient tool (Hurst 1951), but even Mandelbrot (2004) approves.
- Applying it to their social indicators, sociologists could identify whether there is systematic change which ought to be explained.

Outline

1. Hurst's R/S analysis and alternative methods
2. Efficient markets?
3. Prediction markets
4. Social indicators

Hurst's R/S Analysis I (Hurst 1951; Mandelbrot 1972; Sewell 2012)

1. Take a time series; transform it into a variable of **% changes**
2. Divide time series in intervals; calculate **mean**, **sd** for each **interval**



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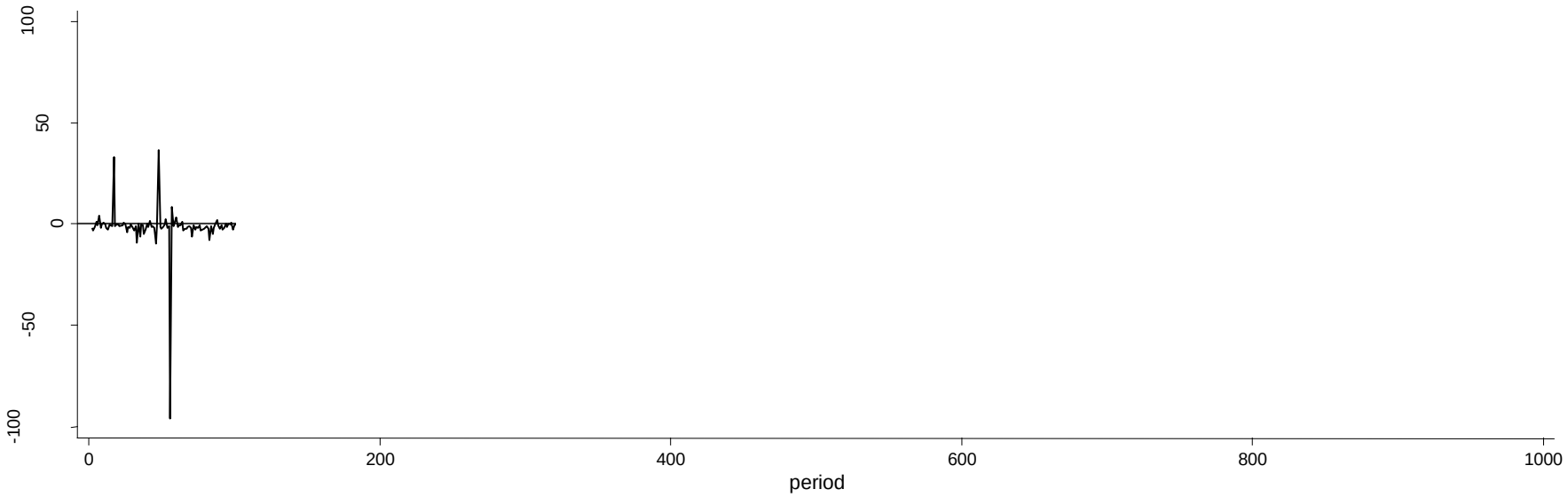
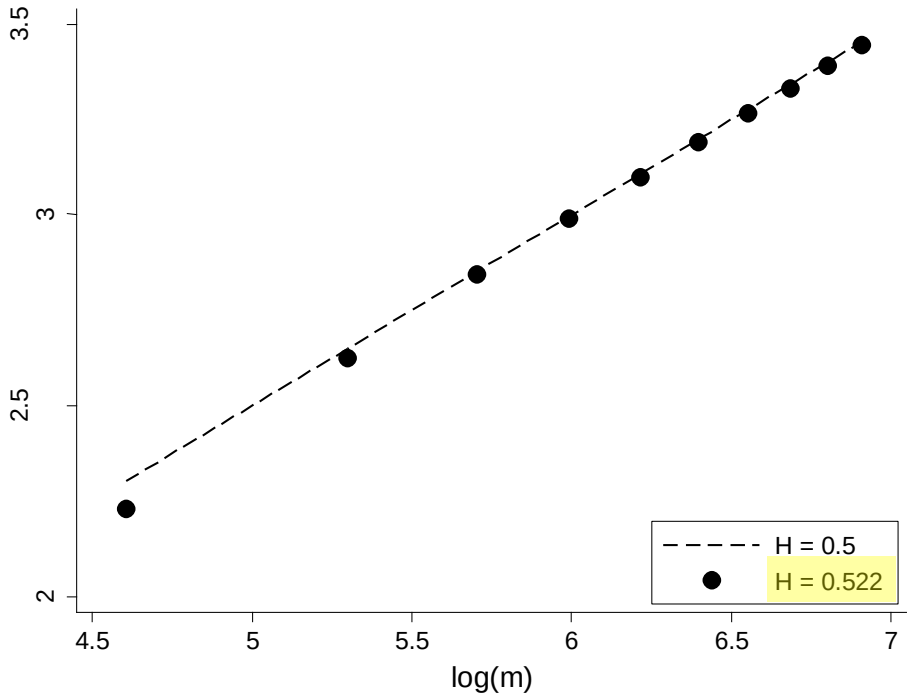


3. Calculate **deviations from** interval‘s **mean**
4. Consecutively **add up** deviations (partial sums)
5. Find **max**, **min** of partial sums; calculate **range** R for each interval
6. Divide R by interval‘s sd to get **R/S** statistic

Hurst‘s R/S Analysis II



H ≈ 0.5	random walk
0.55 < H < 1	persistence (+AR, –AR)
0 < H < 0.45	erratic oscillation

Run Test

dichotom. fluctuations above, below median

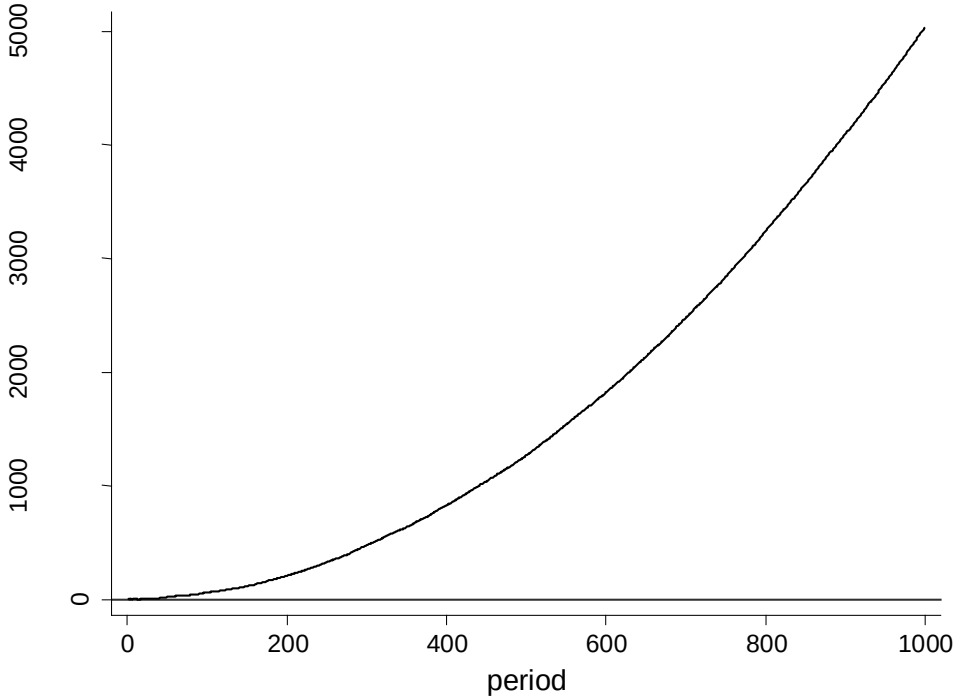
+ + − + − − − +

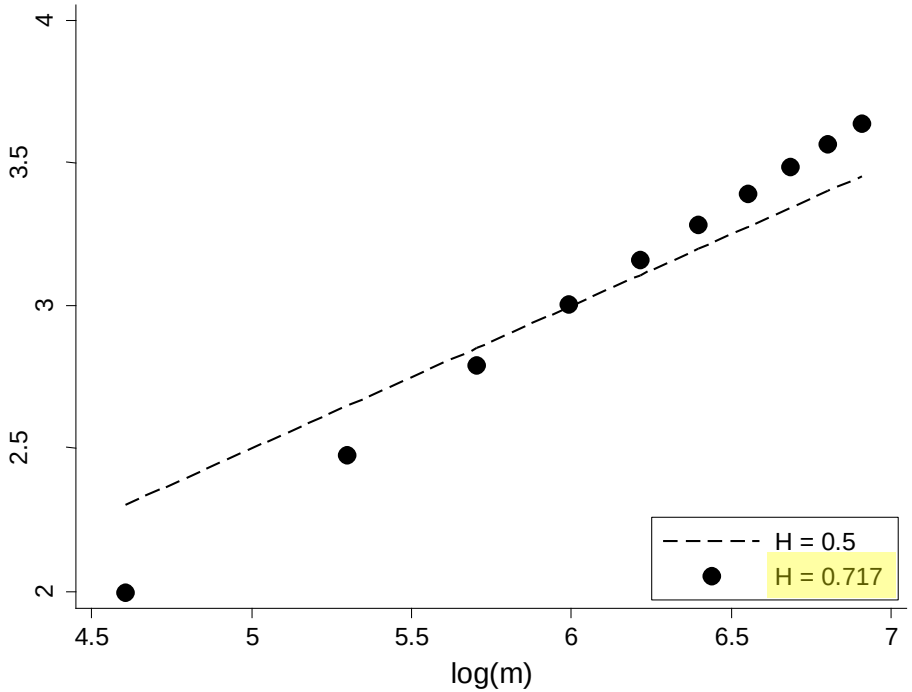
H0: Serial Independence

Expected number	Actual number	p-value
500	505	0.776

GARCH(1,1)

```
Sample: 1 - 1000
Distribution: Gaussian
Log likelihood = -5989.872
------------------------------------
             |      Coef.      P>|z|
-------------+----------------------
       arch  |
         L1. |   .0592183      0.204
             |
      garch  |
         L1. |  -.4374505      0.406
------------------------------------
```





Run Test

H0: Serial Independence

Expected number	Actual number	p-value
500	224	0.000

actual < expected : + AR
actual > expected : – AR

GARCH(1,1)

```
Sample: 1 - 1000
Distribution: Gaussian
Log likelihood = -5989.872
------------------------------------
             |      Coef.     P>|z|
-------------+----------------------
        arch |
          L1. |   .2062308     0.000
             |
       garch |
          L1. |   .7940041     0.000
------------------------------------
```

Why R/S?

- Several well established methods identify non-random patterns in time series
  - various functional forms of AR-processes
  - rare events and fat tails
  - successive vs. sequence of values

	AR-based	Run Test	R/S
non-parametric	–	+	+
magnitude of effects	+	–	+
sequence of values	–	–	+

Application 1: Efficient Markets?

"The predictability of asset prices is closely related to how markets function […]. If markets work well, prices should have very little predictability. […] Suppose investors could predict that a certain stock would increase a lot in value over the next year. Then they would buy the stock immediately, driving up the price until it is no longer attractive. What remains is an unpredictable price pattern, with random movements that reflect the arrival of news. In technical jargon, prices then follow a 'random walk'."

Royal Swedish Academy of Sciences 2013

EMH (Fama 1970) is paradox

- If prices reflect all available information, info searchers would not be compensated.
- Who would then invest in search? Informationally-efficient markets are impossible.

EMH is untestable

- incomplete data on private information
- incomplete data on fundamental values

Weak form efficiency information set includes complete history of prices

Financial Crisis: A Natural Experiment

DAX 2005–2009

197 German stocks*
listed in DAX (26), MDAX (26), TecDAX (11), SDAX (21), CDAX (103) or open trade (10)
weekly returns in %

* I thank Lisa Mußmann for helpful research assistance.

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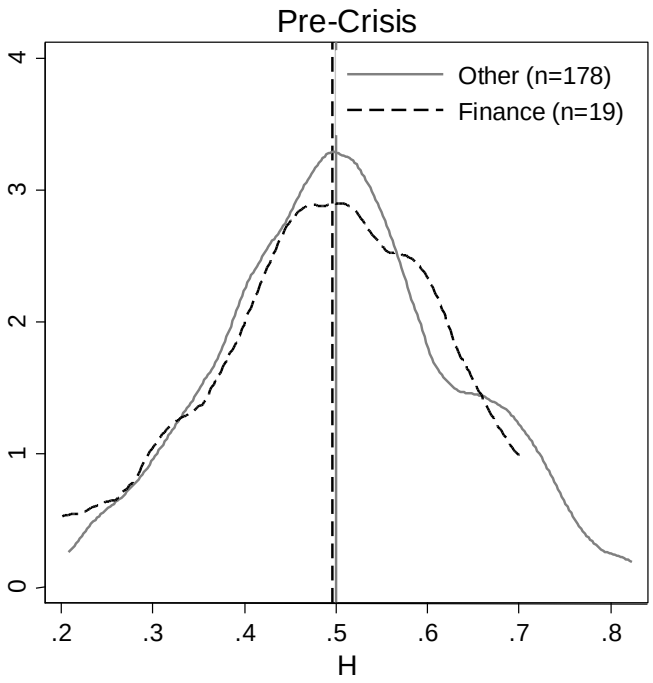
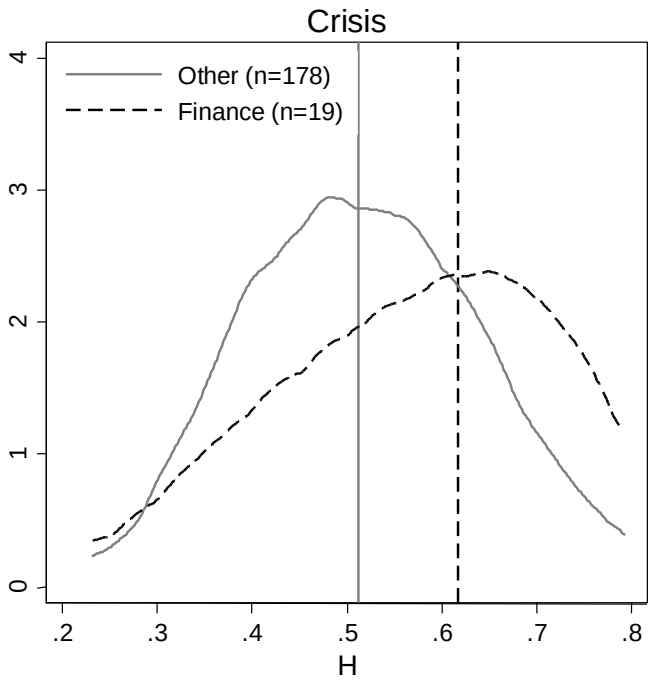
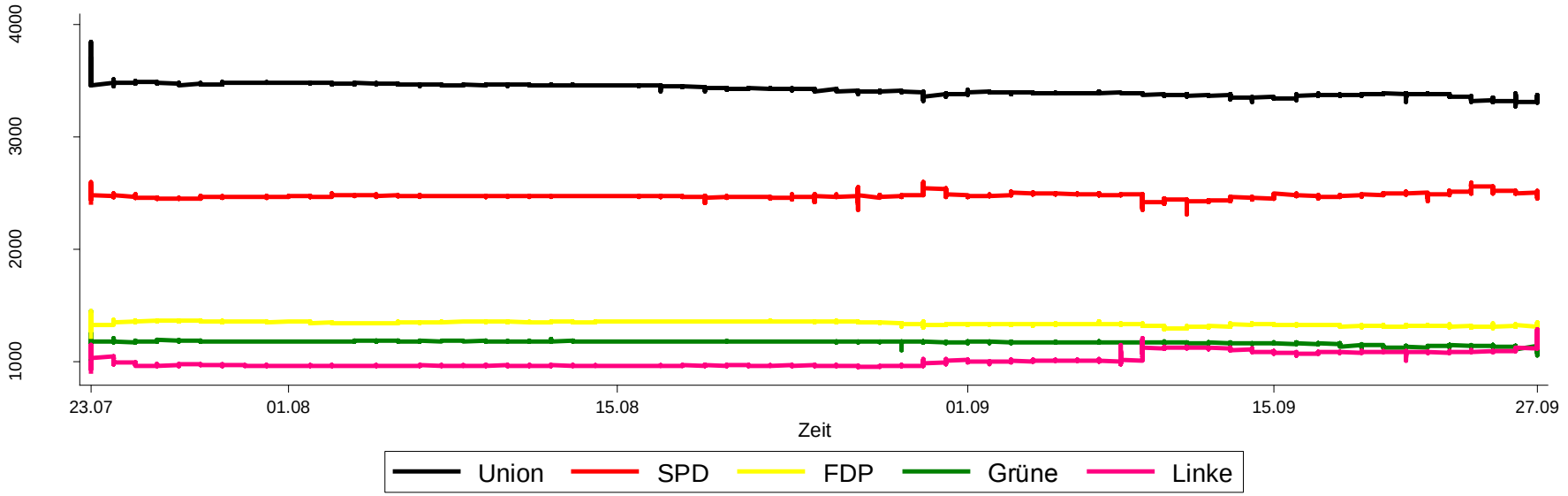


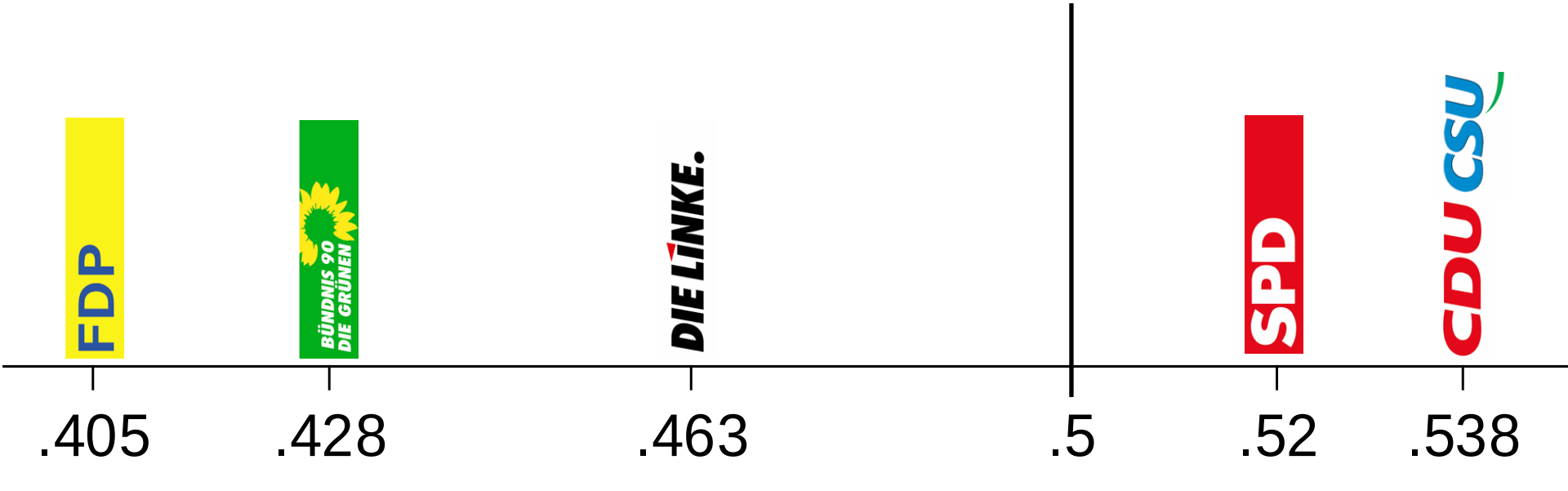


Finance stocks:
AdCapital, ALBIS Leasing, Berliner Effektengesellschaft, Capital Stage, Commerzbank, Cybits Holding, Deutsche Balaton, Deutsche Bank, Deutsche Beteiligungsgesellschaft, DVB Bank, Fritz Nols Global Equity, Generali Holding, GESCO, IKB Industriebank, MLP, Nürnberger Beteiligungsgesellschaft, Sparta, Value Management & Research, Webac Holding

Application 2: Prediction Markets

Bundestagswahl 2009; Wahlstreet (Groß 2012)





Application 3: Social Indicators

Time Series	Country	H	Period	Intervals	Source
Total Fertility	New Zealand	0.711	1850-2012	163	Gapminder.org
	France	0.712			
	Sweden	0.797			
	Denmark	0.818			
	Norway	0.845			
	Australia	0.868			
Female Labor Force	Germany	0.837	1959-2011	53	Destatis
Murder (per 100,000)	Japan	0.569	1950-2005	56	Gapminder.org
	Ireland	0.636			
	UK	0.693			
	Netherlands	0.694			
	Canada	0.837			
	USA	0.995			
Patents	USA	0.663	1790-1900	111	Gesis histat
	UK	0.680			
	France	0.792			
CO_2 Emissions (per cap.)	Poland	0.582	1830-2011	182	Gapminder.org
	Germany	0.608			
	Norway	0.665			
	France	0.685			
	Canada	0.691			
	Spain	0.709			
	Hungary	0.772			
	USA	0.835			
Air Travel Deaths	worldwide	0.496	1970-2008	39	Gapminder.org

Offene Fragen

Besteht in der Soziologie Bedarf nach einem einfachen Verfahren
zur Identifikation überzufälliger Veränderungen von Zeitreihen?

Welche konkreten Anwendungsmöglichkeiten gibt es?

Ist der Mehrwert der R/S-Analyse groß genug,
um gerade diese Methode zu verfolgen?

Vielen Dank

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