Statistical Sightings of Better Angels

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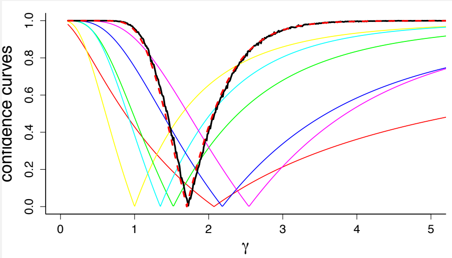
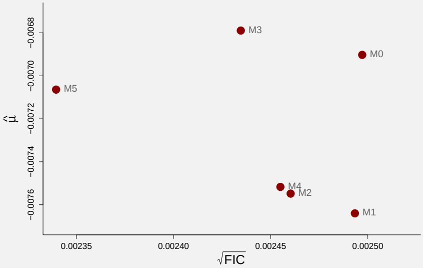
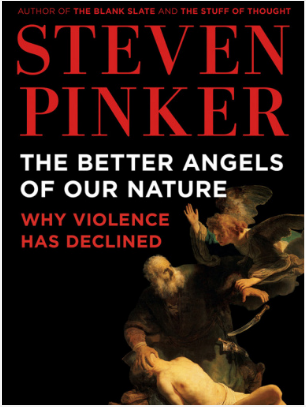
Me





Wars and Whales: Extensions and Applications of Confidence Curves and Focused Model Selection

Background: the World has become less violent



Pinker, S. (2011). The Better Angels of our Nature.

... even when looking at wars

The first and second world wars are not "exceptional" when you take into account the size of the world population:

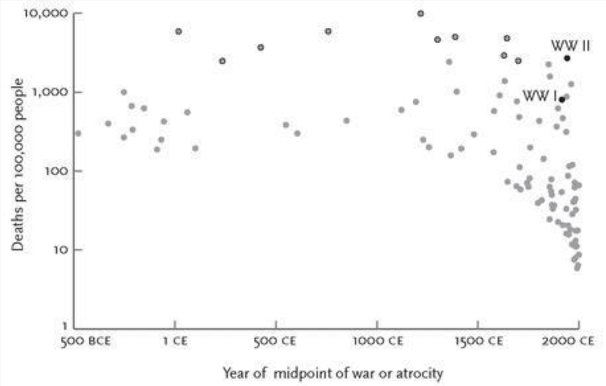


Figure 5.3 from Pinker (2011). The 100 worst wars in human history.

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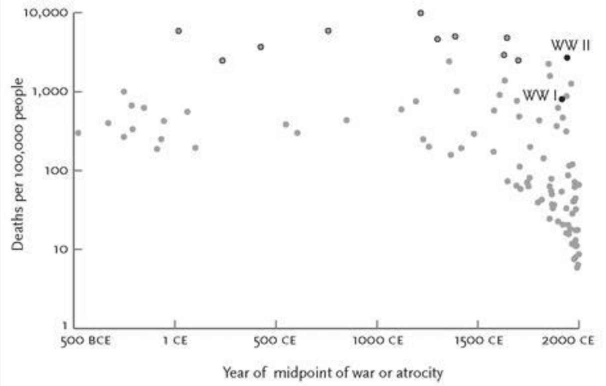

Figure 5.3 from Pinker (2011). The 100 worst wars in human history.

Further, after WWII there has been few big wars: "The postwar years are by far the longest period of peace among great powers since they came into being five hundred years ago."

Debate!

Not everyone agrees:

- **Nassim Taleb** (the one with *The Black Swan*): "Pinker is clueless about anything that has a 2nd order effect. In other words, about practically everything."
  - "We investigate the theses of long peace and drop in violence and find that these are statistically invalid and resulting from flawed and naive methodologies, incompatible with fat tails and non-robust to minor changes in data formatting and methodologies. " (Cirillo and Taleb (2016). *On the statistical properties and tail risk of violent conflicts.*)

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- **Aaron Clauset** (Computer Scientist at University of Colorado in Boulder): partly similar conclusions, but formulated in a less polemical manner.
  - "... both the long peace and the period of great violence that preceded it are not statistically uncommon patterns in realistic but stationary conflict time series. [...] The models indicate that the postwar pattern of peace would need to endure at least another 100 to 140 years to become a statistically significant trend." (Clauset (2018). *Trends and fluctuations in the severity of interstate wars.*)
  - Our work is partly a response to Clauset: same data, similar models (but different methods).

Statistical questions

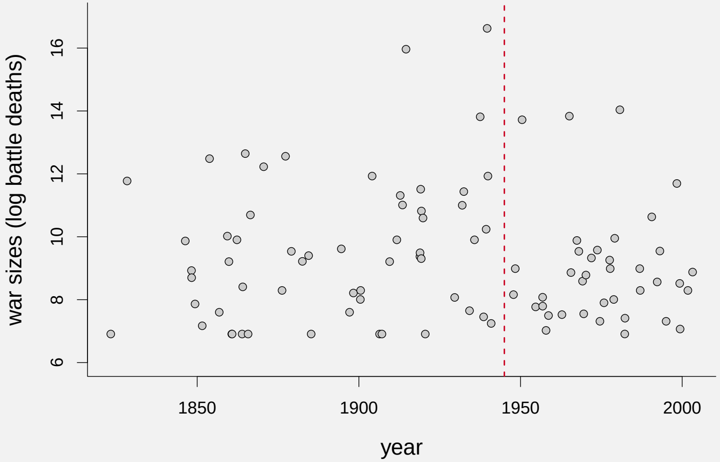
How special is really the Long Peace?

1. Are there significantly less wars?
2. **Have the wars become significantly smaller?**
3. **If yes, when did the change take place?**

Some sharpening:

- We choose to look at **interstate** wars with more than 1000 battle deaths from 1823 till 2017 (since there is a high quality dataset of this type, *Correlates of War* (CoW)).
- War size = battle deaths.
- Many other choices to make, for instance should one take into account the world population? Or the number of independent states?

95 interstate wars



Let z_i be the size of war i, and let d_i be the time between the start of war i and war nr $i - 1$.

Quantitative war research: Lewis F. Richardson

Studied a dataset of historical wars and reached two key insights:

- Wars are generated according to a Poisson process $\rightarrow$ $d_i \sim \mathrm{Expo}(\lambda)$;
- The size of wars are power law distributed, $z_i \sim \mathrm{Pow}(\theta)$.

Richardson, L.F. (1960). Statistics of Deadly Quarrels.

War sizes follow a power law distribution

$$P(Z > z) \propto z^{-\theta} \quad \text{med } \theta > 0$$

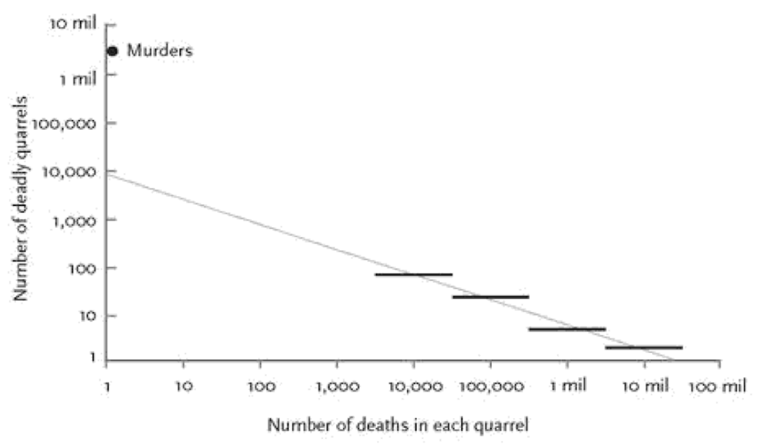


Figure 5.7 from Pinker (2011). Numbers of deadly quarrels of different size.

War sizes follow a power law distribution

$$P(Z > z) \propto z^{-\theta} \quad \text{med } \theta > 0 \tag{1}$$

Usually, the power law only holds for “big” Z and we therefore need to find $z_{\min}$ such that $Z \sim Pow(\theta)$ for $Z > z_{\min}$,

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or choose a distribution where (1) holds in the tails (i.e. a distribution with power law tails).

There are several such distributions to choose between. We have used the following,

$$F(z; \mu, \alpha, \theta) = P(Z \leq z) = \left[\frac{(z/\mu)^\theta}{(z/\mu)^\theta + 1} \right]^\alpha,$$

the so-called inverse Burr distributions.

How does one investigate a trend?

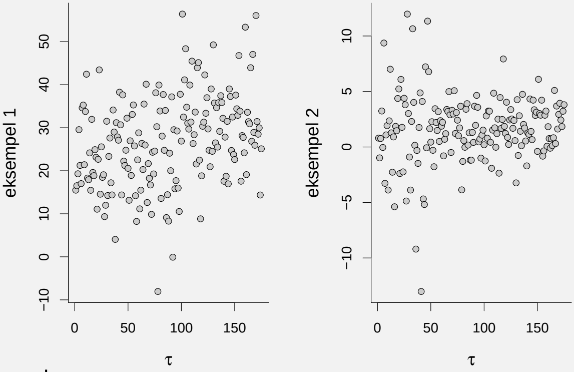
Many possibilities:

- regression methods?
- homogeneity tests: testing H_0: *the world is constant*
- change-point analysis; + the *degree of change* $\rightarrow$ implicit test of homogeneity?

Change-point problems

Say we have

- $y_1, \ldots, y_\tau$ from $f(y_i, \gamma_L)$
- $y_{\tau+1}, \ldots, y_n$ from $f(y_i, \gamma_R)$.

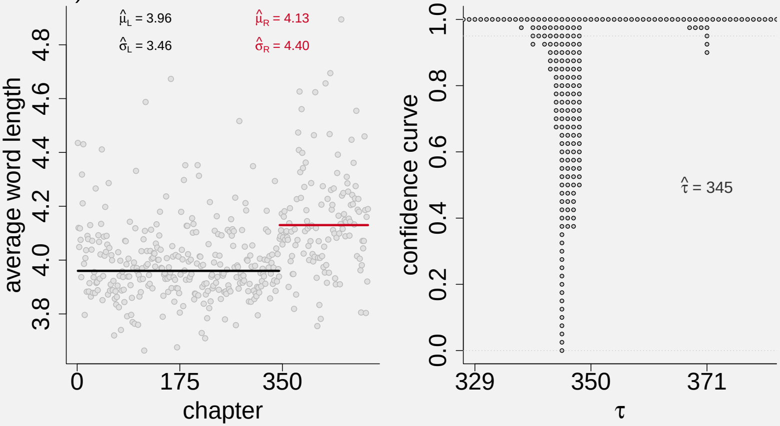


And we want

- $\hat{\tau}$ and a measure of the uncertainty around it;
- an estimate of the degree of change (with uncertainty).

Confidence curves

We summarise our inference about τ as a confidence curve. For instance, it could look like this (a curve from a completely different dataset),



(Remember that $\hat{\tau}$ is a discrete parameter)

A change-point method

1. Find the *profile log-likelihood function* for τ, make the *deviance* function for τ;
2. Find a *confidence curve* by simulating the distribution of the deviance for every possible τ-value.

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The profile log-likelihood function of τ is

$$\begin{aligned}\ell_{\mathrm{prof}}(\tau) &= \max_{\gamma_L,\gamma_R}\Big\{\sum_{i\le\tau}\log f(y_i,\gamma) + \sum_{i\ge\tau+1}\log f(y_i,\gamma)\Big\}\\ &= \sum_{i\le\tau}\log f(y_i,\widehat{\gamma}_L(\tau)) + \sum_{i\ge\tau+1}\log f(y_i,\widehat{\gamma}_R(\tau)),\end{aligned}$$

and the deviance $D(\tau, Y) = 2\{\ell_{\mathrm{prof}}(\widehat{\tau}) - \ell_{\mathrm{prof}}(\tau)\}$. The confidence curve is defined as

$$\mathrm{cc}(\tau) = P_\tau\{D(\tau, Y) < D(\tau, y_{\mathrm{obs}})\},$$

where Y is generated from $f(y,\widehat{\gamma}_L)$ to the left and from $f(y,\widehat{\gamma}_R)$ to the right for all τ-values.

Benefits and drawbacks of this method

Benefits:

- flexible, we can discover changes in any characteristics of the distribution;
- we do not need to specify any priors;
- we can display the uncertainty in the change-point position;
- we can obtain a confidence curve for the degree of change (by a similar method).

Drawbacks:

- mostly restricted to problems with a single change-point;
- the method always finds a change-point... then the user has to decide whether he/she trusts the finding, taking into account the uncertainty displayed in the confidence curve, and the inference for the degree of change.

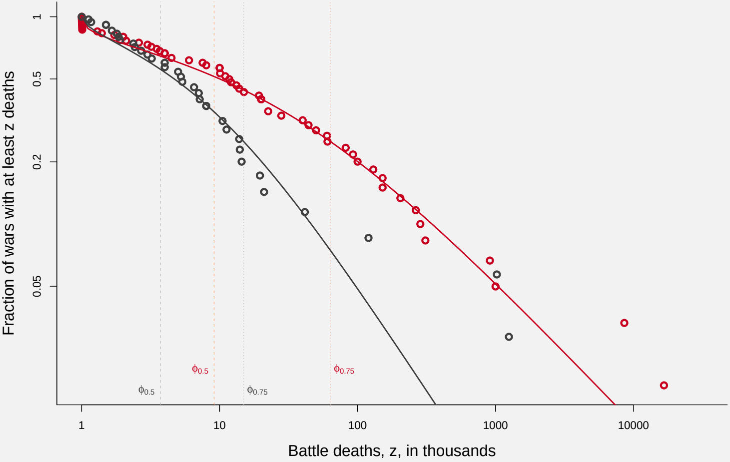
95 interstate wars

- $z_1, \ldots, z_\tau \sim \mathrm{InvBurr}(\mu_L, \alpha, \theta_L)$
- $z_{\tau+1}, \ldots, z_n \sim \mathrm{InvBurr}(\mu_R, \alpha, \theta_R)$

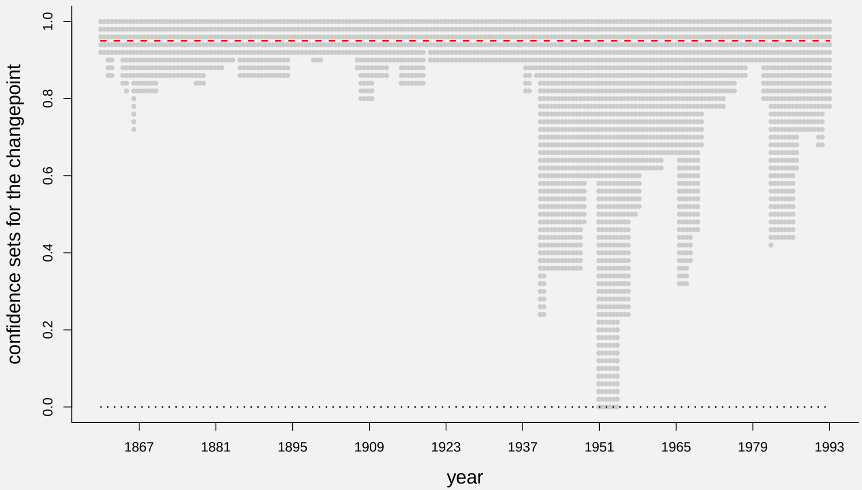
Results

The point estimate is $\widehat{\tau} = 1950.483 \rightarrow$ the Korean War.

One should check that the model fits well to the data,



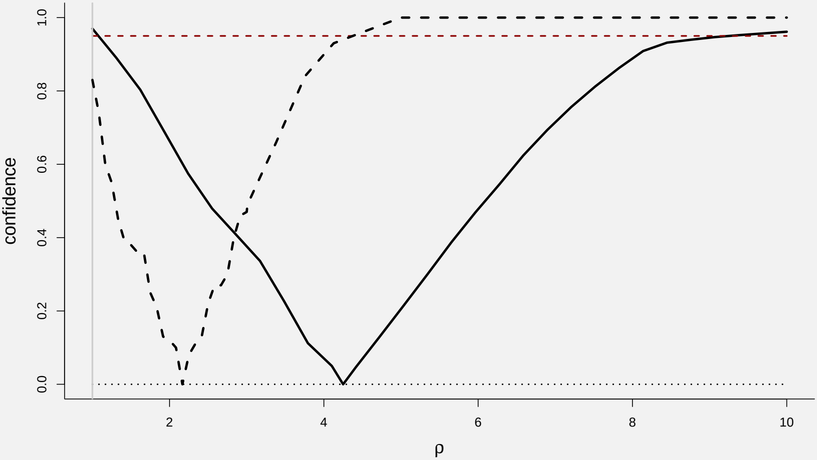
Confidence curve for τ



But.. in what what direction is the change happening, and how big is it?

Confidence curve for the degree of change

Let $\rho_1 = \phi_{0.50,L}/\phi_{0.50,R}$ (dashed) and $\rho_2 = \phi_{0.75,L}/\phi_{0.75,R}$ (fully drawn),



At $\rho = 1$ we are testing H_0: *the world is constant*.

Statistical questions

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3. **If yes, when did the change take place?** After the Korean war.

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What about question 1? fewer wars would mean longer time between each war. Remember $d_i \sim \mathrm{Expo}(\lambda)$, do we see a change inn λ? No.

But, now there are 15 years since the last interstate war with more than 1000 battledeaths. Isn't that quite unlikely? Yes, p-value $= 0.0004$.

Conclusions

- Wars can be modelled!
- If one believes that the Long Peace is "significantly" different from the periods preceding it, one may have reasons to believe that *something* really did change in the times after WWII, and then one can start searching for what caused that change (international relations? attitudes towards war? democracy?).
- But this is only a beginning. Whether there has been a statistically significant trend or not, the patterns observed in incidences and sizes of wars are worth exploring and explaining, and we therefore need to move from the simple models used here (with independence!), to more complex and theoretically driven models.
- Many people care about these questions (and that is nice), but one should be careful to **not over-interpret the findings**.

Media attention

Clauset (2018). *Trends and fluctuations in the severity of interstate wars.*

Express (UK):

World War 3? 'Long peace' UNDER THREAT as huge conflict is OVERDUE, claims mathematician

THE WORLD could be on the brink of a huge global war because the statistics claim the "long peace" that has been enjoyed since 1945 might be an anomaly, a leading mathematician has declared.

By THOMAS MACKIE

Media attention

Cunen, C., Hjort, N.L., Nygård, H. (2019). *Statistical sightings of better angels.*

The world has become more peaceful

February 25, 2019 - 06:00

Although the war in Syria is in its eighth year, statisticians have established that the world is becoming increasingly peaceful.

Keywords: Conflict, Peace, statistics

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By: Yngve Vogt, Apollon

- Analyses based on statistics/mathematics are usually considered very convincing ("objective", "advanced",...). Here we have a responsibility to communicate clearly and carefully!