Regions at Risk: Predicting Conflict Zones in African Civil Wars

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Abstract

A method for predicting conflict zones in civil wars based on Spatial Point Pattern Analysis is presented. The study region is delimited to eight countries in Sub-Saharan Africa that have experienced civil wars or strong communal violence since 2000. Following the classic literature on (counter-)insurgency and insights from contemporary conflict research, a stylized model of unconventional fighting is derived and fitted to empirical data. Out-of-sample predictions are used to assess the model's predictive capabilities quantitatively and visualized predictions allow for side-by-side comparisons with the empirical record. Generally, predicting regions that face an increased risk of becoming conflict zones in civil war seems possible based on the presented approach.

Theoretical Assumptions

Spatial modeling of conflict events in civil wars requires an understanding of the strategic objectives of the actors. Most civil conflicts are fought as asymmetric or symmetric-unconventional wars (Kalyvas&Bacells 2010). The (counter-)insurgency literature describes securing civilian loyalties as the key objective for the military actors. Winning "hearts and minds" and revolutionaries that "move among the peasants as the fishes swim in the sea" are classic examples. Moreover, both the state and guerrilla movements need to secure resources to finance their fight. Rebels sometimes collaborate with neighboring states to launch cross-border attacks and smuggle arms into the theater. They also utilize international borders and rough terrain to escape the state's reach. Rebels employ small and independent units that usually enjoy the tactical initiative.

Mechanisms and Explanatory Variables

Conflict zones are defined as high intensity clusters of conflict events. Therefore, the number of events that fall into any area was chosen as the dependent variable. Based on the theoretical insights, spatial expectations of what determines the number of events and suitable data sources can be identified:

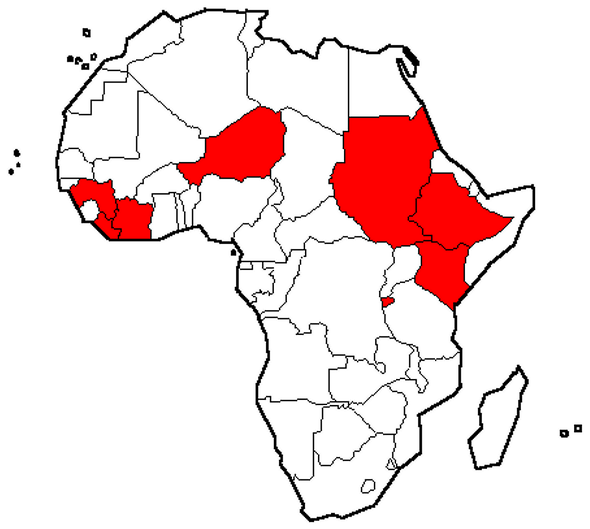
- Conflict events
  - Conflict zones are characterized by high numbers of conflict events.
  - The "Armed Conflict Location and Event Dataset" was used as an empirical sample of conflict events.
  - `http://www.acleddata.com/`
- Population
  - Actors fight over popular loyalties. Therefore, population concentrations see the most sever fighting.
  - The "Gridded Population of the World" dataset provides time-variant, geo-referenced population figures.
  - `http://sedac.ciesin.columbia.edu/gpw/`
- Capital distance
  - Over time, rebels advance toward the capital city which the state seeks to protect.
  - Distances to the capital city were calculated based on the "Cshapes" dataset.
  - `http://nils.weidmann.ws/projects/cshapes`
- Border distance
  - Rebels sometimes escape the state's reach across international borders and launch cross-border attacks.
  - Distances to the nearest international border were calculated based on the "Cshapes" dataset.
  - `http://nils.weidmann.ws/projects/cshapes`
- Terrain accessibility
  - Rebels sometimes escape the state's reach by utilizing rural and inaccessible areas.
  - Distances to the nearest city of 50,000 were calculated based on the "Travel times to major cities" dataset.
  - `http://bioval.jrc.ec.europa.eu/products/gam/index.htm`
- Diamond mines
  - Both actors fight over access to lootable resources.
  - Distance to diamond mines was calculated based on (Gilmore el. al 2005).
  - `http://cmp.sagepub.com/content/22/3/257.refs`
- Disaggregated wealth
  - Actors try to secure wealthy regions to finance the fight.
  - Spatially disaggregated data on wealth was obtained from (Nordhaus, et al 2006).
  - `http://gecon.yale.edu`

Statistical Model

Since most attacks are carried out independently of one another by small groups of combatants, attacks can be modeled as a direct function of the spatial covariates. Attack counts are modeled as a Spatial Inhomogeneous Poisson Process: the number of events falling into any region is a Poisson random variable. The expected value of events varies from region to region and is estimated based on the covariates. This modeling technique induces some bias for the problem on hand since spillover effects and reactive patterns in the data are not accounted for. However, more advanced modeling techniques that take spatial lags into account also generate higher variances in the predicted patterns.

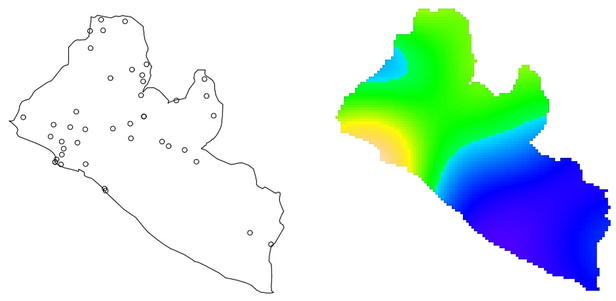
Case Selection

Eight countries from Sub-Saharan Africa were chosen for the analysis. A geographically confined study region was chosen to ensure comparable contextual conditions.



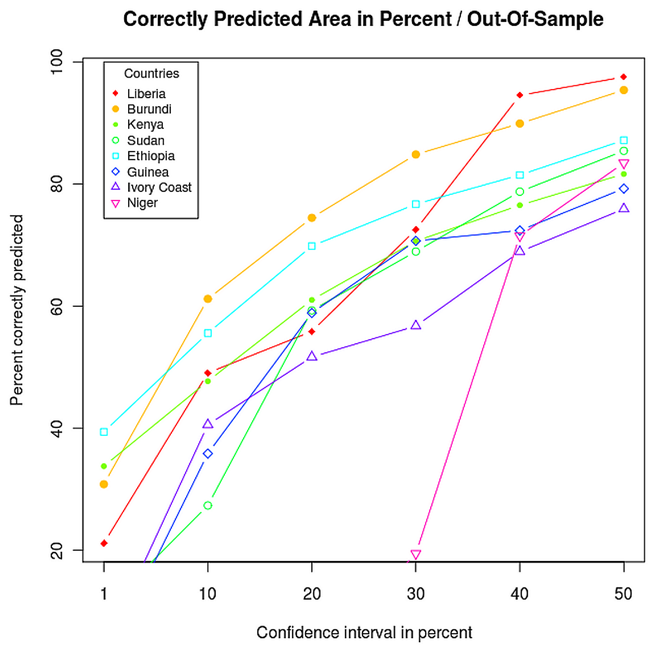
Unit of Analysis

In order to allow for meaningful comparisons between empirically observed and predicted conflict zones, event counts were simulated and aggregated into Gaussian density surfaces. Deviations between simulated and empirically observed event densities were used to quantify the model's predictive performance. The figures below show the empirical pattern of events from the Second Liberian Civil War and the corresponding density surface.



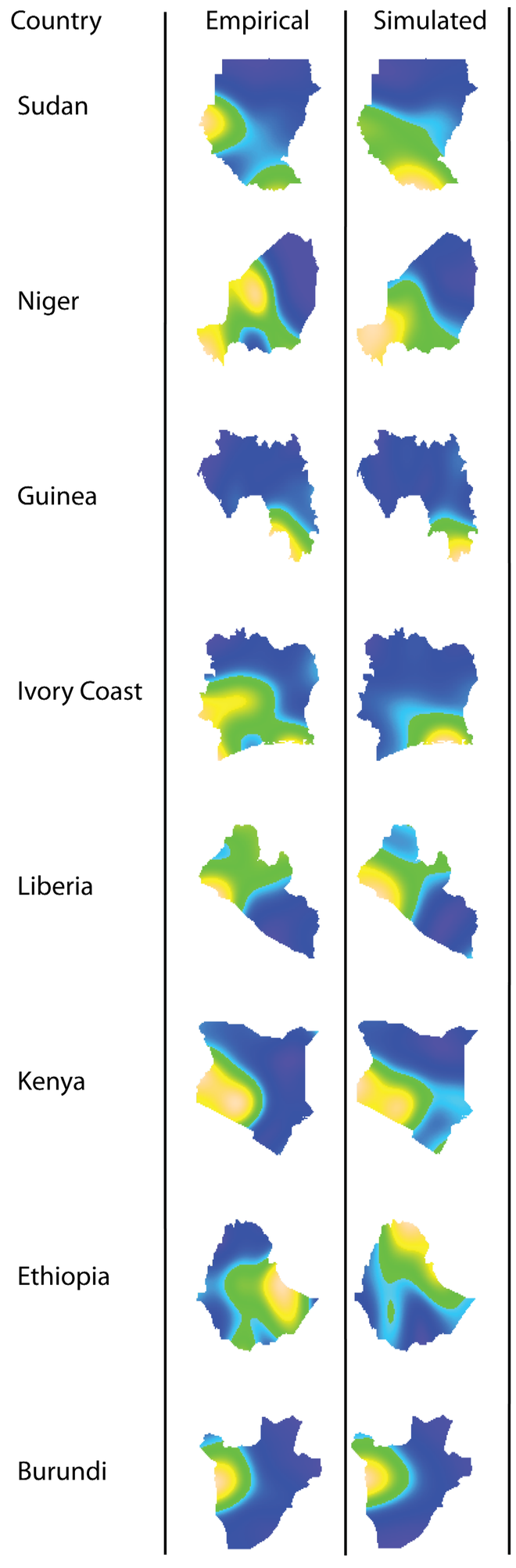
Quantitative Predictive Performance

Predictive performance was generally assessed based on leave-one-out cross validation: the model was fitted on all but one country and then used to predict that missing country. This setup emulates the real-world situation of having to predict future conflict zones based on historical observations in other countries. The figure below shows correctly predicted areas for different allowed deviations between empirical and simulated densities.



Qualitative Predictive Performance

A side-by-side comparison shows the predominantly correct predictions of general conflict zones. While absolute densities may differ, most predictions match with regard to relative event distributions.



Conclusion and Outlook

Reliable spatial patterns of violence exist in civil wars. While more data is needed to generate accurate predictions of regions at risk, a first step has been taken. The presented technique could be used to anticipate refugee flows and identify suitable regions for long-term development programs. A tight integration with crisis mapping would allow for extrapolations from already reported conflict events into the future. Future extensions of this approach will also identify explanatory variables that enhance predictive performance in a more systematic and possibly automated fashion.

Want to Learn More?

A more extensive presentation can be found at:
`www.youtube.com/watch?v=X8Hokpv7TQo`