The Fractured Land Hypothesis

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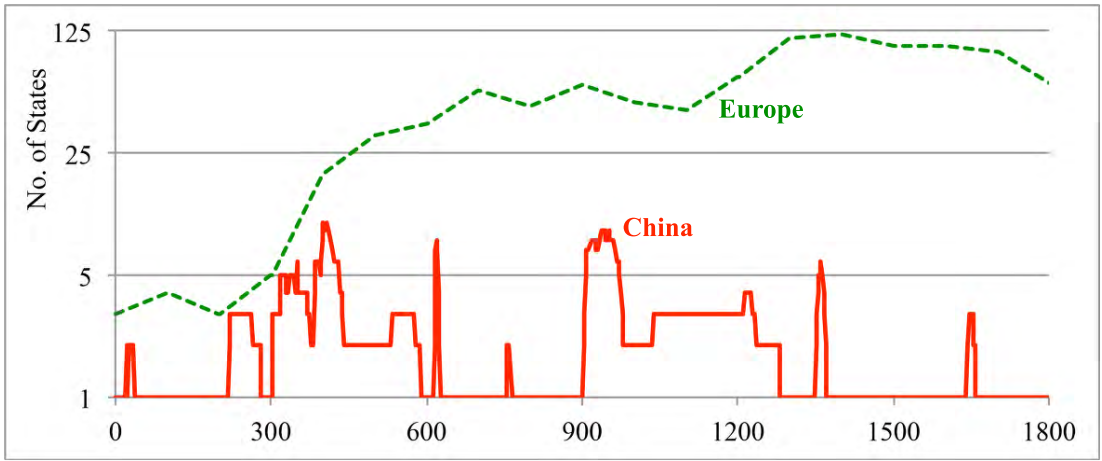
Unified China, divided Europe

Figure: Number of States in China and Europe



Sources: Nussli (2011)

Motivation

- Why?
- Why do we care?
  - Economic rise of Western Europe often attributed to its competitive state system: Montesquieu (1748), Jones (1981), Mokyr (2016), and Scheidel (2019).
  - Conversely, many explanations of China's comparative failure focus on its long history as a centralized empire.
  - Thus, thinking about the factors that account for the prevalence of political fragmentation in Europe and political centralization in China might teach us much about the origins of economic growth.
  - Even if one does not embrace the idea that a polycentric state system was behind the great divergence between Europe and China, political unification is a salient observation we want to understand.

"Fractured-land"

- Idea traceable to David Hume.
- Diamond (1997, 1998): "fractured-land" such as mountain ranges and dense forests impeded the development of large empires in Europe in comparison to other parts of Eurasia.
- However:
  - Hoffman (2015): China is, in fact, more mountainous. Also Turchin (2013) and Greer (2013).
  - Hui (2005): Contingent outcome.
- Most of these arguments are not assessed quantitatively.
- Hard to gauge events such as the formation of the Roman Empire, and its disappearance.

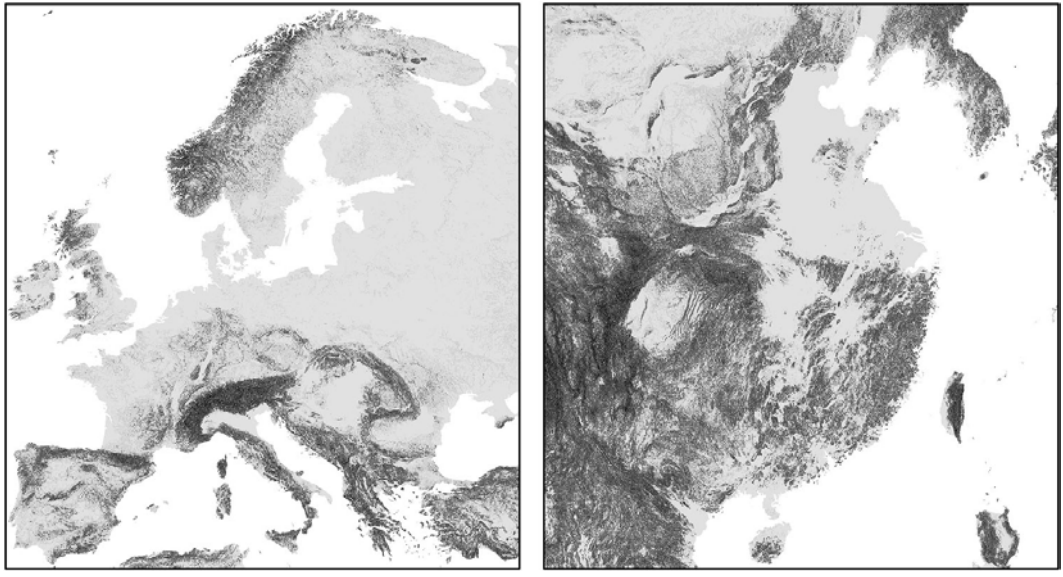


Figure: Ruggedness in Europe and China proper.

Our investigation

- We build a dynamic spatial model of state formation for Eurasia from 1,000 BCE–1,500 CE.
- We (1) divide Eurasia into small grid-cells, and (2) provide each cell with their corresponding topography, climate, and land productivity information.
- Cells will engage in inter and intra-state competition, leading to (stochastic) consolidation and fragmentation.
- These processes will be mediated by the characteristics of each cell.
- We simulate the model and obtain probability distributions of state system outcomes.

Our results

- "Fractured-land" provides a robust explanation for the political divergence observed at the two ends of Eurasia: a unified China and a fragmented Europe.
- Two *sufficient* mechanisms:
  1. Topography: The location of Europe's mountain ranges created several geographical cores that could provide the nuclei for European states; China was dominated by a single vast plain between the Yangtze and the Yellow River.
  2. Productive land: The presence of a dominant core region of high land productivity in the North China Plain and the lack thereof in Europe.
- Only when we neutralize both topography and productive agricultural land, Europe and China cease to move at different paces.
- A battery of robustness tests confirm the key role of fractured-land in a broad sense.
- Our methodological approach leaves plenty of room for extensions (culture, religion, etc.)

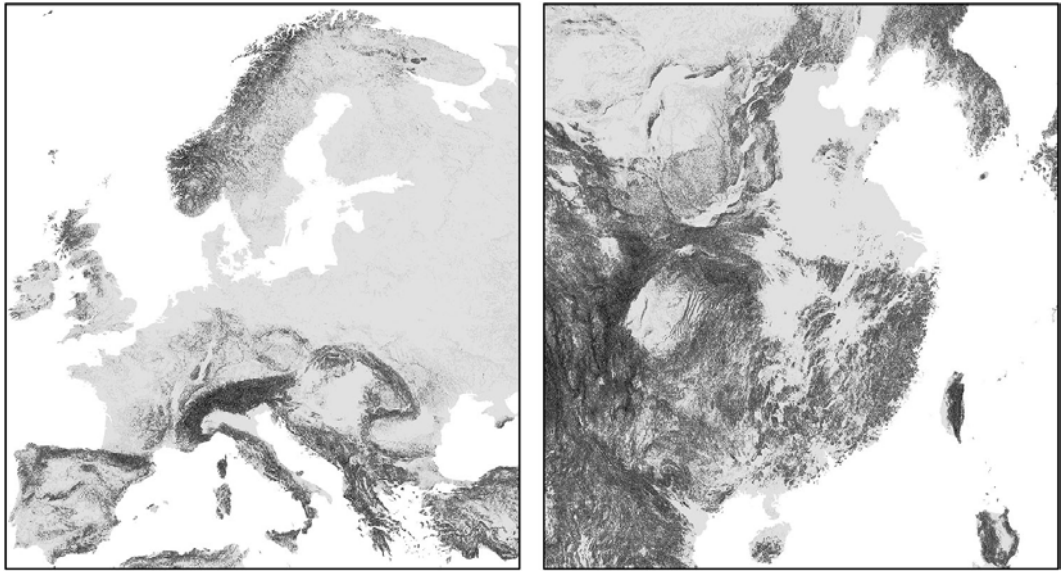


Figure: Ruggedness in Europe and China proper.

Our model

- A world with 20,637 hexagons of radius 28km.
- Each cell is initially an independent polity (c. 1,000 BCE).
- In each period, a conflict may stochastically take place between two adjacent cells.
- If the cells in conflict belong to different polities, a war occurs, possible leading to annexation.
- If the cells in conflict belong to the same polity, a secession might occur.
- Outcome of conflicts will depend on:
  - The resources that the polities control.
  - The geographical characteristics of the cells in conflict.

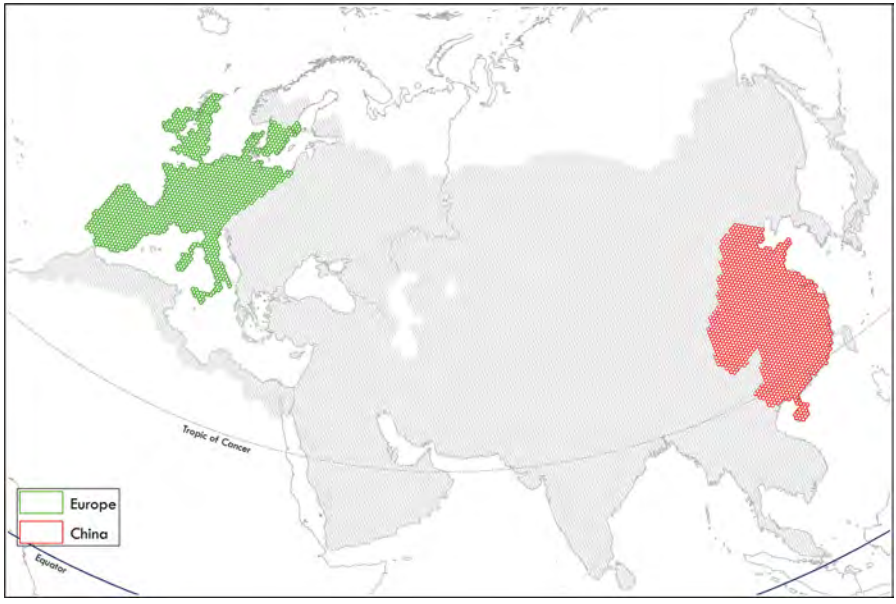
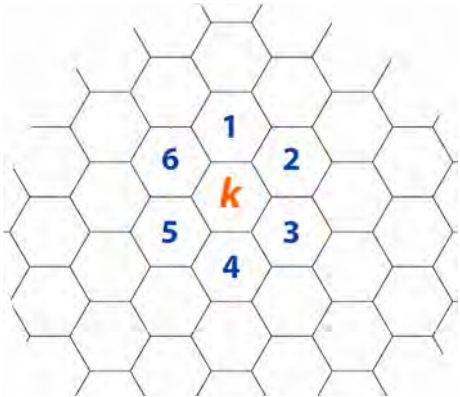


Figure: Study Area.

Hexagons

Figure: Cell k and adjacent cells.

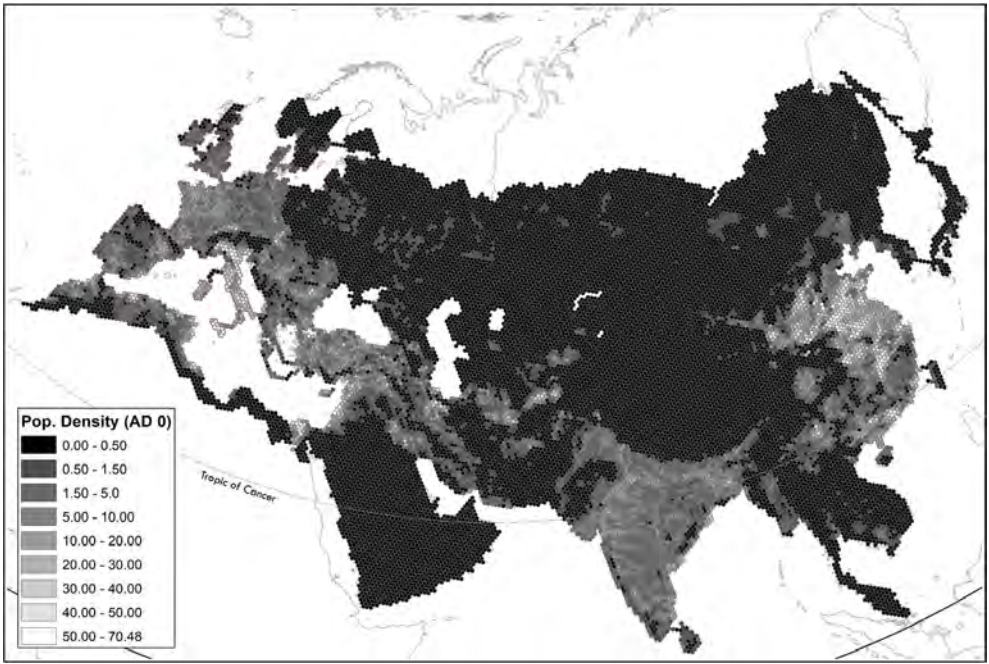


Each cell k is characterized by its:

- Spatial location.
- Productivity y_k.
- Geographical attributes x_k.

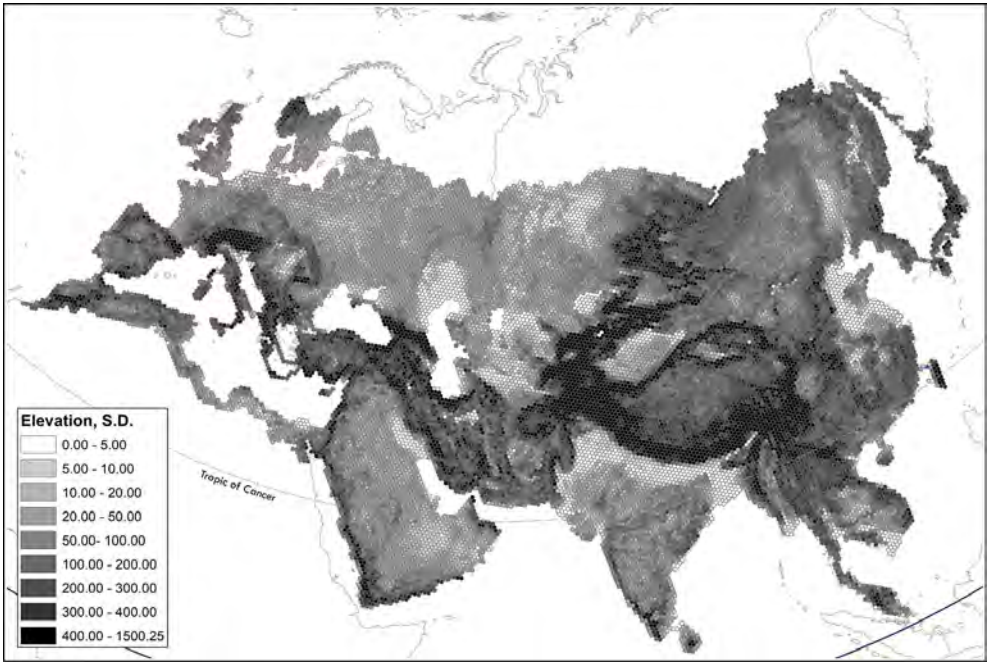
Key variables I

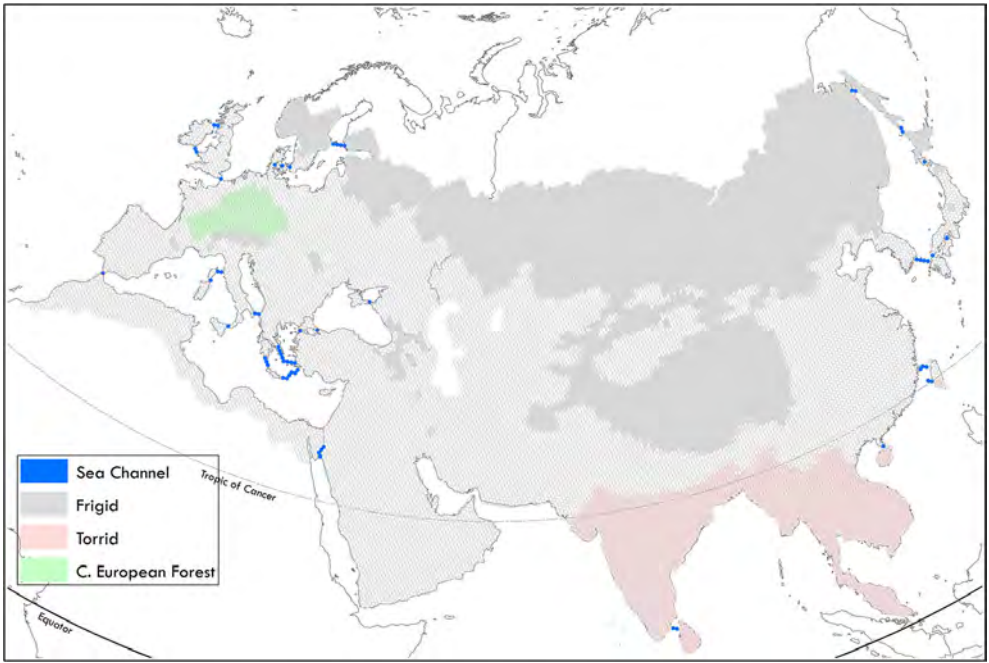
- Productivity y_k is measured using estimated population in 0 CE, Goldewijk et al. (2011).
  - Alternative measure 1: agricultural suitability (Ramankutty et al., 2002).
  - Alternative measure 2: potential caloric yield (Galor and Özak, 2016).


Pop. Density (AD 0)
0.00 - 0.50
0.50 - 1.50
1.50 - 5.0
5.00 - 10.00
10.00 - 20.00
20.00 - 30.00
30.00 - 40.00
40.00 - 50.00
50.00 - 70.48
Tropic of Cancer

Key variables II

- $\mathbf{x}_k$ is a vector of geographical attributes:
  1. Terrain ruggedness.
  2. Whether cell k is a sea channel.
  3. Whether cell k is frigid (below freezing for 6 months or more in 8,000 BCE).
  4. Whether cell k is torrid (based on the Köppen climate classification).
  5. Whether cell k was part of the ancient forests of central and northern Europe.

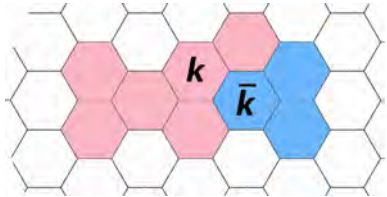

Elevation, S.D.
0.00 - 5.00
5.00 - 10.00
10.00 - 20.00
20.00 - 50.00
50.00- 100.00
100.00 - 200.00
200.00 - 300.00
300.00 - 400.00
400.00 - 1500.25
Tropic of Cancer


Sea Channel
Frigid
Torrid
C. European Forest
Tropic of Cancer
Equator

The Central European Forest

- Compared with North America and East Asia, Central European forests dominated by hardwood species (e.g., oaks, beeches, birches) that could not be cleared with primitive tools (Huntley and Birks, 1983).
- Tacitus (1877) describes Germania as a land that "bristles with forests or reeks with swamps", and the various German tribes "all defended by rivers or forests."
- As late as 1700, about 40% of Germany remained forested (Wilson, 2012).

Contest function



- If war occurs between polities i and j, which controlled cells k and $\overline{k}$, i wins with probability:

$$\frac{Y_i}{(Y_i + Y_j) \times (1 + max\{\Theta \cdot x_k, \Theta \cdot x_{\overline{k}}\}} \quad (1)$$

  where $Y_i = \sum_{s \in i} y_s$ and x_k denotes the geographical characteristics of cell k.

- Probability of the war ending with no annexation is $1 - \frac{1}{1+max\{\Theta \cdot x_k, \Theta \cdot x_{\overline{k}}\}}$, which is:
  - strictly positive; increasing in $max\{\Theta \cdot x_k, \Theta \cdot x_{\overline{k}}\}$.
- We could enrich this contest function with religion/culture/linguistic traits etc.

Secession

- Border cells may secede.
- At each period, the probability of border cell k of regime i seceding is:

$$\beta \times \Theta \cdot \mathbf{x}_k \times \sum_{s=1}^{20{,}637} (\mathbb{1}_i(s) \cap \mathbb{1}_B(s))$$

- Secession more likely if:
  1. The cell has a high $\Theta \cdot \mathbf{x}_i$ (i.e., natural obstacles that make secession hard to suppress).
  2. If the parent regime i controls a large number of cells (i.e., heterogenous polity).
  3. If regime i has a long frontier relative to its interior (which increases the difficulty of monitoring and controlling the population).
- Again, easy to enrich.

Timing

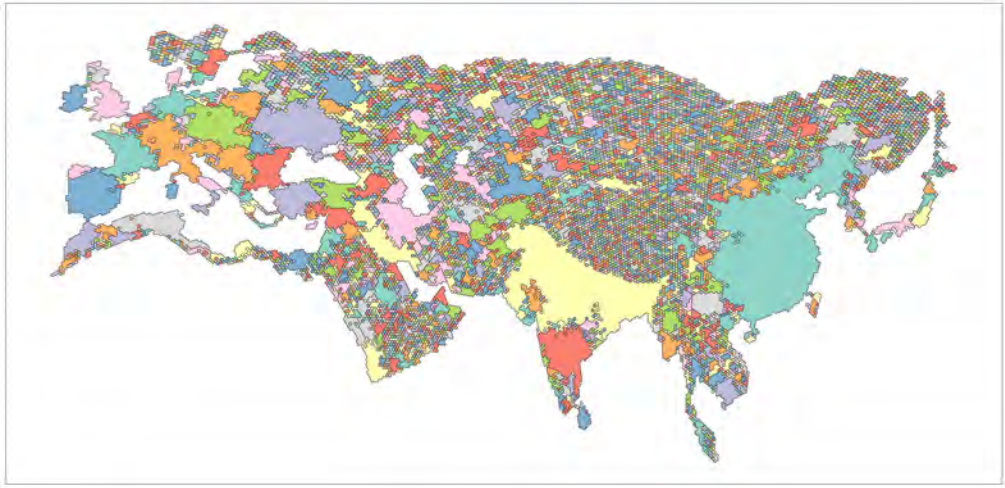
1. At $t = 0$, each cell is a separate polity (i.e., 20,637 polities).
2. At each time period, the probability of conflict breaking out in cell k is $\alpha \cdot y_k$, where $\alpha > 0$ and y_k is the productivity of cell k.
3. If cell k encounters a border conflict, only one of its six borders is affected. The conditional probability that its adversary is cell $\overline{k} \in \{1, 2, 3, 4, 5, 6\}$ is $\frac{y_{\overline{k}}}{y_1+y_2+y_3+y_4+y_5+y_6}$, where $y_1, ..., y_6$ are the productivities of the six cells bordering cell k.
4. Conflicts between adjacent cells controlled by different polities result in a war.
5. In a war between cells k and $\overline{k}$, controlled respectively by polity i and j, polity i wins and annexes $\overline{k}$ with probability given by contest function.
6. A polity may fight no war, one war, or multiple wars at any period. In the latter case, it splits its resources proportionally according to the resources of its adversaries.
7. Cell k secedes from polity i with probability given by secession equation.

Baseline calibration

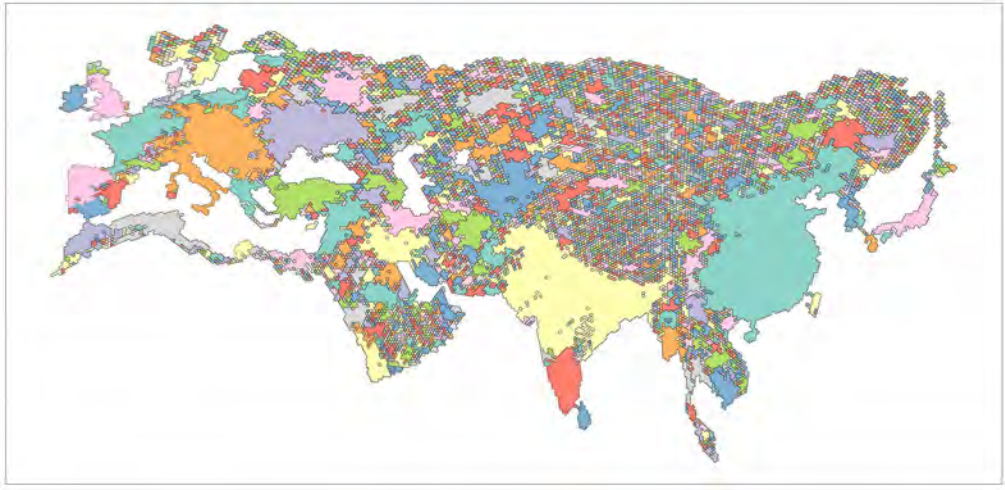
Parameter	Value
α	$\frac{1}{y_{max}}$
β	0.000005
θ_{rugged}	$\frac{2}{x_{rugged}=90th \text{ percentile}}$
θ_{sea}	2
θ_{frigid}	2
θ_{torrid}	2
θ_{forest}	1

Period 50

Period 300



Period 500



Results: 49 simulations of benchmark model

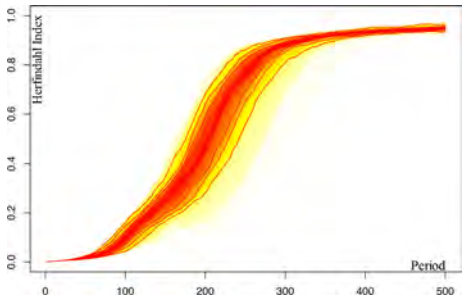


Figure: China

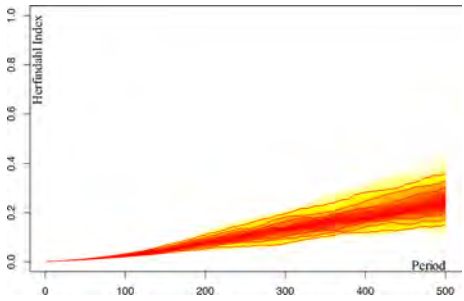
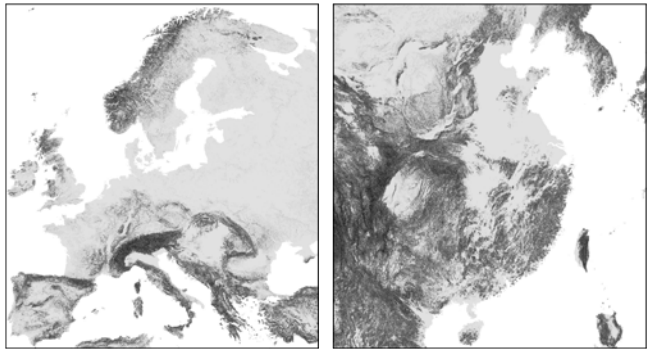


Figure: Europe

The role of North China



- China significantly more mountainous than Europe (37% vs. 10%).
- But the location of China's mountains are in the west and south. They do not intersect the key fertile plain between the Yangtze and Yellow rivers.
- Relative proximity of Wei River, Yellow River, Huai River, and Middle-Lower Yangzi $\Longrightarrow$ One extended region dominates the rest.

The role of North China

Figure: China's macroregions.

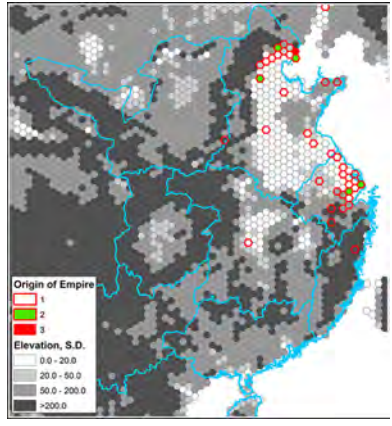


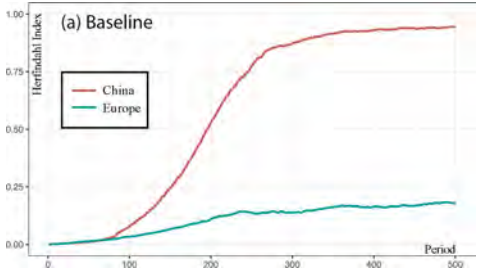
Figure: Flatness and centrality of North China.

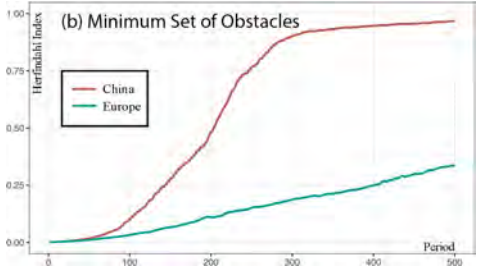
The role of North China

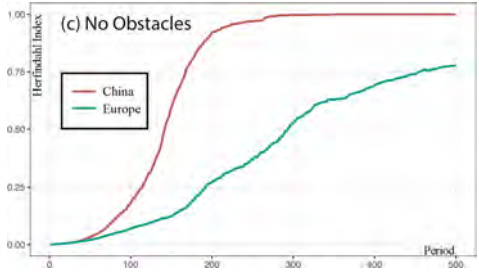
Table: Major Unifications of China

Dynasty	Period	Capital Region
Qin	221–206 BCE	Northwest
Han	202 BCE–220	Northwest, North China
Western Jin	280–316	North China
Sui	581–618	Northwest, North China
Tang	618–907	Northwest, North China
Northern Song	960–1127	North China
Yuan	1206–1368	North China
Ming	1368–1644	Lower Yangtze, North China
Qing	1644–1912	North China

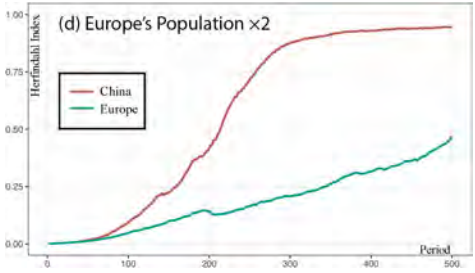
Sensitivity Analysis I (×49 simulations; Median Plot)

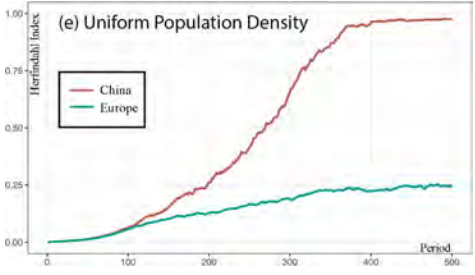


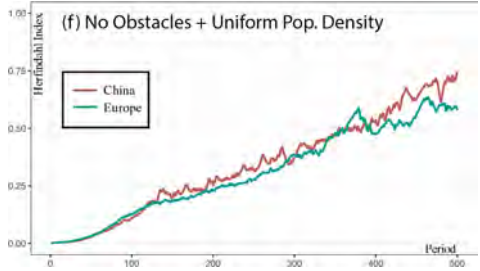




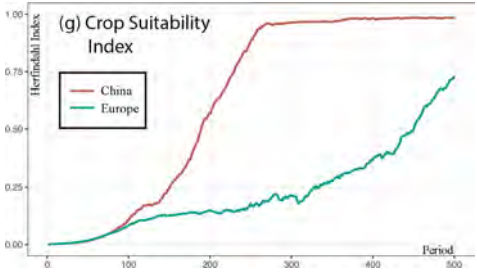
Sensitivity Analysis II (×49 simulations; Median Plot)

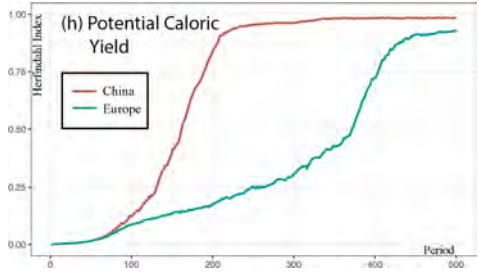


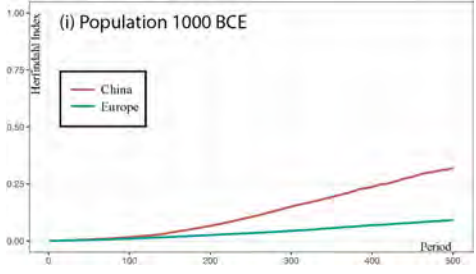


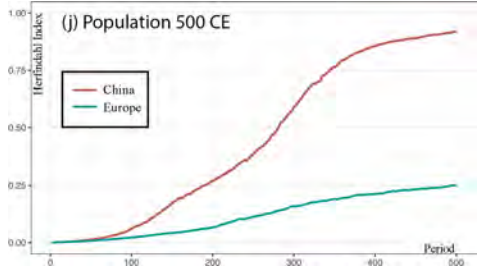


Sensitivity Analysis III (×49 simulations; Median Plot)









Extensions

1. The Eurasian steppe.
   - Regions bordering the steppe advantaged in large scale military operations.
2. Major rivers.
   - A river connects upstream with downstream; separates left and right banks.
3. The Mediterranean Sea.
   - What if the Mediterranean Sea is traversable by large armies?
4. Shocks and cycles.
   - General shocks and polity-specific shocks.

Extensions I and II: Steppe and rivers

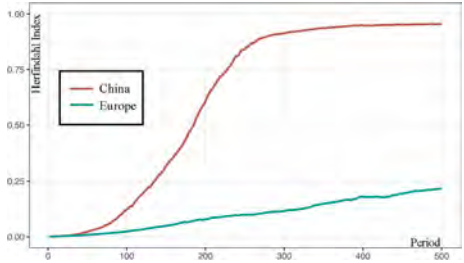


Figure: Steppe (Median Herfindahl index plot for 49 simulations).

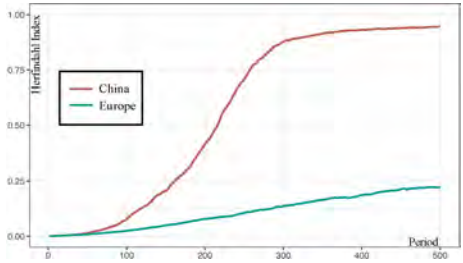


Figure: Rivers (Median Herfindahl index plot for 49 simulations).

Extension III: The Mediterranean Sea

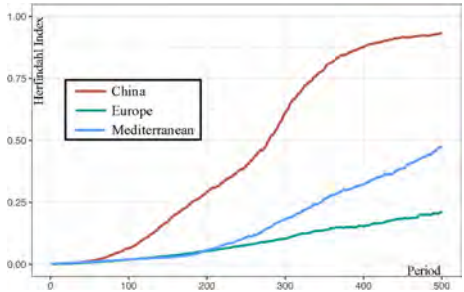


Figure: Based on population in 0 CE.

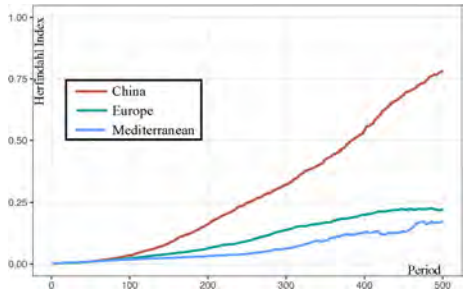


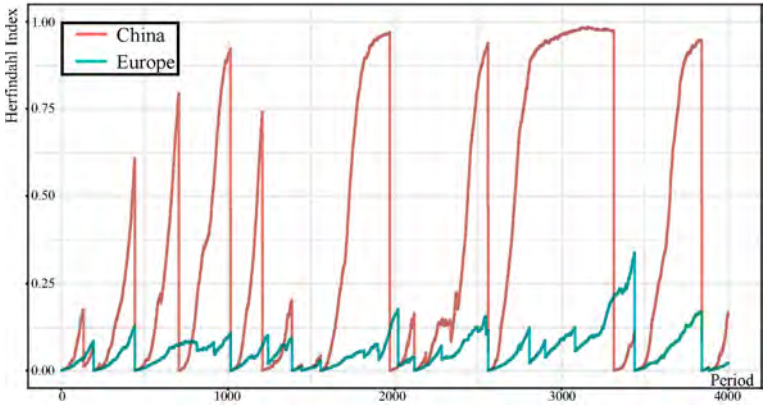
Figure: Based on population in 1000 CE.

- Roman Empire
  - *Sui generis* — no other stable, long-lasting European empire (Scheidel, 2019).
  - Necessary conditions? Roman warm period; control of the Mediterranean.

Extension IV: Shocks and cycles

- We extend the model to 4,000 periods.
- A $\frac{1}{1000}$ probability of a general shock occurring and a $\frac{1}{300}$ probability of a regime specific shock occurring per period.
- General shock: all regimes will break up.
- Regime specific shock: just the regime in question that breaks up.
- Under this specification there is a regime specific shock on average once every 300 periods and a general shock on average once every 1,000 periods.

Extension IV: Shocks and cycles



- States rose and fell, sometimes synchronized (e.g. $t \approx 400, 1000, 2600, 3800$).
- Cycles more pronounced in China than in Europe.

State formation across Eurasia

- Probability of a large state arising in China, Europe, India, Middle East, or Southeast Asia:

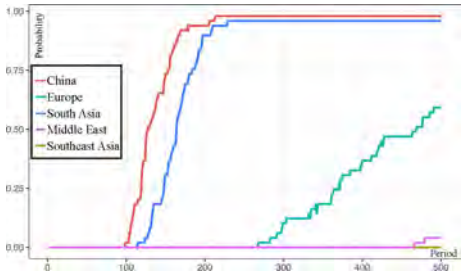


Figure: Basic Model.

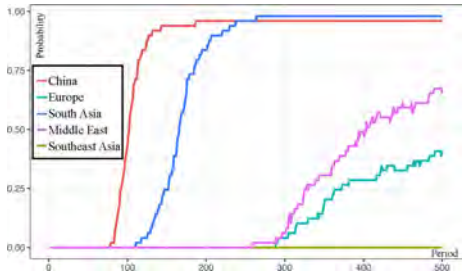


Figure: Incorporating the Steppe Effect.

Conclusions

- We build a simple dynamic spatial model of state formation.
- We explicitly model the role of terrain in mediating conflict within and among states.
- We demonstrate, through our simulations, that either topography or the location of productive land can generate political unification in China and persistent political fragmentation in Europe.
- Flexible methodological framework to which we can add many extensions (military technology, culture, religion, ...).