Conflict Technology as a Catalyst of State Formation

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Motivation

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- In early modern Europe, war makes states (Tilly 1975, 1990)
- Fiscal capacity increased to meet challenges of funding warfare (Stasavage 2014; Gennaioli and Voth 2015; Abramson 2017; Dincecco, Cox, and Onorato 2020, 2022; Cox and Dincecco 2021)
- New military technology transformed security environment (Tilly 1990; McNeill 1982; Onorato, Scheve, and Stasavage 2014; Gennaioli and Voth 2015; Cantoni, Mohr, and Weigand 2019; Queralt 2019)

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Artillery required defensive response that increased geographic economies of scale and encouraged territorial consolidaton.

Timeline

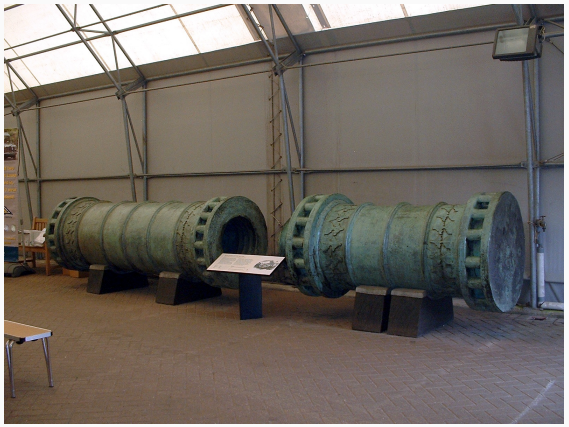
c. 1525

c. 1470
Improvements to
artillery transport

1346
First military
use of artillery

c. 1450

1543
Decrease in artillery cost



Preview

- Argument: Artillery created a security crisis for individual cities that necessitated membership in a territorial state.
- Data: Digitized data on defensive fortification timelines of over $6,000$ European towns and cities (Stoob 1988).
- Findings: In post-gunpowder Europe defensive investments were concentrated in newly relevant border areas.

Theory

Gunpowder Revolution as a Security Crisis

- Constructing *trace italienne* prohibitively expensive for most cities
    - Siena (Parker 1996); Antwerp (Limberger 2016)
- Costs continue after the fortification is complete
    - Must be updated as artillery evolves

Gunpowder Revolution as a Security Crisis

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- Costs continue after the fortification is complete
    - Must be updated as artillery evolves
- Hard to enforce security pacts between cities
    - Free riding on defensive investments of others (Hanseatic League in Sweden (Postel 1996))
    - Intra-alliance conflict (Swiss Confederacy (Greengrass and Gordon 2002))
    - Wealthy cities might overinvest in defense at cost to others (Dutch Republic (Hart 1989))

Territorial States as a Solution

- States can geographically amortize costs by upgrading defenses of border cities
- Border defenses offer protection to interior (Tracy 2000):
  - outside invaders stretch supply lines further
  - interior cities difficult to hold once conquered
  - border cities double as garrisons
- States internalize the benefits of defensive investment
- States can use political authority to reallocate resources

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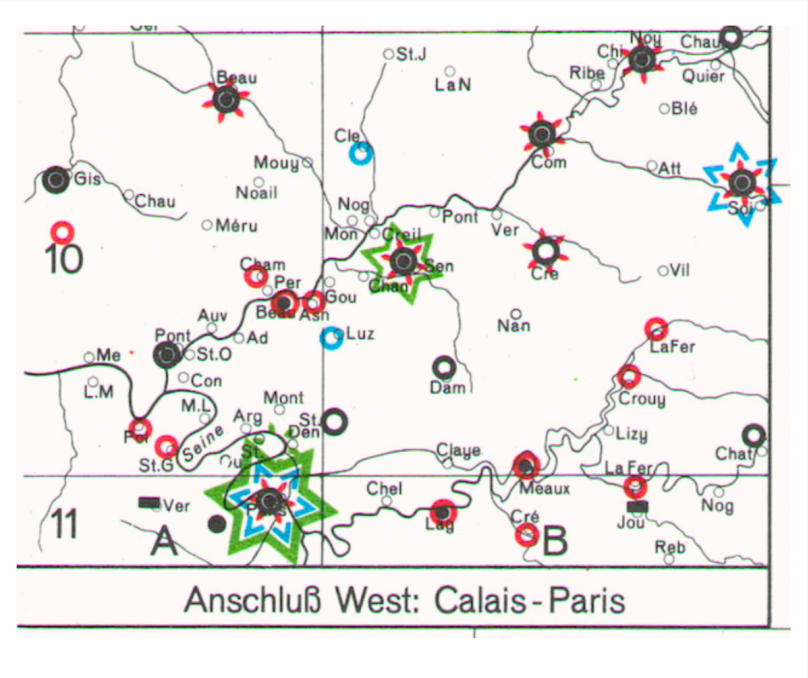
When is security is provided by alliances or by extending the state's borders?

Cities facing a severe security crisis agglomerate into states when existing institutions cannot coordinate collective defenses.

Data

Data

Source: Stoob (1988)



Pre-1190: wooden palisade

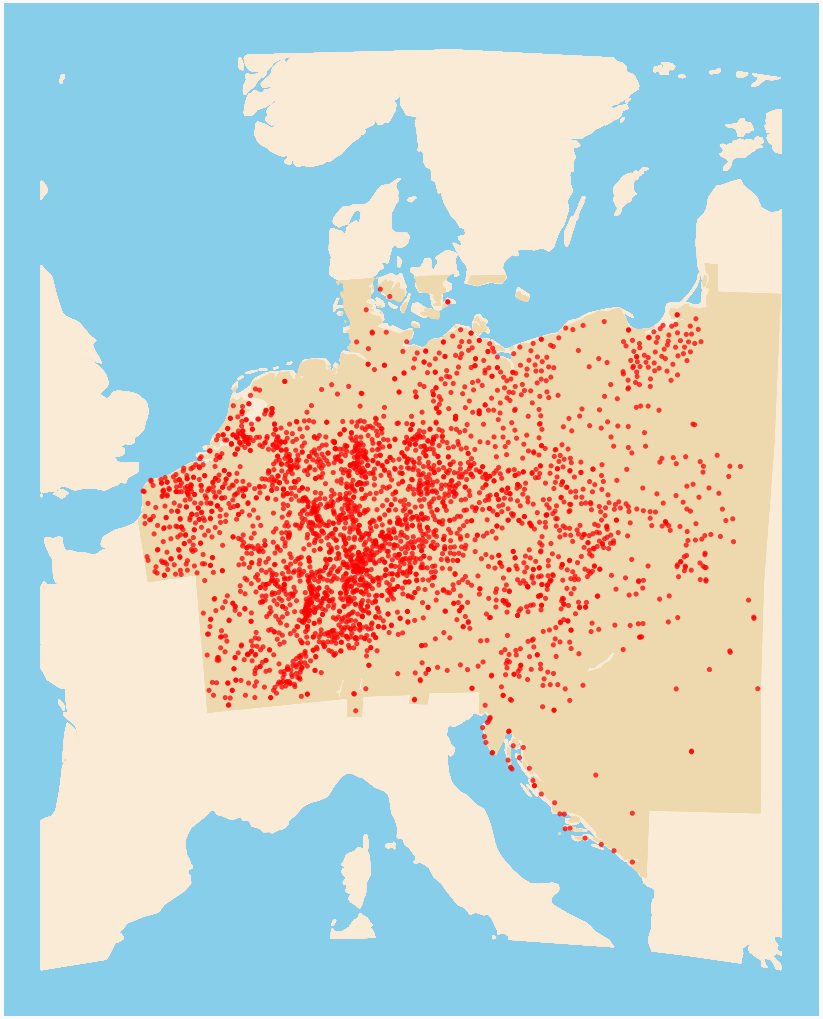
Pre-1190: stone wall

Between 1190 and 1250: reinforcement to stone wall

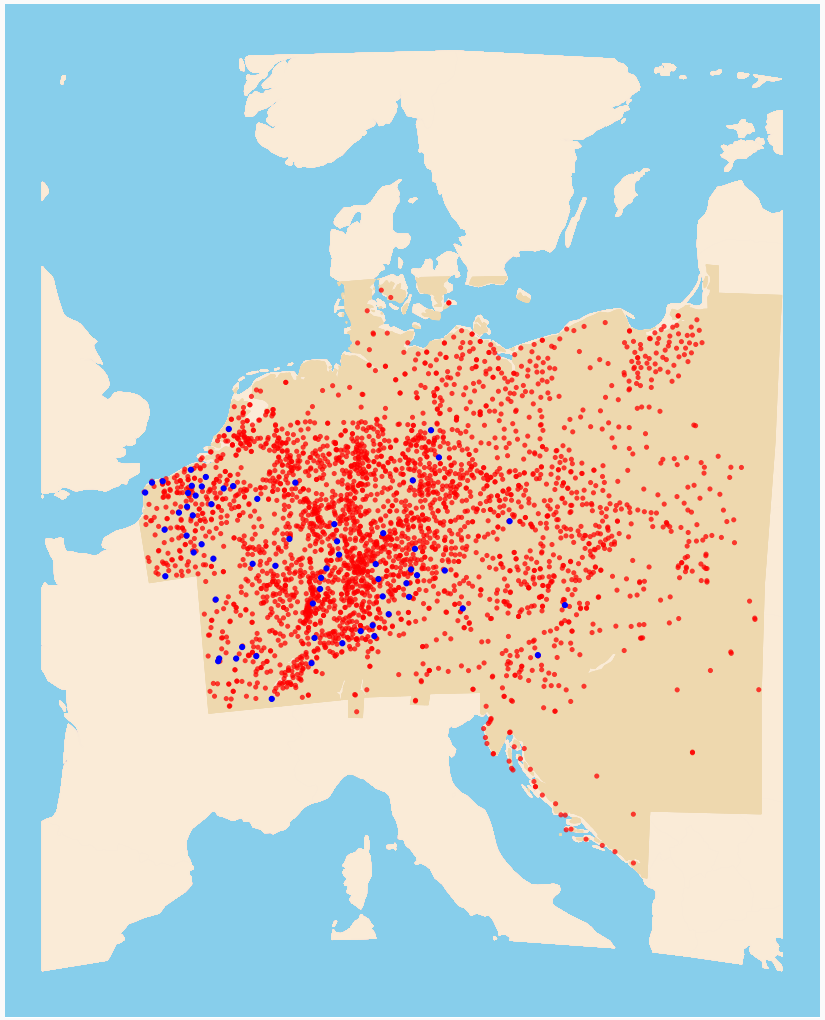
Between 1250 and 1450: bulwarks

Post-1450: bastion (*trace italienne*)

Stone Walls, Pre-1450

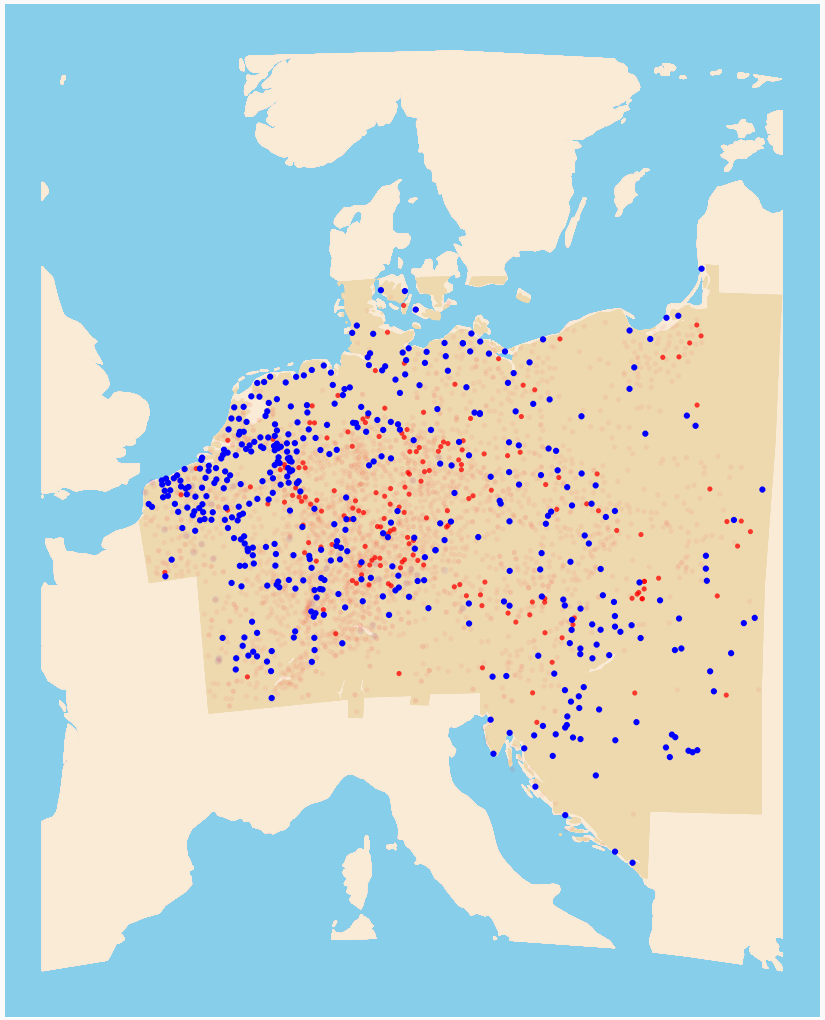


Early Defensive Reponse to Artillery Threat



Post-1450: Some Simple Walls Still Built

Post-1450: Complex Walls Spread



Analysis

Measuring Proximity to Border

Prediction: States direct defensive investments towards politically relevant borders.

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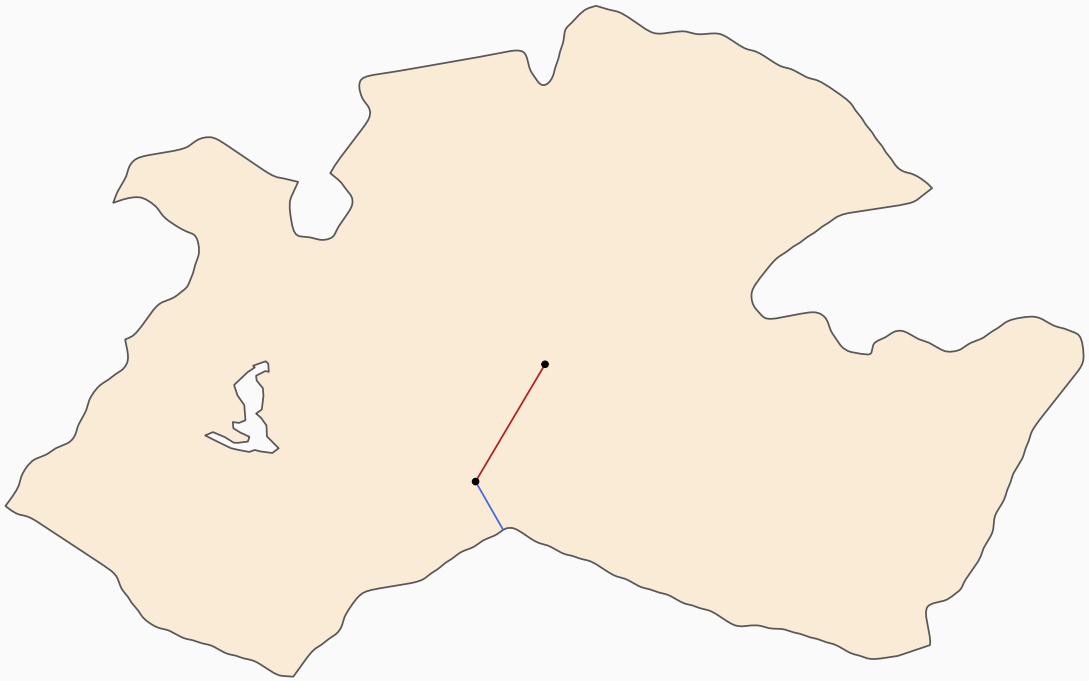
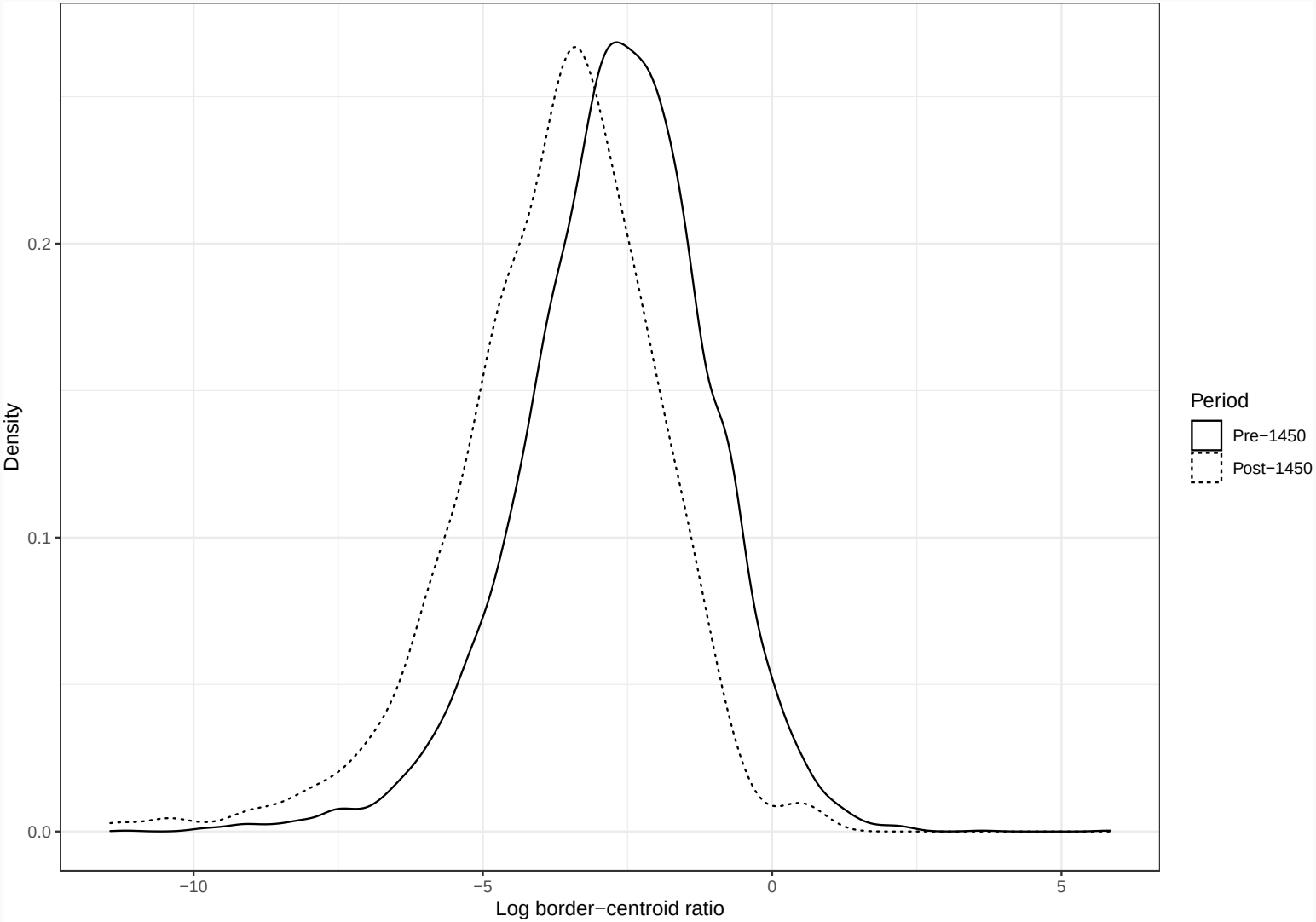
Border-centroid ratio: ratio of distance from city i to nearest border in period t vs. distance from city i to centroid of state containing i in period t



Post-1450 New Construction is Closer to Borders



Robustness

Proximity to Territorial Consolidation

Prediction: Investment should be concentrated in areas where states contest territory with rival powers.

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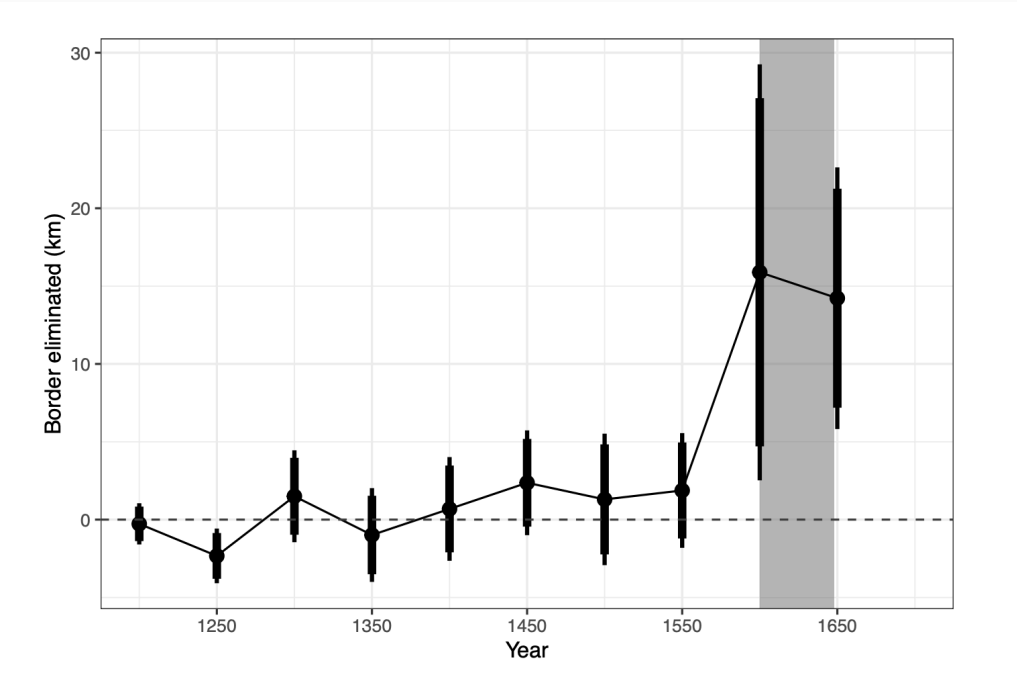
Our approach: look for proximity of walls to places where borders disappeared



Error bars show 90% and 95% confidence intervals. Grey bar highlights Thirty Years' War.

Discussion

Other Analyses

- Case study: France
- Complex walls co-located with artillery manufacture
- City-level building costs matter in pre-period, but not in post-period
- Cities that moved from lagging to leading technological frontier located near agglomeration hotspots

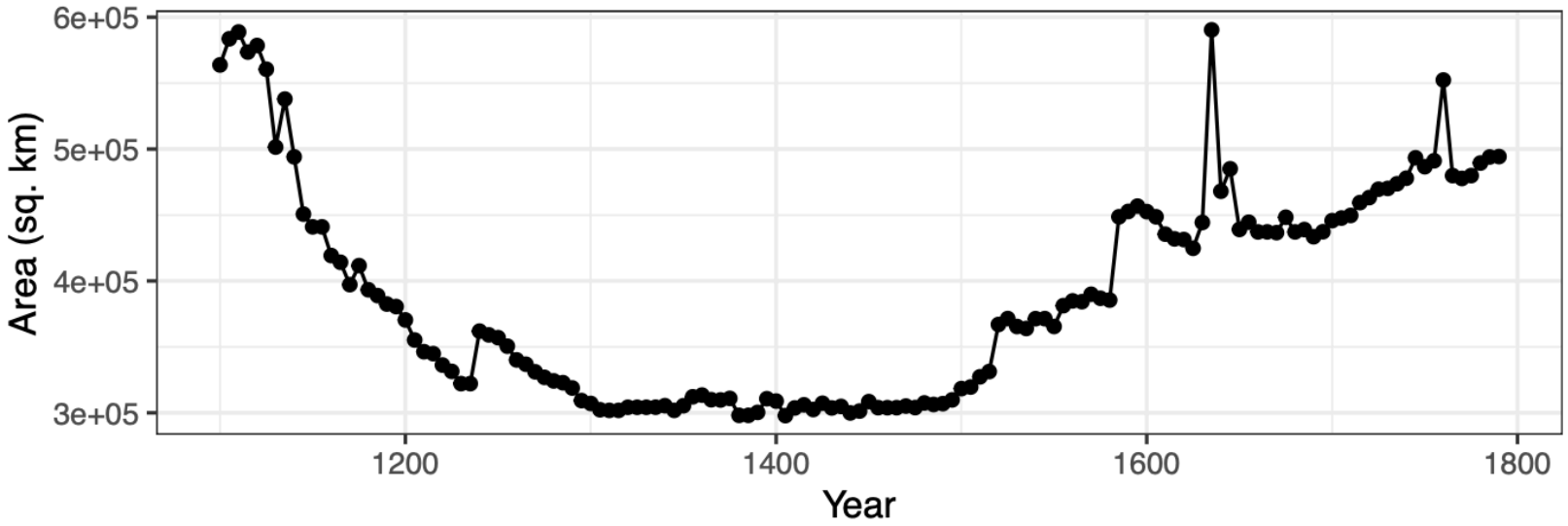
- Future directions: look at urban defense and instance of actual conflict (Fearon 1998; Dincecco and Onorato 2018)
    - Locations of artillery manufacturers, locations of conflicts, duration of urban sieges

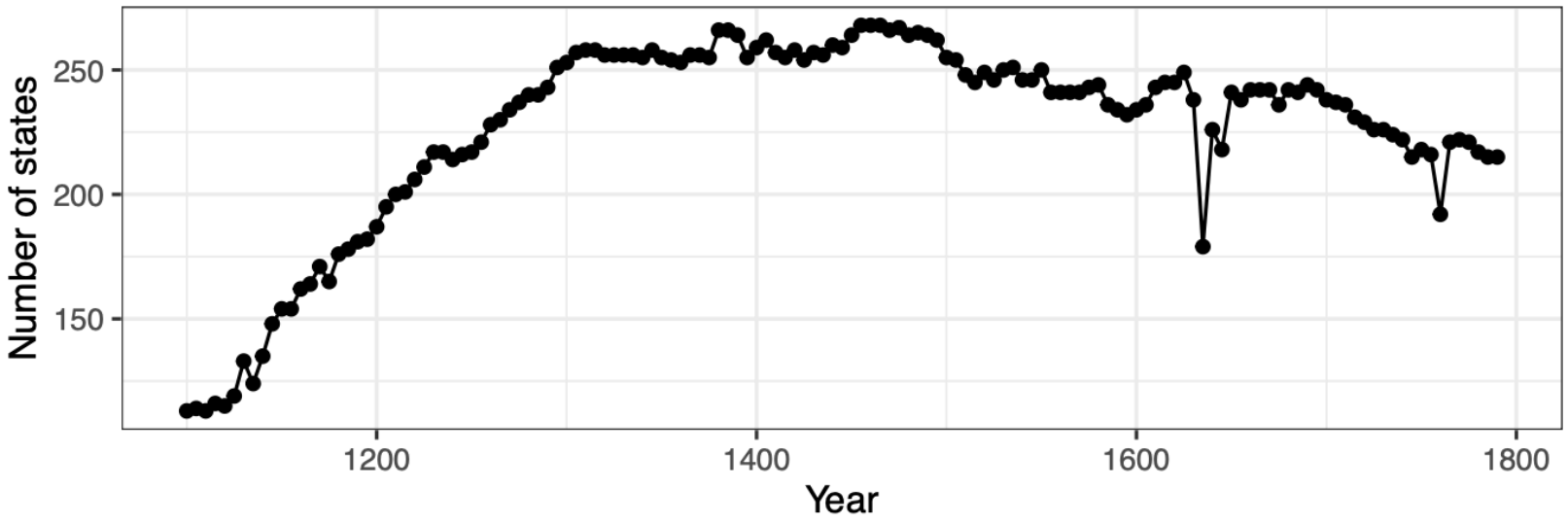
Summary of Contributions

- Our theory: innovation in military technology in Europe c. 1450 gave advantage to territorial states
- Evidence from large digitized dataset of cities' defensive investment timelines
    - Compared to pre-artillery Europe, defense is funneled towards polity borders and places where states contest territory.
- Implications: when and how does conflict $\longrightarrow$ political development?

Appendix

Timeline


6e+05
5e+05
4e+05
3e+05
Area (sq. km)
1200
1400
1600
1800
Year

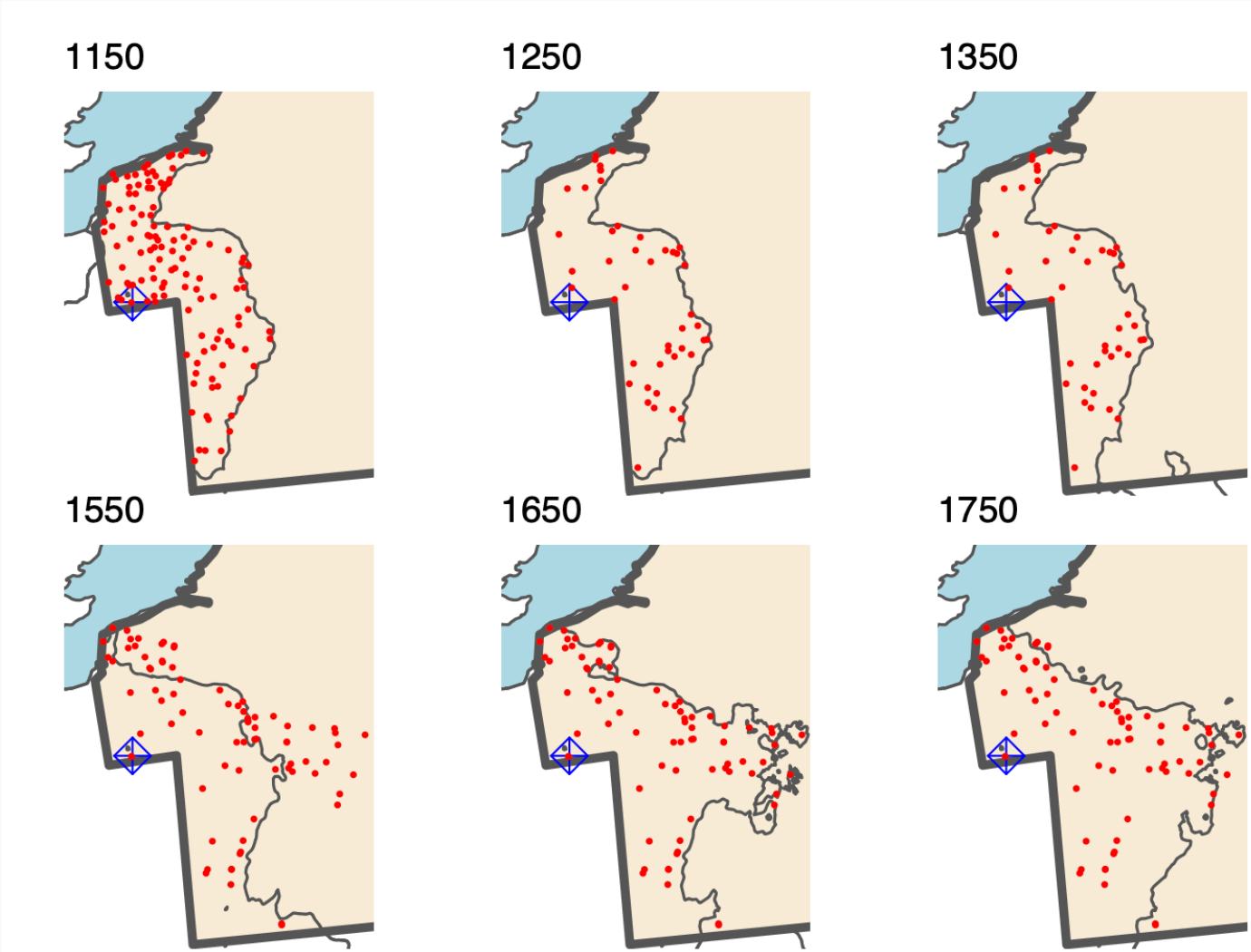

250
200
150
Number of states
1200
1400
1600
1800
Year

Political Data and Covariates

- Politically relevant borders from Abramson (2017)

- Historical and geographic covariates to adjust for pre-modern spatial and economic-political conditions:
  - Navigable rivers (Bosker, Buringh, and Van Zanden 2013)
  - Ag prod (FAO Geospatial Unit - CBDS 2021)
  - Terrain (Nunn and Puga 2012)
  - Atlantic coastline proximity
  - Roman legacy investments (McCormick 2021)

Case Study: France



Border-Centroid Ratios

For each city i with coordinates (x_i, y_i) and each five-year period t, we calculate border-centroid ratio:

$$\text{BC}_{i,t} = \frac{\min d((x_i, y_i), B_t)}{d((x_i, y_i), (x_{it}^C, y_{it}^C))}$$

where B_t is the set of all border polylines that exist in t and (x_{it}^C, y_{it}^C), is the centroid of polity to which i belongs in t.

←

Border-Centroid Ratios

To control for confounders, we run following regressions:

1: new construction is post-1450 (vs. pre-1450) (sample all cities that received any new construction)

$$\log \min_T BC_{i,t} = \alpha + \beta 1_{T=\text{post-1450}} + \mathbf{X} \ + \mathbf{e_i}$$

2: post-1450 new construction is complex (vs. simple) (sample is all cities that received new construction post-1450):

$$\log \min_T BC_{i,t} = \alpha + \beta 1_{\text{complex}} + \mathbf{X} \ + \mathbf{e_i}$$

3. post-1450 new complex construction is a bastion (vs. bulwark) (sample is all cities that received complex post-1450 construction)

Border-Centroid Ratios

	Dependent variable:		
	Log min. border-centroid ratio		
	(1)	(2)	(3)
Post-1450 (v. Pre-)	−1.032***		
	(0.105)		
Gunpowder (v. not)		−0.346**	
		(0.144)	
Bastion (v. bulwark)			−0.394**
			(0.194)
Observations	6,559	735	483
Adjusted R^2	0.049	0.063	0.057

de Chaisemartin and D'Haultfœuille 2020 Estimator

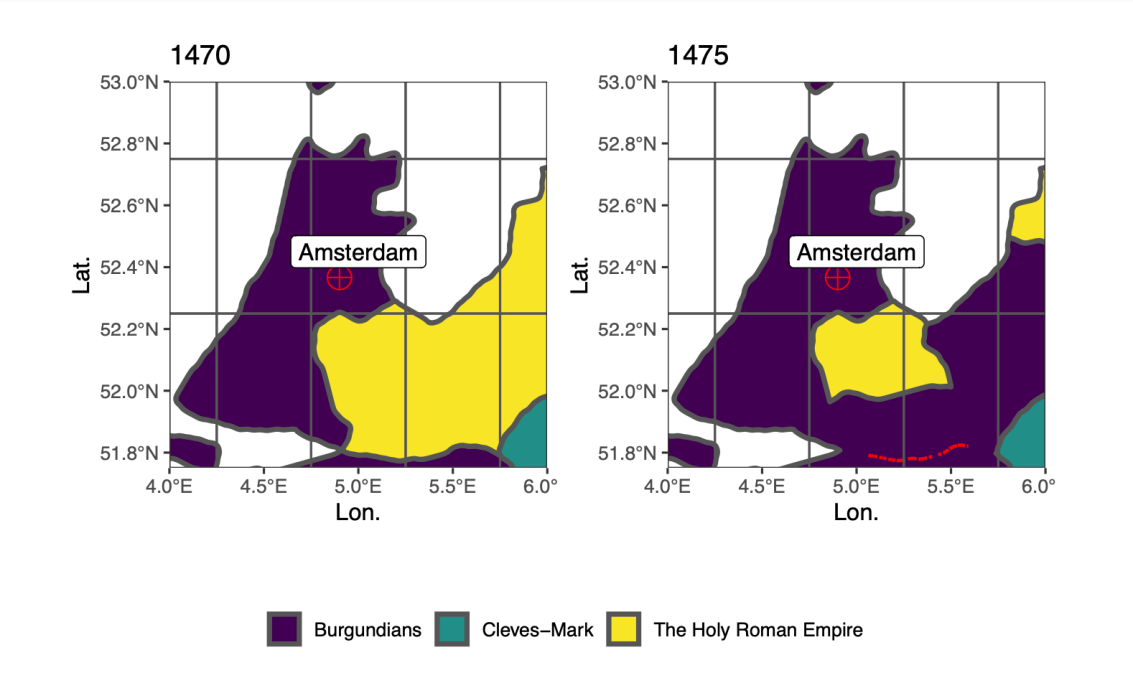
We divide map into 0.5×0.5-degree cells and, for each 50-year period between 1200-1650, sum total (smoothed) length of borders eliminated during cell i and period t

Due to the potential presence of these unobserved confounders, we employ the DID_M estimator of De Chaisemartin and d'Haultfoeuille (2020) which guarantees that all observations are given non-negative weights when forming the estimates. Other approaches to estimating a differences-in-differences model in the presence of heterogeneous effects could sometimes assign negative weights to some observations, potentially leading to a scenario where the estimated effect within every subgroup has the opposite sign of the overall average effect.

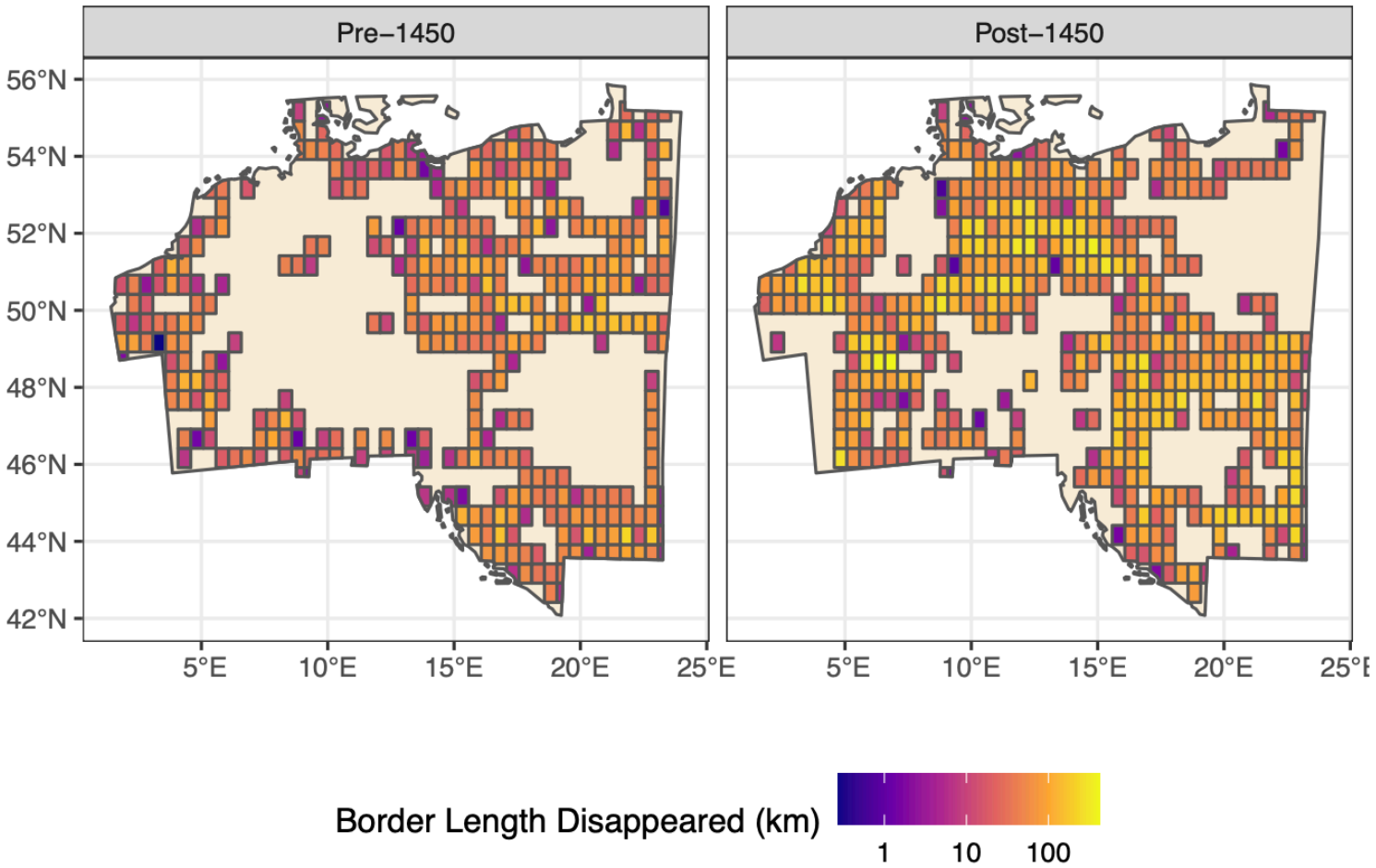
For each cell i in 50-year period t, we estimate the difference in summed border length eliminated in i during t as the weighted average differences-in-differences

$$\frac{T_{i,t}}{N}$$

Measuring Proximity to Territorial Consolidation



Heatmap of Border Eliminations



Local Costs of Building

How did need to update defenses affect investment trajectory of individual cities?

- Distance to natural limestone deposits (Asch 2003) proxies for local costs of construction

- Compare cities that “leapfrogged” to technological frontier post-1450 to those that remained on pre-1450 defensive trajectory

Local Costs of Building

	Dependent variable:		
	Builds any stone-and-mortar wall		
	(1)	(2)	(3)
Log dist. to limestone	−0.007***	−0.004***	−0.004***
	(0.001)	(0.001)	(0.001)
Post-1450	−0.315***	−0.319***	−0.321***
	(0.021)	(0.020)	(0.020)
Log dist. to limestone x post-1450	0.007***	0.006***	0.006***
	(0.002)	(0.001)	(0.001)
Controls	None	Lat-lon	Full
Observations	10,893	10,893	10,893
R^2	0.092	0.142	0.160
Adjusted R^2	0.092	0.142	0.159
Residual Std. Error	0.435	0.422	0.418
F Statistic	367.737***	361.709***	188.340***
Note:			*p<0.1; **p<0.05; ***p<0.01

III. The Changing Spatial Distribution of Defensive Investment

- We compare cities that “leapfrogged” to defensive technological frontier after 1450 to those with other development paths
    - Leapfrogged: no permanent wall pre-1450; complex wall post-1450
    - Always lagged frontier: no permanent wall pre-1450; no complex wall post-1450
    - Always at frontier: permanent (simple) wall pre-1450; complex wall post-1450
    - Fell behind post-1450: permanent (simple) wall pre-1450; no complex wall post-1450

III. The Changing Spatial Distribution of Defensive Investment

	Dependent variable:		
	Log dist. to border eliminiation post-1450		
	(1)	(2)	(3)
Falls behind	−0.085	0.072	0.105
	(0.125)	(0.120)	(0.112)
Catches up	−0.286**	−0.165	−0.246**
	(0.116)	(0.120)	(0.110)
Progressive development	−0.245	−0.068	−0.114
	(0.203)	(0.187)	(0.180)
Controls	None	Lat-lon	Full
Observations	4,489	4,489	4,489
R^2	0.004	0.032	0.059
Adjusted R^2	0.003	0.031	0.057
Residual Std. Error	1.421	1.401	1.382
F Statistic	5.468***	29.919***	28.058***
Note:			*p<0.1; **p<0.05; ***p<0.01

Further results: local building costs

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