

Mining for Peace

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KIEL-CEPR African Economic Development Conference, September 2024



Motivation

Background:

- ▶ Increasing global demand for minerals (energy transition) offers opportunities for resource-rich countries in Africa.
- ▶ But it may fuel ethnic conflicts (e.g., Berman et al., 2017).
- ▶ It is crucial to develop strategies to effectively mitigate mining-related conflict risks.

Our main contribution:

- ▶ We let the effect of new mines on conflict depend on a country's entire mining and ethnic geographies.
- ▶ We bridge different strands of the literature on resources, diversity, and conflict:
 1. Old: Country-level aggregate effects
 2. New: Local effects
 3. This paper: Countries as interconnected systems

This paper

Theory:

- ▶ Novel model with arbitrary distributions of ethnic groups and resource rents in space.
- ▶ Possibility of intra-ethnic coalitions at local and national levels can lead to bargaining failure (as in Morelli and Rohner 2015).
- ▶ Mechanism design approach and second-best analysis offer two concepts to predict the effects of new mines on aggregate and local conflict risks.
- ▶ Key role of ethnic groups from resource-rich regions, who feel deprived of local resource rents (Berman et al. 2023).
 - ▶ More realistic picture of ethnic conflicts by endogenizing grievances and mobilization.

This paper

Empirics:

- ▶ Empirical validation of our theory-based proxies for aggregate and local conflict risks.
- ▶ Granular spatial data from Sierra Leone.
- ▶ Adapt a state-of-the-art empirical strategy exploiting changes in global mineral prices.

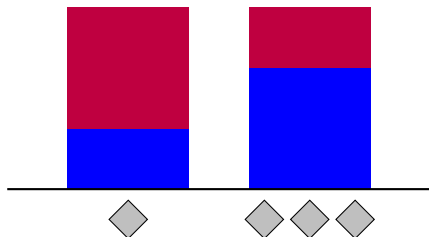
Counterfactual policy analysis:

- ▶ Simulations of (planned) new mining projects in Sierra Leone.
- ▶ Large heterogeneity in aggregate and local effects on conflict risks.
- ▶ Mining for peace is possible in the right locations.
- ▶ Rich policy implications.

Flavor of theory: Model

- ▶ General distributions of ethnic groups and resource rents across locations.
- ▶ Ethnic groups can contest resource rents at two levels:
 - ▶ Local conflicts: Local group members fight for local rents
 - ▶ National conflict: All group members fight for aggregate rents
 - ▶ Conflict is costly, and conflict costs are private information
 - ▶ Winning probabilities are proportional to group sizes
- ▶ Planner can transfer rents across groups and locations.
 - ▶ Metaphorically, planner represents the outcome of efficient bargaining between ethnic groups in the shadow of conflict.
- ▶ Planner's objective is:
 1. Guarantee peace at the national level
 2. Maximize the number of locations with peace (where we can add weights, e.g., to capture ethno-regional favoritism)

Flavor of theory: Problem (or why peace fails)



- ▶ Any ethnic group may start a national conflict unless they get a rent share proportional to their size.
- ▶ Planner transfers rents to **groups over-represented in resource-poor locations** to ensure national peace.
- ▶ **Groups over-represented in resource-rich locations** experience “discord” between high local resource rents and comparatively low post-transfer incomes and may start local conflicts.

Flavor of theory: Results

1. Impossibility to guarantee peace everywhere in presence of ethnic segregation and spatial resource inequality.
 - ▶ **Peace deficit:** hypothetical monetary amount necessary to guarantee peace everywhere, i.e., to pacify **discordant groups** in all locations.
 - ▶ It's our measure for the aggregate propensity to conflict.
2. Impossibility to implement peace via truthful revelation of private conflict costs in presence of ethnic segregation and spatial resource inequality.

Flavor of theory: Results

3. Characterization of second-best transfer scheme and the resulting spatial distribution of conflict risks:

► **Local conflict exposure:**

$$e_l(\mathbf{t}_l, \mathbf{s}_l, r_l) := (r_l/r) \left[\prod_{g \in G^*} (s_l^g / s^g) \right]^{1/|G^*|}$$

► It's our measure for the local propensity to conflict.

► Intuition:

- Higher conflict risks in locations where “buying peace” is more costly for the planner.
- Peace is most costly in locations with relatively high **local resource rents** and high **local ethnic diversity among discordant groups G^*** (i.e., where discordant groups are manifold and locally over-represented).

Empirical setting



Empirical setting and sample

Sierra Leone:

- ▶ Civil war 1991–2002: > 50,000 casualties
- ▶ Ethnicity is salient, but only one of several factors in the war.
- ▶ Diamond mining was important during the war, industrial bauxite and iron mining thereafter: 65% of export revenues, large share of government revenues.

Sample:

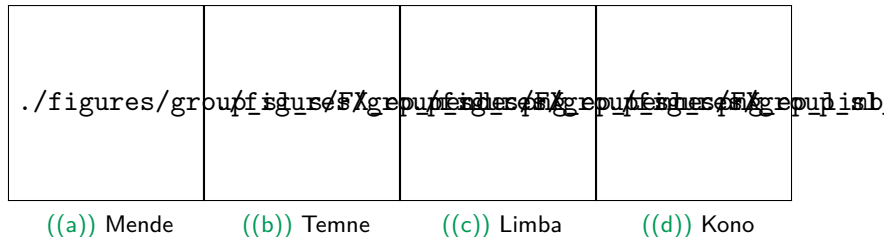
- ▶ Units: 107 wards in Sierra Leone.
 - ▶ Typically one or more historical chiefdoms.
 - ▶ Average area 670 km² (<1/4 of 0.5×0.5 DD grid cells).
- ▶ Sample period: 1997–2018.

Data: Ethnic geography

Data on population and ethnicity:

- ▶ Source: 2004 Housing and Population Census of Sierra Leone; 10% of all households; ward-level.
- ▶ Ethnic groups: Mende (33%), Temne (32%), Limba (8%), Kono (5%), plus 8 smaller, less important groups.

Figure: Local over-representation (s_l^g/s^g) of largest ethnic groups

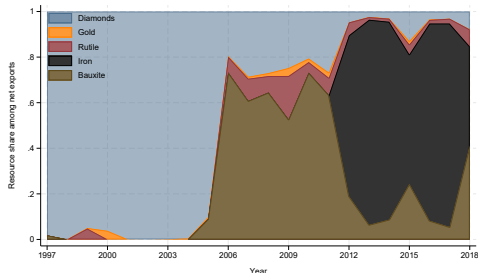
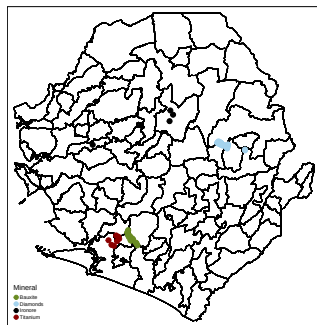


Data: Mining geography

Data on mining and minerals:

- ▶ Source for mines: Raw Material Data (RMD) plus polygons by Maus et al. (2020).
- ▶ Source for net exports: UN Comtrade
- ▶ Interesting variation.

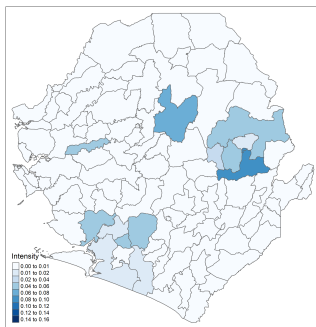
Figure: Mining locations and net export shares



Data: Mining geography

- ▶ Assumption: Local resource rents r_l increase in
 - ▶ size of nearby mines and the inverse distance to these mines (due to spatial spillovers), and
 - ▶ importance of the corresponding mineral in a given year.

Figure: Time-averaged relative local resource rents r_l/r

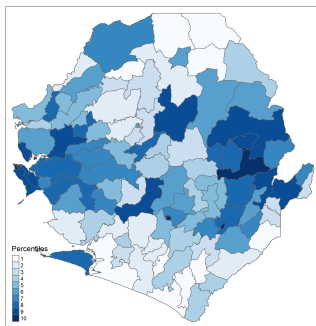


Data: Conflict

Observed local conflict exposure:

- ▶ Source: Armed Conflict Location and Event Data (ACLED)
- ▶ Events included: Battles, riots, violence against civilians (Eberle et al. 2020).

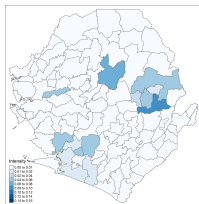
Figure: Time-averaged observed local conflict exposure



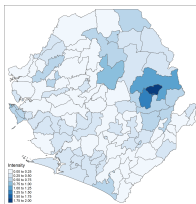
Empirical validation: Predicted local conflict exposure

Computation of predicted local conflict exposure:

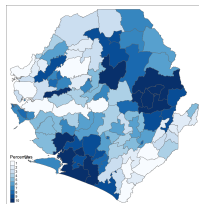
1. Determine country-level set of discordant groups.
 - ▶ Examples: Mende (Limba) are over-represented in the bauxite-mining (iron-mining) area and thus a discordant group in the bauxite (iron) period.
2. Compute ethnic diversity among discordant groups in each ward.
3. Compute predicted conflict exposure in each ward:



((a)) Relative
resource rents



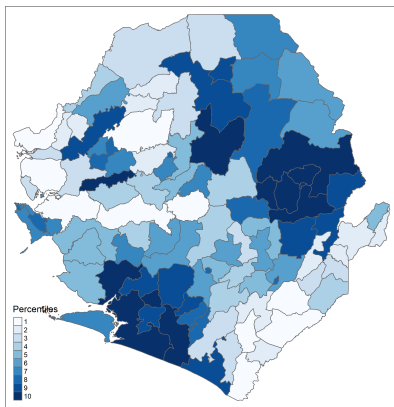
((b)) Diversity
discordant groups



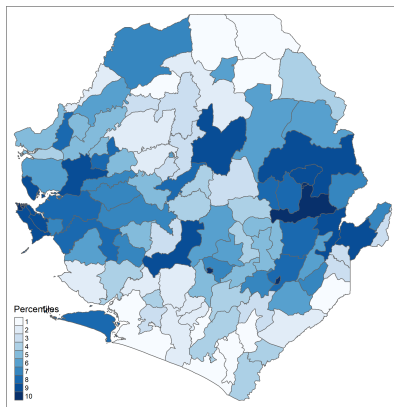
((c)) Predicted
conflict exposure

Empirical validation: Visual econometrics

Figure: Time-averaged predicted vs observed local conflict exposures



((a)) Predicted conflict exposure



((b)) Observed conflict exposure

Empirical validation: Regression-based econometrics

Cross-sectional OLS regressions:

- ▶ Full period and diamond/bauxite/iron periods.

Two-way fixed effects regressions with/without generated instrument.

- ▶ Endogeneity concern: Conflict reduces mining activities and, thereby, local resource rents and predicted conflict exposure.
- ▶ Standard approach: Shift-share instruments for identification via exogenous global price shocks.
- ▶ Adaptation: Interact global prices and proximity to different mines to predict r_l/r and then use $\widehat{r_l/r}$ to compute predicted conflict exposure.

Findings: [▶ Tables](#)

- ▶ Positive and significant effects of log predicted conflict exposure on log observed local conflict exposure.

Empirical validation: Robustness and external validity

Robustness: ▶ Figures and tables

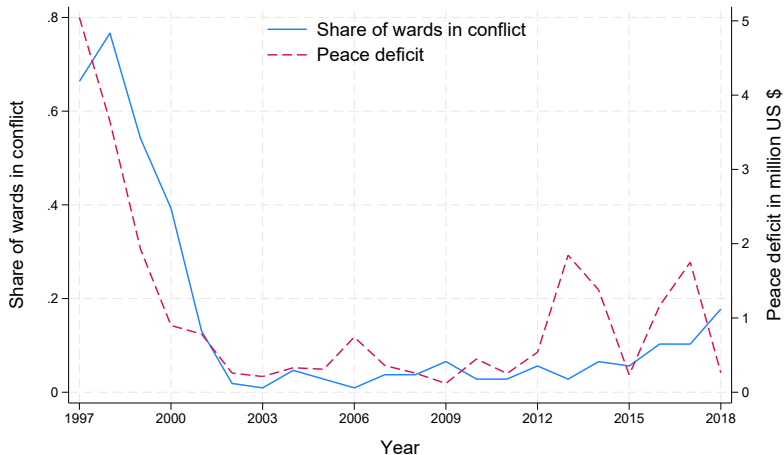
- ▶ All or different types of conflict events (or actor types)
- ▶ Inclusion of artisanal and small-scale mining
- ▶ Restriction to four largest ethnic groups
- ▶ Alternative distance decays
- ▶ Alternative distance cutoffs for spatially clustered SE
- ▶ Controlling for local resource rents and Berman et al. (2017) interaction term

External validity: ▶ Figures and tables

- ▶ Similar cross-sectional results in a sample of 8 West African countries with less granular spatial data.

Empirical validation: Peace deficit

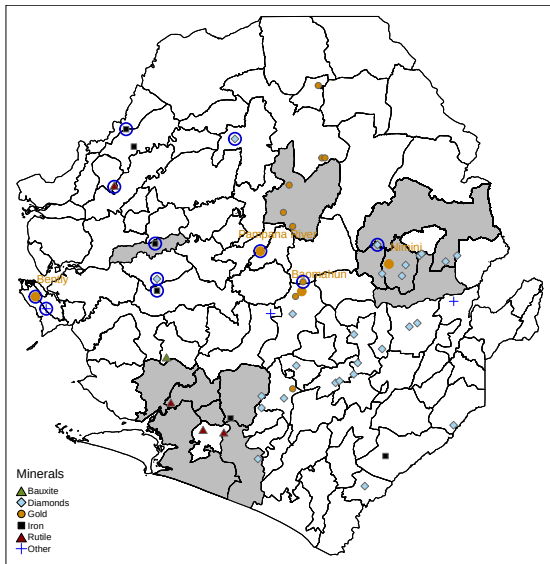
Figure: Changes in country-wide propensity for conflict over time



Notes: Correlation coefficient is 0.82

Counterfactual analysis

Question: Effect of developing known mineral deposits on conflict?



Counterfactual analysis

Idea:

- ▶ Change in peace deficit predicts effects on aggregate propensity for conflict.
- ▶ Changes in local conflict exposure predict relative effects across locations.

Decomposition:

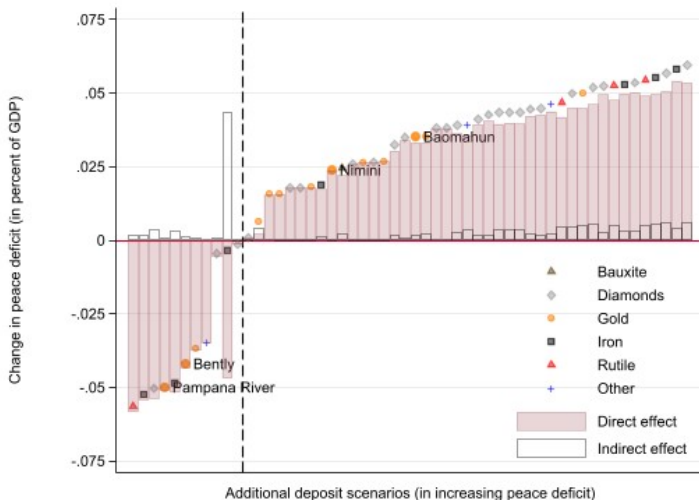
- ▶ Direct effects: changes in spatial distribution of resource rents – conditional on the set of discordant groups.
- ▶ Indirect effects: changes in the set of discordant groups.

Assumptions (easy to modify):

- ▶ Revenues of existing mines: unchanged.
- ▶ Revenues of new mines: 10% of current total mining revenues.

Counterfactual analysis

Figure: Aggregate effects of new mining projects on conflict



- Mining for peace is rather rare, but possible.

Counterfactual analysis

Figure: Effects of new mining projects on local conflict at deposits

`./figures/main/F7b_deposits_conflict_sym.jpg`

Counterfactual analysis

Intuition: Pampana River deposit

- ▶ Location: Close to the center.
- ▶ Main ethnic group: Temne, who are not a discordant group.
- ▶ Lower conflict risk at national level:
 - ▶ Substantial negative direct effect: Reduction in spatial resource inequality, with an increase in resource rents in locations where discordant groups are under-represented.
 - ▶ Small positive indirect effect: Kono (over-represented in the diamond-mining area in the East) leave the set of discordant groups.
- ▶ Only small increase in local conflict risk:
 - ▶ Discordant groups are all locally under-represented.

Conclusions and policy implications

- ▶ We argue that the effects of new mines on conflict depend on:
 - ▶ Location of new mines and local ethnic diversity.
 - ▶ Country's entire mining and ethnic geographies.
- ▶ We provide two theory-based, empirically validated concepts to predict the effects of new mines on aggregate and local conflict risks.
- ▶ Our concepts and simulations can be useful for governments, international mining companies, and other stakeholders.
 - ▶ Least conflictual deposits to develop (or close).
 - ▶ Peace deficit to price mining licences.
 - ▶ Mining company's production and transportation costs.
 - ▶ Social license to operate, human rights due diligence.

Appendix

Theory: Setup

- ▶ Country with ethnic groups $g = 1 \dots G$ and locations $l = 1 \dots L$.
- ▶ Each location has a resource rent $r_l > 0$, with $r = \sum_l r_l$.
- ▶ Resource rents can be contended in **local** or **national** conflicts.
- ▶ Group g (in location l) believes that the share of the rents preserved in a **local**/**national** conflict is $v_l^g \in [0, 1]$ / $v^g \in [0, 1]$.
- ▶ Group g (in location l) wins the share $s_l^g \in [0, 1]$ / $s^g \in [0, 1]$ of the preserved rents in a **local**/**national** conflict.
 - ▶ These shares may depend on a group's local and national population m_l^g and m^g , e.g., ratio forms $s_l^g = m_l^g / m_l$ and $s^g = m^g / m$.
- ▶ Group g 's payoff from **local**/**national** conflict is $r_l v_l s_l^g / r v s^g$.

Theory: Setup

- ▶ A central planner can redistribute resource rents.
- ▶ A transfer system $\mathbf{t}$ is a $|G| \times |L|$ dimensional matrix with t_l^g as typical element.
- ▶ A transfer system is *budget feasible* iff $\sum_g t_g \leq r$.
- ▶ Group g 's payoff from peace is t_l^g / t^g at the local/national level, where $t^g = \sum_l t_l^g$.
- ▶ The planner's objective is to (i) guarantee peace the national level and (ii) maximize the number of locations with peace.
 - ▶ Benevolent political leaders are rare, but even non-benevolent leaders care about security and stability.
 - ▶ Other objectives (e.g., ethnic or regional favoritism) would imply a tightening of the budget constraint, making ours a best-case scenario.

Theory: Peace guaranteeing transfers

Main result:

- **Proposition 1:** There exists a transfer system that is budget feasible and implements peace everywhere if and only if

$$1 = \sum_l (r_l/r)(s_l^g/s^g) \text{ for each } g. \quad (1)$$

- Assuming ratio forms, peace condition (1) holds only in very special cases:
 - No spatial resource inequality, i.e., $r_l/m_l = r/m$ for all l .
 - No ethnic segregation, i.e., $m_l^g/m_l = m^g/m$ for all l and g .

Theory: Peace guaranteeing transfers

Intuition:

- ▶ A transfer system implements peace everywhere for all v^g and v_l^g if and only if $t^g \geq s^g r$ and $t_l^g \geq s_l^g r_l$ for all g and l .
- ▶ First, each group gets $t^g = s^g r$ to guarantee national peace.
- ▶ Groups over-represented in resource-rich locations are then short of (local) transfers from this national-level constraint:

$$rs^g = t^g = \sum_{l \in L} t_l^g < \sum_{l \in L} r_l s_l^g$$

- ▶ Formally, the set of these groups is

$$G^* = \{g \in G : 1 < \sum_{l \in L} (r_l/r)(s_l^g/s^g)\}$$

- ▶ These groups feel deprived of the resource rents accruing in the locations where they predominately live.
- ▶ They may start local conflicts (unlike other groups).

Theory: Peace guaranteeing transfers

Remark:

- ▶ Bargaining failure follows from the presence of multiple threat points.

Useful measure:

- ▶ We define the peace deficit as the amount of extra funds that would allow the planner to guarantee peace everywhere:

$$D := \sum_{g \in G^*} \left(\sum_{l \in L} r_l s_l^g - r s^g \right)$$

- ▶ It measures the general tendency to conflict in a country.

“Extension:”

- ▶ **Proposition 2:** There exists a mechanism that is peace maximizing and incentive compatible if and only if peace condition (1) holds.

Theory: Second-best transfers

- ▶ Government minimizes aggregate probability of local conflict subject to ensuring peace at the national level:

$$\min_t \sum_l p_l(t_l, \dots) \text{ s.t. } t^g = s^g r \text{ for each } g.$$

- ▶ Deprived groups $g \in G^*$ are again conflict initiators.
- ▶ Assumption: Groups' signals of preserved shares are iid with power-form CDF $\Phi(x) = x^\alpha$ with α sufficiently small.
- ▶ **Proposition 3:** Given the optimal system of transfers, the probability of conflict at each location $l \in L$ is increasing in the conflict exposure index

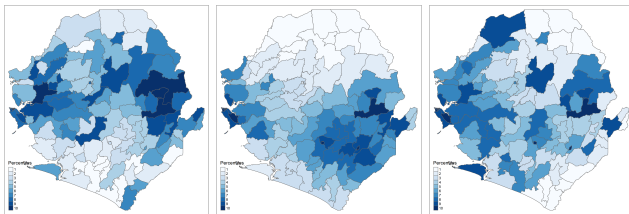
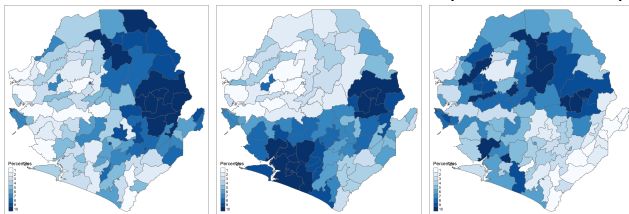
$$e_l(\mathbf{t}_l, \mathbf{s}_l, r_l) := (r_l/r) \left[\prod_{g \in G^*} (s_l^g / s^g) \right]^{1/|G^*|}.$$

Data: Summary statistics

Variable	Mean	SD	Min	Max	N
<i>Panel A: Cross-sectional sample</i>					
Relative resource rents	0.01	0.02	0.00	0.10	107
Diversity among discordant groups	0.34	0.30	0.04	1.76	107
Log observed conflict exposure	-5.51	0.65	-6.33	-3.00	107
Log predicted conflict exposure	-7.04	1.18	-9.13	-2.63	107
Log population (2004)	10.57	0.50	9.53	12.67	107
Log area	5.93	1.61	-0.23	7.97	107
<i>Panel B: Panel sample</i>					
Log observed conflict exposure	-5.51	1.04	-7.43	-0.81	2,354
Log predicted conflict exposure	-7.04	1.68	-11.24	-0.16	2,354
Log bauxite proximity $\times$ log bauxite price	-41.58	6.24	-50.90	-10.82	2,354
Log diamond proximity $\times$ log diamond price	-24.96	4.25	-30.48	-7.91	2,354
Log iron proximity $\times$ log iron price	-20.74	5.07	-32.06	-3.34	2,354
<i>Panel C: Time-series sample</i>					
Share of wards in conflict	0.15	0.22	0.01	0.77	22
Peace deficit in percent of GDP	1.03	1.23	0.12	5.05	22

Empirical validation: Visual econometrics

Figure: Predicted vs observed local conflict exposures across periods



Empirical validation: Cross-sectional OLS evidence

	<i>Dependent variable: Log observed conflict exposure</i>			
	(1)	(2)	(3)	(4)
<i>Panel A: Full period</i>				
Log predicted conflict exposure	0.140*** (0.044)	0.120*** (0.041)	0.055** (0.024)	0.053* (0.028)
R2	0.0648	0.245	0.773	0.833
<i>Panel B: Diamond period</i>				
Log predicted conflict exposure	0.097*** (0.023)	0.085*** (0.016)	0.068** (0.030)	0.089** (0.035)
R2	0.0967	0.238	0.537	0.684
<i>Panel C: Bauxite period</i>				
Log predicted conflict exposure	0.105** (0.048)	0.117*** (0.044)	0.065** (0.027)	-0.021 (0.032)
R2	0.0649	0.245	0.736	0.794
<i>Panel D: Iron period</i>				
Log predicted conflict exposure	0.174* (0.096)	0.127* (0.074)	0.091*** (0.031)	0.071** (0.028)
R2	0.0695	0.218	0.762	0.832
Population control	—	✓	✓	✓
Area control	—	—	✓	✓
Province-fixed effects	—	—	—	✓
Observations	107	107	107	107

Notes: Standard errors are spatially clustered with a distance cutoff of 100km.

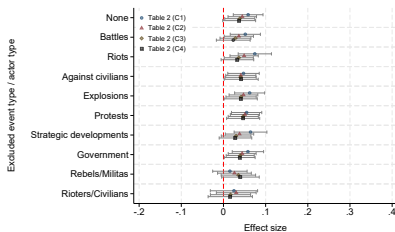
Empirical validation: Panel and IV evidence

	<i>Dependent var.: Log observed conflict exposure</i>			
	(1)	(2)	(3)	(4)
<i>Panel A: OLS – Dependent variable: Log observed conflict exposure</i>				
Log predicted conflict exposure	0.064 (0.020)	0.047 (0.017)	0.041 (0.018)	0.041 (0.020)
<i>Panel B: 2SLS, second stage – Dependent variable: Log observed conflict exposure</i>				
Log predicted conflict exposure	0.164 (0.050)	0.162 (0.050)	0.172 (0.055)	0.190 (0.066)
<i>Panel C: 2SLS, first stage – Dependent variable: Log predicted conflict exposure</i>				
Log generated conflict exposure	0.941 (0.066)	0.889 (0.090)	0.839 (0.096)	0.841 (0.114)
First-stage F-stat	180.7	84.89	66.59	42.69
<i>Panel D: Zero stage – Dependent variable: Relative local resource rents</i>				
Bauxite proximity-price interaction	0.420 (0.050)			
Diamond proximity-price interaction	-0.851 (0.054)			
Iron proximity-price interaction	0.109 (0.015)			
Ward- & year fixed effects	✓	✓	✓	✓
Province trends	–	✓	–	–
District trends	–	–	✓	–
Ward trends	–	–	–	✓
Observations	2354	2354	2354	2354

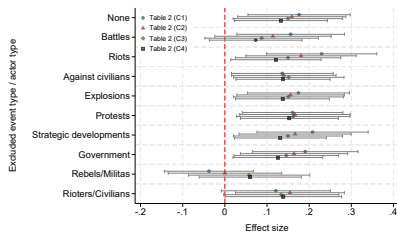
Notes: Standard errors are spatially clustered with a distance cutoff of 100km.

Robustness

Figure: Alternative outcome variables



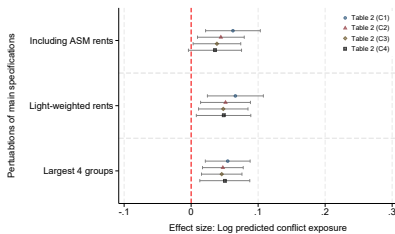
((a)) OLS panel



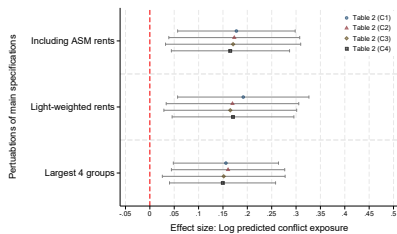
((b)) 2SLS panel (second stage)

◀ Return

Figure: Alternative independent variables



((a)) OLS panel

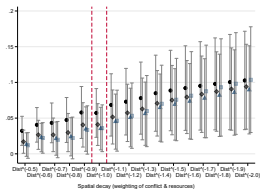


((b)) 2SLS panel (second stage)

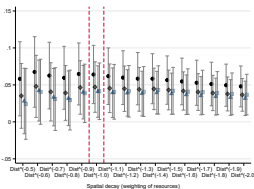
Return

Robustness

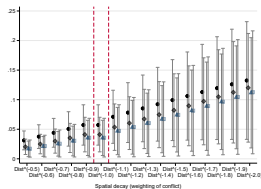
Figure: Alternative distance decays



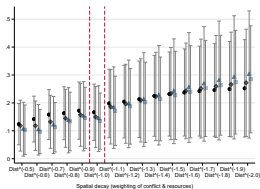
((a)) OLS panel (both)



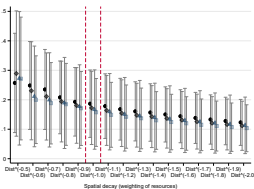
((b)) OLS panel (rents)



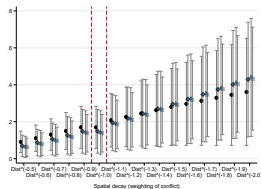
((c)) OLS panel (conflict)



((d)) 2SLS panel (both)



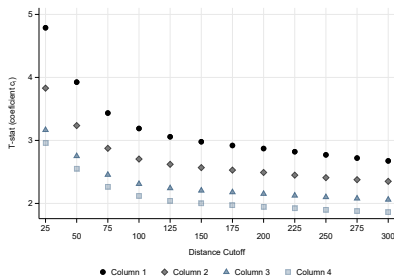
((e)) 2SLS panel (rents)



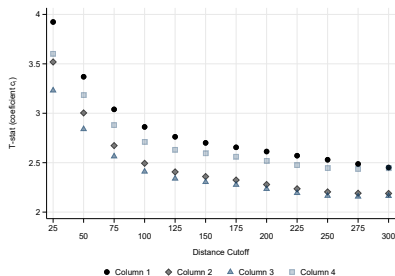
((f)) 2SLS panel (confl.)

Robustness

Figure: Alternative distance cutoffs for spatially clustered standard errors



((a)) OLS panel

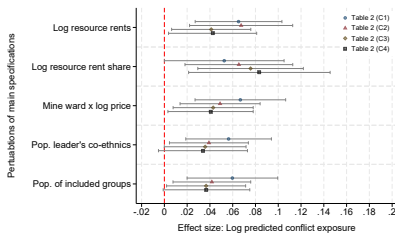


((b)) 2SLS panel

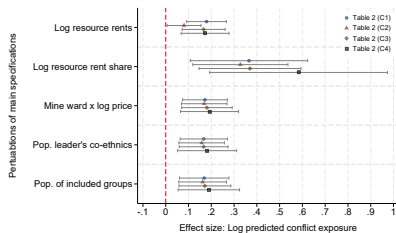
◀ Return

Robustness

Figure: Ward-level control variables



((a)) OLS panel



((b)) 2SLS panel (second stage)

◀ Return

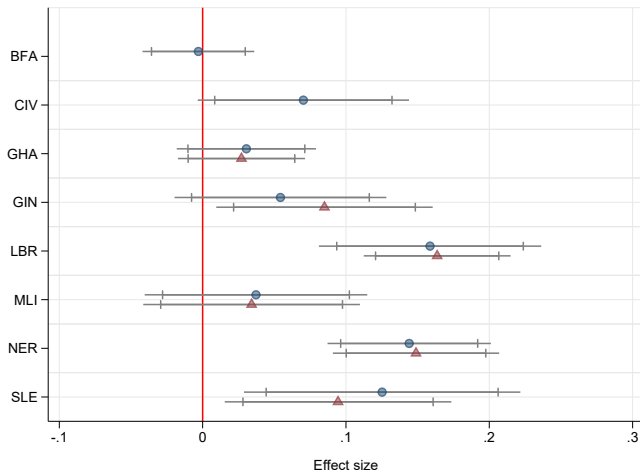
External validity

Table: External validity

	<i>Dependent variable: Log observed conflict exposure</i>			
	<i>Sierra Leone</i>		<i>West Africa</i>	
	(1)	(2)	(3)	(4)
<i>Panel A: All ethnic groups</i>				
Log predicted conflict exposure	0.121** (0.059)	0.150*** (0.053)	0.074*** (0.015)	0.061*** (0.013)
Obs.	39	39	1534	1534
<i>Panel B: Politically relevant ethnic groups</i>				
Log predicted conflict exposure	0.103** (0.040)	0.117*** (0.040)	0.090*** (0.015)	0.090*** (0.015)
Obs.	39	39	1275	1275
Population and area controls	—	✓	—	✓
Country-fixed effects	✓	✓	✓	✓

External validity

Figure: External validity: Single-country estimates



Counterfactual analysis

Figure: Predicted effects of hypothetical mining projects on conflict around the Tonkolili iron mine

