Lecture in Political Economy of Conflicts

- A Quantitative Guide for Pacification -

Mathias Thoenig

School of Business and Economics, University of Lausanne
and CEPR

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Introduction

Why should economists care about conflict - I

- *Direct loss of human life*: Since 1945 an estimated 3.3 million people got killed in 25 interstate wars, and 16.2 million direct fatalities took place in 127 civil wars.
- *Indirect effect of wars on human life*: Works through diseases after the end of conflicts. Ghobarah, Huth and Russett (2003, APSR) find that the indirect fatalities are at least as large as direct casualties.

Introduction

Why should economists care about conflict - II

- *Large economic costs*. Civil wars tend to reduce growth by 2.3 percent per year, so the average civil war which lasts about 7 years reduces GDP by about 15 percent (Collier, 2007, The Bottom Billion).
- *Major obstacle to growth and development:* 20 of the world's 34 poorest countries are affected by armed conflict (OECD, 2009, Armed Violence Reduction).
- The study of conflict becomes an increasingly important area of development economics.

Contents

Main Theories of War

War as Bargaining Failure

- Goal of this approach is to explain why conflict takes place. Key authors are e.g. Fearon, Powell.
- Conflict is costly and one would expect bargaining over contentious issues being able to avoid war. This literature focuses on reasons for bargaining failure:
  Private information // Issue indivisibilities // Psychological gains from war (that outweigh the destruction and armament costs) // Political bias (people who decide on war are not the same who bear these costs // Commitment problems (incentives to renege on peace deals)
- Powell (2006, IO) argues that commitment problems, together with informational problems, are the main source of bargaining failure.
- Other sources like issue indivisibilities or risk-acceptance can be reduced to commitment problems

War as Rent-seeking

- This approach takes conflict, or. anarchy without property rights protection as given, and focuses on how many resources are devoted to "appropriative activities" in equilibrium.
- It can be used to explain intensity or duration of conflict.
- Some classic authors are Jack Hirshleifer, Herschel Grossman, Stergios Skaperdas, Kai Konrad.
- Main theoretical setup: Contest Success Function

Ethnic Polarization and Conflict

- Empirical motivation: Class conflict is less salient than ethnic conflict.
- Contest over public goods –> groups want to get control over a larger share of the budget to spend it for public goods in which they are interested (e.g. primary versus higher education, Hindu versus Muslim festival).
- Key authors are J. Esteban and D.Ray
- Polarization vs fractionalization (Montalvo and Reynal-Querol, 2005): Polarization is largest when there are only two groups of similar size. Fractionalization increases in the number of groups.

Distrust and Grievances

- Old literature in political science on "security dilemma" or "spiralling model of war" –> mutual distrust drives arms races and conflict (Herz 1950, Jervis 1978). Formalised with global games by Baliga and Sjostrom, 2004.
- Rohner, Thoenig and Zilibotti (2013) links trust to war, using dynamic models of belief updating:

  $\longrightarrow$ War today erodes inter-ethnic trust
  $\longrightarrow$ Distrust reduces trade opportunities and the opportunity cost of future war falls
  $\longrightarrow$ This leads to recurrent war

- Distrust may be "unwarranted"...without being irrational. Culprit: imperfect information / learning trap (related to information cascades)
- Bad luck (a series of bad draws) may result in a permanent war trap (which is an absorbing state)

Main Empirical Results

Main Empirical Results

Overview

- Here we focus on civil wars and their determinants.
- Qualitative case studies have existed for a long time, but proper econometric analysis has only started towards the end of the 1990s.
- Pioneers of this literature are Fearon and Laitin (2003, APSR) and Collier and Hoeffler (2004, OEP) (each of these papers has above 4000 citations in scholar.google ...). Both use a panel of around 150 countries and 50 years.
- Weaknesses of this early literature are:

  $\longrightarrow$ Endogeneity bias of explanatory variables is only addressed using lags.

  $\longrightarrow$ Omitted variable bias is a concern, as typically the cross-section drives the results.

  $\longrightarrow$ Crude measures and proxies

Main Empirical Results

Methodological improvements in recent years

- Addressing endogeneity concerns: For example, Miguel et al. (2004, JPE) use rainfall to instrument for the impact of growth on conflict in Africa.
- Addressing omitted variables bias:

  → Econometric studies focusing on a single country: e.g. for Colombia by Dube and Vargas (2013, ReStud).

  → Studies using disaggregated and geo-referenced conflict data: e.g. Berman and Couttenier (2015, RESstat).

Main Empirical Results

Poverty and lack of growth

- Mechanism: Rebellion and appropriation requires time. In poor and unproductive countries the opportunity cost of conflict is therefore smaller.
- Low GDP per capita is a powerful predictor of civil conflict (Fearon and Laitin, 2003, APSR; Collier and Hoeffler, 2004, OEP).
- But hard to disentangle the effect of poverty, as GDP per capita may be endogenous, and there may be omitted variables.
- To establish *causality*, Miguel, Satyanath and Sergenti (2004, JPE) use rainfall variation as instrument for economic growth and still find a strong conflict-reducing effect.

Main Empirical Results

Natural resources

- Natural resource rents increase the "pie" to be appropriated. Particularly "dangerous" resources are:
  - → Oil (Fearon and Laitin, 2003, APSR; Ross, 2006, ARPS; Fearon, 2005, JCR; Humphreys, 2005, JCR).
  - → Diamonds (Lujala, Gleditsch and Gilmore, 2005, JCR; Humphreys, 2005, JCR; Ross, 2006, ARPS; Olsson, 2007, JDE; Lujala, 2010, JPR).
  - → Narcotics (Angrist and Kugler, 2008, ReStat; Lujala, 2009, JCR).
- Identification concern: Extraction and Production are impacted by local conflict.
  - → Causal analysis exploits shocks on the World price of the natural resources.

Main Empirical Results

Overall democracy levels (I)

- Mechanism: Democratic representation could reduce "grievances" (Gurr, 1971, *Why men rebel*, Princeton University Press), but at the same time it is easier to mobilize groups in a democracy (principles of free speech and right of assembly). Hence, net effect is likely to be ambiguous.
- Examples violence related to elections: Côte d'Ivoire 2010, Kenya 2007, Nigeria 2007.
- Unsurprisingly, most empirical studies find that the relationship between democracy scores and the risk of civil conflict is non-monotonic.

Main Empirical Results

Overall democracy levels (II)

- There is evidence for an "inverted U-shape", i.e. "anocracies" with intermediate democracy scores fare worst (see, for example, Hegre *et al.*, 2001, APSR; Reynal-Querol, 2002, JCR; and Fearon and Laitin, 2003, APSR). $\Rightarrow$ In most full democracies people feel represented and in full autocracies people have no chance against the regime (e.g. North Korea, Myanmar).

Main Empirical Results

Disaggregating democracy: What institutions foster peace? (I)

- Mechanism: Institutions which lower the stakes of controlling the government can reduce the risk of conflict.
- *Proportional representation* decreases the risk of civil conflict (Reynal-Querol, 2002, JCR; Saideman et al, 2002, CPS) $\Rightarrow$ Even if a group loses the election, it is still represented.
- *Federalism* decreases the risk of rebellion (Saideman et al, 2002, CPS) $\Rightarrow$ More regional autonomy makes it less crucial to control the central government.
- *Power-sharing* in government and administration reduces conflict risk (Cederman and Girardin, 2007, APSR) $\Rightarrow$ Minorities included in the government coalition can peacefully represent their interests.

Main Empirical Results

Disaggregating democracy: What institutions foster peace? (II)

- *Welfare State* (i.e., universal access to some social assistance and public education) reduces risk of civil war (Thyne, 2006, ISQ) $\Rightarrow$ poverty reduction and higher education increases the opportunity cost of fighting.
- *Rule of Law* (in particular, executive constraints, contract protection, freedom from expropriation and reliable bureaucracy) reduce the conflict risk (Easterly, 2001, EDCC; Besley and Persson, 2011, QJE) $\Rightarrow$ Protects minorities who can defend their interests by peaceful means.

Main Empirical Results

Ethnic cleavages

- It is controversial whether ethnicity matters in civil wars, and in what ways what forms of ethnic divisions could play a role.
- The results are not conclusive for ethnic fractionalization, i.e. the number of groups (Fearon and Laitin, 2003, APSR; Collier and Hoeffler, 2004, OEP).
- But ethnic polarization, i.e. the relative group sizes, is tightly linked to conflict (Reynal-Querol, 2002, JCR; Montalvo and Reynal-Querol, 2005, AER).
- Also ethno-nationalist exclusiveness, i.e. the political dominance of one ethnic group, has been found to matter (Bates, 1999, mimeo; Collier and Hoeffler, 2004, OEP; Cederman and Girardin, 2007, APSR).

Main Empirical Results

Other predictors of civil war

- **Previous wars** - 68 percent of all civil conflict outbreaks in the second half of the 20th century took place in countries experiencing multiple wars. There is a strong effect of war recurrence (Walter, 2004, JPR; Collier and Hoeffler, 2004, OEP; Quinn et al, 2007, II; Collier et al, 2009, OEP).
- **Young men** - A high proportion of young men has been found to increase the risk of civil war (Urdal, 2005, JPR)
- **Mountainous terrain** - Fearon and Laitin (2003 APSR), Collier et al (2009, OEP).
- **Trade** - Martin et al. (2008, ReStud) find ambiguous effects (multilateral vs. bilateral).

Pacification Policies

Pacification Policies - Scant Evidence

- Pacification Policies : Lack of theoretical/empirical studies in the academic literature
- **Economic and trade sanctions** - Tend to reduce civil war duration, but can substantially hurt the civilian population (e.g., Escribà-Folch, 2010, JPR).
- **Targeted arms trade embargoes** - During civil wars could be a less costly alternative, but are hard to enforce (Moore, 2010, JCR).
- **International Criminal Court** - Double-edged knife.

  → Harder to convince dictators with a bad track record to step down if they face prosecution (Snyder and Vinjamuri, 2003, IS)

  → ICC can give powerful incentives to new leaders to not become "criminal dictators" (Akhavan, 2001, AJIL).

Pacification Policies - Imperfect Theoretical Guidance

- Pacification is a complex question: Many wars involve multiple actors with intricate webs of alliances & rivalries:

  $\longrightarrow$ Recent civil wars: Somalia, Syria, Uganda, Democratic Republic of Congo, ...

- Existing theorical guidance focus on two player/coalition wars...

  $\longrightarrow$ Alliances are often not unified coalitions; each participant retains its independent agenda and decision power (e.g. Warsaw insurrection; ongoing rebellion in Syria; etc.)

Quantitative Guide for Intervention - I

A first (and imperfect) attempt

- "Network in Conflict: Theory and Evidence from the Great War in Africa", by M. Koenig, D. Rohner, M. Thoenig and F. Zilibotti.
  - → How does the network of military alliances and rivalries affect overall conflict intensity, destruction and death toll?
- Use network analysis as a guide for policy:
  - → Due to the externalities, pacifying a group affects the actions of all the other groups in a complex way
  - → A mis-designed intervention may result into an increase in violence.
  - → Network structure reveals which actors are the most critical for the escalation/containment of violence

Quantitative Guide for Intervention - II

- Theory: We combine insights from network theory with standard conflict theory tools (i.e. contest success function)
  - → A non-cooperative theory of strategic fighting with the purpose of fitting disaggregated battlefield data
- Empirics: Dem. Rep. of Congo - 1998-2010. Ideal setting: 80 fighting groups; rich network of alliances/enmities

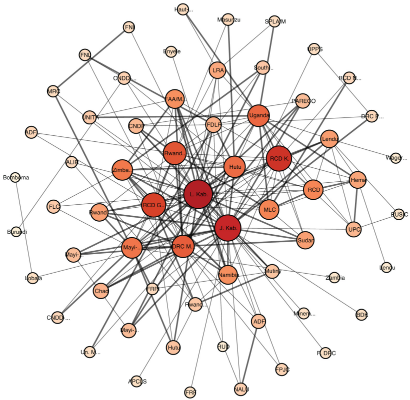
We perform a structural estimation of the fighting externalities

- We simulate counterfactual pacification policies
  - → The most destructive groups are not necessarily the most active, but rather the most influential ones through their alliance/enmity links
  - → Dismantling RCD (8.6% obs. violence) would reduce violence by 15.7% (multiplier effects)

Context of DRC conflict

- We study the Second Congo War ("Great African War"), 1998-2010 (after the end of the 1996-97 conflict).
- Although the war is officially over in 2003, fighting continues till today on a large scale.
- The deadliest conflict since WWII, with 3-to-5 million excess deaths (Olsson and Fors, 2004; Autesserre, 2008).
- An emblematic conflict for the involvement of many inter-connected domestic and foreign actors: "Three Congolese rebel armies, 14 foreign armed groups, and countless militias" (Autesserre, 2008).

Network of alliances & enmities in DRC



Setup I

- One period model. Exogenous network G of Groups $i \in \mathcal{N} = \{1, \ldots, n\}$ with *signed* adjacency matrix $\mathbf{A} \equiv \mathbf{A}^{+} - \mathbf{A}^{-}$

$$a_{ij} \equiv a_{ij}^{+} - a_{ij}^{-} = \begin{cases} 1, & \text{if } i \text{ and } j \text{ are allied} \\ -1, & \text{if } i \text{ and } j \text{ are enemies} \\ 0, & \text{if relationship } (i,j) \text{ is neutral.} \end{cases}$$

- We assume:
  1. $a_{ij} = a_{ji}$ (reciprocity of alliance & enmity)
  2. alliance and enmity are mutually exclusive

Setup II

- Pay-off (utility) function: standard ratio-form (Tullock) contest success function

$$\pi_i = \frac{\varphi_i}{\sum_{j=1}^{n} \varphi_j} \times \underbrace{V}_{\text{Territory}} - \underbrace{x_i}_{\text{fighting effort}}$$

- Generalization of the CSF:
  Group i's fighting strength, φ_i, depends on its own fighting effort, x_i, and on that of its allies and enemies:

$$\varphi_i\left(x_i, x_{-i}, \mathbf{A}\right) = x_i + \left[\beta \sum_{j=1}^{n} a_{ij}^{+} x_j - \gamma \sum_{j=1}^{n} a_{ij}^{-} x_j\right] + \underbrace{\mathbf{Z}_{it}\delta + e_i + \varepsilon_{it}}_{\text{Shifters}}$$

- Structural shifters $(\mathbf{Z}_{it}, e_i + \varepsilon_{it})$ are resp. observed and unobserved (by the econometrician): group size, scale of operation, foreign affiliations, climatic shocks, weaponry efficiency, moral of troops, leadership

Discussion of assumptions

- Even allied groups compete one with another over V.
  Alliances are no "unitary" coalitions
  $\longrightarrow$ Rwanda and Uganda in the DRC war
  $\longrightarrow$ Rebel forces in Syria
- The externalities through the fighting strength, ϕ_i,compound with those already present in the CSF
- Not over-parametrized: the model spans from totally destructive anarchy to a peaceful sharing without any rent dissipation (e.g. our theoretical example of a $k-$regular graph in the paper)

Structural Equation

- The system of FOC $\{\partial \pi_i / \partial x_i = 0\}_{i=1}^{n}$ allows us to characterize equilibrium as a simple linear closed-form expression

$$x_{i,t}^* = -\beta \sum_j a_{ij}^+ x_{j,t}^* + \gamma \sum_j a_{ij}^- x_{j,t}^* - \mathbf{Z}_{it}\delta + \underbrace{\frac{\Phi(1-\Phi/V)}{1+\beta d_i^+ - \gamma d_i^-}}_{\text{Network Feedback}} - e_i - \varepsilon_{it}$$

- Interpretation
  Contest effect (enemies) and free-riding effect (allies)
- This system of equations will be estimated to obtain $(\hat{\beta}, \hat{\gamma})$

Welfare

- Aggregate Welfare:

$$\mathcal{W} \equiv \sum_{i=1}^{n} \pi_i = V - \mathcal{D}$$

  where $\mathcal{D} \equiv \sum_{i=1}^{n} x_i$ represents rent dissipation, (e.g. cost of mobilizing troops, casualties, damages...)
- The rent dissipation hinges on the network structure..We can study policies to minimize $\mathcal{D}$, e.g., bribing/eliminating leaders, weapons embargo, etc.
- The key player is defined as the agent whose removal reduces total destruction the most

Two properties of the equilibrium

1. Centrality determines fighting effort
   In our contest game Bonacich centrality gauges the network multiplier effect attached to rivalries or alliances.
2. Many friendships (enmities) scale down (up) conflict and rent dissipation

Empirical Strategy (overview)

- Assume a time-invariant network (later, relaxed).
- A repetition of static conflicts.
- Violence changes over time driven by exogenous shocks.
- Steps of analysis
  - $\longrightarrow$ panel IV estimate of structural parameters β and δ
  - $\longrightarrow$ policy counterfactuals (remove some groups, pacification policies, etc.).
- Extensions:
  - $\longrightarrow$ time-varying network.
  - $\longrightarrow$ network recomposition after policy shocks.

Mapping the Model into Observables

- Mapping of main model variables:
  1. Fighting effort
     $\longrightarrow$ extent to which each group is involved in fighting
  2. Network links
     $\longrightarrow$ expert coding, observed behavior in battlefields
  3. Exogenous shocks
     $\longrightarrow$ rainfall variation across times and regions of DRC

Measuring Fighting Effort

- ACLED contains 4765 violent events in the DRC
  - → For each event, information over location, date and actors involved on the two opposing sides.
- We construct a time-varying (non-bilateral) measure of fighting effort:
  $x_{it} \equiv$ yearly number of violent events involving group i.
- Panel of fighting effort of 80 armed groups over 1998-2010.

Network of Alliances&Enmities in DRC

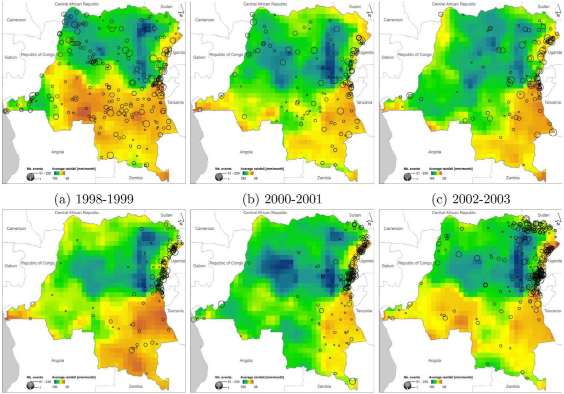
Coding of Alliances and Enmities

- We use hierarchically:
  1. Expert coding (Stockholm International Peace Research Institute, Cunningham *et al.* 2013, International Crisis Group (NGO), Williams 2013)
  2. Bilateral information from ACLED
     - we code as allied two groups which fought together at some point and never fought on opposing sides;
     - we code as enemies two groups that are recorded fighting on opposite sides at least twice and never on the same side.
- Otherwise, neutrals (we do robustness analysis...)
  - # of problematic dyads boil down to 4

Weather Shocks

- Play a key role in identification:
  - rainfall increases the opportunity cost of fighting (Miguel et al. 2004, Jia 2014, etc.).
- Geolocalized rainfall measures (grid of 0.5 x 0.5 degree^2 cell).
- Source: GPCC (gauge-based)
  - we compare it with satellite measures

Geolocalized Violence in DRC



(a) 1998-1999 (b) 2000-2001 (c) 2002-2003

(d) 2004-2005 (e) 2006-2007 (f) 2008-2010

Identification Strategy I

$$x^*_{i,t} = -\beta \sum_j a^+_{ij} x^*_{j,t} + \gamma \sum_j a^-_{ij} x^*_{j,t} - \underbrace{\mathbf{Z}_{it}\delta}_{\text{OBS.}} + \underbrace{\frac{\Phi(1-\Phi/V)}{1+\beta d^+_i - \gamma d^-_i} - e_i}_{\text{FE}} - \varepsilon_{it}$$

- Time-invariant unobserved heterogeneity $\longrightarrow$ panel allows for group FE
- Endogeneity bias

  $\longrightarrow$ A's effort depends on B's effort, but B's effort is in turn affected by A's effort [Reflection Problem + Contextual factors]

  $\longrightarrow$ OLS yields inconsistent estimates

Identification Strategy II

$$x^*_{i,t} = -\beta \sum_j a^+_{ij} x^*_{j,t} + \gamma \sum_j a^-_{ij} x^*_{j,t} - \mathbf{Z}_{it}\delta + \mathbf{FE}_i - \varepsilon_{it}$$

- We use $\sum_j a^+_{ij}\mathbf{Z}_{jt}$ and $\sum_j a^-_{ij}\mathbf{Z}_{jt}$ as excluded instruments (consistent with our structural equation)

  $\longrightarrow$ $\mathbf{Z}_{jt}$: time-varying climatic shocks (rainfall) impacting fighting group "homelands". Rationale: exogenous shocks on income and military efficiency

  $\longrightarrow$ The instruments are the weather conditions at t in the homeland of group i's friends and in that of its enemies

  $\longrightarrow$ Note: in the second-stage we control for weather conditions in *i*'s own homeland

Baseline results (second stage)

Table 2: Baseline regressions (second stage).

	Dependent variable: Total Fighting					
	(1)	(2)	(3)	(4)	(5)	(6)
Tot. Fight. Enemies	0.09***	0.06***	0.12**	0.08	0.14***	0.09**
	(0.02)	(0.02)	(0.05)	(0.07)	(0.05)	(0.05)
Tot. Fight Allies	-0.01	-0.02	-0.16**	-0.17**	-0.15*	-0.14**
	(0.02)	(0.01)	(0.07)	(0.08)	(0.08)	(0.07)
Group FE, annual TE, rain controls	Yes	Yes	Yes	Yes	Yes	Yes
Additional controls	No	Yes	No	Yes	No	Yes
Estimator	OLS	OLS	IV	IV	IV	IV
Set of Instrument Variables	n.a.	n.a.	Restricted	Restricted	Full	Full
Observations	1190	1190	1190	1190	1105	1105
R-squared	0.340	0.415	0.241	0.323	0.254	0.364

Notes: An observation is a given armed group in a given year. The panel contains 85 armed groups between 1998 and 2010. Robust standard errors allowed to be clustered at the group level in parentheses. Significance levels are indicated by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Robustness checks - I

1. Using only IVs of degree two (e.g., rain fall of enemies' enemies, enemies' friends,...)
2. Using the (non-overlapping) historical homelands of the affiliated ethnic group from Murdock (1959) to compute the rain fall measure for each given group
3. Non classical measurement error in rainfall.
   We compare our ground (gauge) data to Satellite data (TRMM and GPCC)
4. Restrict the sample to groups with at least one enemy
5. Restrict the sample to groups with at least 1 enemy& 1 ally
6. Exclude bilateral fighting events when computing the fighting effort on the RHS
7. Control for the fighting effort of "neutral" groups (zero coefficient)
8. Control for lagged fighting efforts of allies/enemies (zero coefficient)

Robustness checks - II

9. Only violent events
10. Only battles
11. Only events until 2007
12. Alternative coding rules of the network
13. Mismeasurement of links (attenuation or expansion bias). Monte Carlo approach: we rewire links in the observed network at random, and measure the robustness of our estimates in such perturbed networks
14. Different definitions of group (merging factions)
15. TOBIT estimators (to account for zeroes in fighting)

Counterfactual Experiments

- We can quantify the effect of pacification policies (i.e. a change in the network structure $\mathbf{A}^+, \mathbf{A}^-$).
- Based on the point estimates of β and γ, we simulate counterfactual equilibria with the reduced form of the model.

$$\mathbf{x} = (\mathbf{I} + \hat{\beta}\mathbf{A}^+ - \hat{\gamma}\mathbf{A}^-)^{-1}\left[\hat{\Lambda}(1 - \hat{\Lambda})\Gamma - (\mathbf{Z}\widehat{\boldsymbol{\alpha}} + \widehat{\mathbf{e}} + \boldsymbol{\epsilon})\right]$$

Key Player Analysis - I

Multipliers

- Removing some groups has a large *multipliers*; others have small effects
  - → RCDs 1.7, Rwandan Army 1.4, LRA 1.4, MayiMayi Mil. 0.5
  - → one group has a negative multiplier
- Removing multiple players:
  - → Uganda, Rwanda & ass.: -43%;
  - → all Hutu groups: -8%; actors Ituri conflict -10%
  - → all Mayi Mayi Militias: -5%.
  - → all foreign groups: -29%
- Multiple key players: Rwanda&RCD-G always top 10.

Pacification Policies

Switching enmities into neutrality

- Pacifying all rebel group with the DRC govt. forces reduces fighting by 60%
- Large multipliers (relative to bilateral fighting) for Rwanda (9), Uganda (5), RCD-G (1.7), RCD-K (1.5)
- Resolve enmities with some small players surprisingly important (e.g., Lobala Enyele Militia)
- Re-wiring Hutu-Tutsi enmities into neutral: -8.5% (small)
- Rewiring Rwanda-Uganda into a stable alliance: -10%

Network Recomposition

Motivation

- So far, exogenous network.
- However, the network of enmities&alliances may respond to policy interventions

  $\longrightarrow$ For example, removing FDLR may lead its 7 allies (5 enemies) to form new alliances and/or reduce their enmities.

  $\longrightarrow$ How are pacification policies impacted by endogenous rewiring of the network?
- Realm of endogenous network formation.

Network Recomposition

What we do I

- The unit of analysis is a dyad.
- We propose a random utility model (RUM) to predict the probability for each dyad to be in state -1, $+1$, or neutral.
- If we could predict the nature of links based on exogenous characteristics only (e.g., common ethnicity), we would have a model of endogenous network formation.
- However, such a model would have a low predictive power.

Network Recomposition

What we do II

- We add explanatory variables:
  1. Following the computer science literature, we allow links to be predicted also by network characteristics (e.g., # of common enemies).
  2. We also include the payoff associated to each state (i.e., how much extra rent would accrue to a dyad if the two groups were neutral instead of enemies)
  3. Finally, we include group fixed effects.
- We estimate the RUM, and use it to predict the effect of policy changes (e.g., remove one player) on network links.

Network Recomposition

Random Utility Model

- The unit of analysis is a dyad ij with alternatives $a \in \{-1, 0, 1\}$.
- The observed link is $a_{ij}^{obs} = \arg\max U_{ij}(a)$ where

$$U_{ij}(a) = FE_i + FE_j + CSF_{ij}(a) + \\ +\mathbf{Z}_{ij}^{\top} \times \delta(\mathbf{a}) + \mathbf{X}_{ij}^{\top} \times \boldsymbol{\psi}(\mathbf{a}) + \tilde{u}_{ij}(a)$$

- $CSF_{ij}(a)$ – Joint surplus of the fighting game
- $\mathbf{Z}_{ij}$ – Structural charact.: spatial distance, historical rivalries, joint ethnicity, $ij \in$ {Tutsi,Hutu, Foreign,Gov}
- $\mathbf{X}_{ij}$ – Network-related charact.: # common enemies, # common allies, # antagonistic common neighbors
- $\tilde{u}_{ij}(a)$ – extreme value type I distributed shocks

Network Recomposition

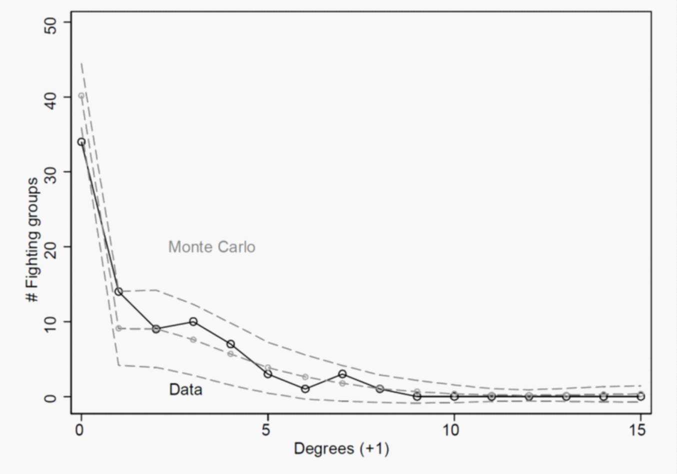
Multinomial Logit

$$\begin{aligned} U_{ij}(a) &= FE_i + FE_j + CSF_{ij}(a) + \mathbf{Z}_{ij}^{\top} \times \boldsymbol{\delta}(\mathbf{a}) \\ &\quad + \mathbf{X}_{ij}^{\top} \times \boldsymbol{\psi}(\mathbf{a}) + \tilde{u}_{ij}(a) \end{aligned}$$

- We estimate the RUM through multinomial conditional logit.
- We obtain the probability that each dyad ij is in each state, $a \in \{-1, 0, 1\}$, as a function of the RHS variables.
- The model fits well the data...

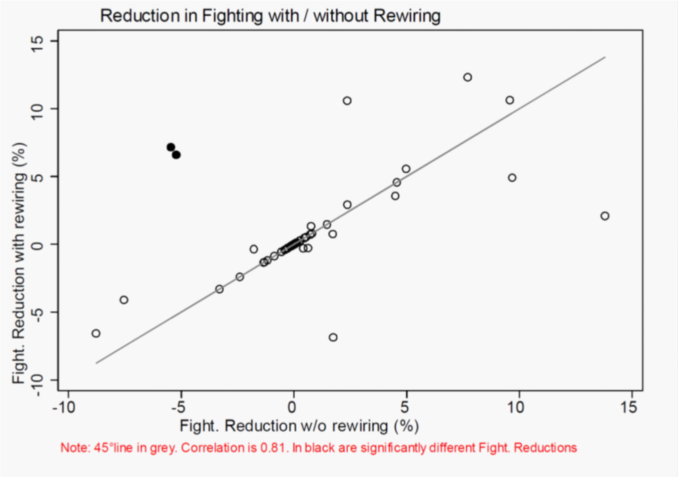
Network Recomposition

MLogit - Goodness of Fit: Degree minus distribution for 1000 pre-policy predicted networks



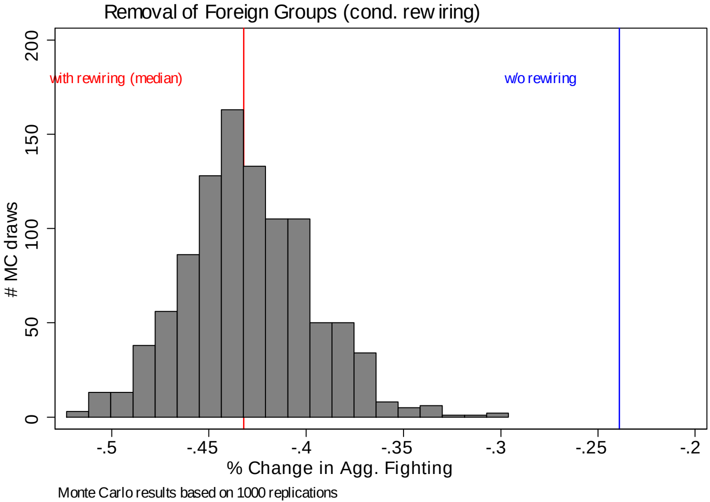
Network Recomposition

Key Player Analysis with rewiring - Comparison of Aggregate Fighting



Network Recomposition

Key Player Analysis with rewiring - Ex: Removing foreign groups



Conclusion

- New tool to analyze complex alliance/rivalry networks in conflicts
- Helps one to understand why violence may escalate or stay low
- Structural estimation of the model
- Analysis of different types of interventions aimed at scaling down conflict (removing actors, pacifying enmities, etc.)
- The methodology can be exported to other war contexts

Network Recomposition

Pacification Policies with Network Rewiring

$$U_{ij}(a) = FE_i + FE_j + CSF_{ij}(a) + \mathbf{Z}_{ij}^{\top} \times \boldsymbol{\delta}(\mathbf{a}) + \mathbf{X}_{ij}^{\top} \times \boldsymbol{\psi}(\mathbf{a}) + \tilde{u}_{ij}(a)$$

- A policy change, e.g., the removal of group k
  - changes $CSF_{ij}(a)$ (for all players)
  - changes $\mathbf{X}_{ij}$ for degree 1 neighbors only.
  - leaves other covariates unchanged.
- $\tilde{u}_{ij}$ is unobserved and cannot be estimated from the data.
  - We rely on 1000 Monte Carlo draws of $\tilde{u}_{ij}(a)$ for predicting post-intervention rewired networks.

Network Recomposition

Key Player Analysis with rewiring - Multiple key player

- Results confirm key role of RCD-G, Rwanda and Uganda
- May Mayi Militia becomes more important
- FDLR less important.

Network Recomposition

One-step vs. multisteps

- So far, we only allow for one-step recomposition.
- However, recomposition can lead to further changes.
- Allow for n rounds of rewiring until we converge to a new steady state
    - convergence not guaranteed

Literature (conflict)

- Theoretical conflict literature studying alliances and conflict in settings with 3 players, or sometimes with *n* identical players (Konrad, 2009, 2011, Kovenock and Roberson 2012, Bloch, 2012).
- Conflict and collective action (why do masses follow?): Esteban and Ray 2008.
- Recent development literature using fine-grained geo-localised data on fighting events: Dube and Vargas (2013), Cassar *et al.* (2013), La Ferrara and Harari (2012), Michalopoulos and Papaioannou (2013), Rohner, Thoenig, and Zilibotti (2013), Yanagizawa-Drott (2012).
- Context and economic motives of DRC war: e.g., Olsson and Congdon 2004; Lalji 2007; Carpenter 2012.

General Model - Equilibrium

- Solving for the fixed-point we obtain a closed form characterization of the equilibrium fighting efforts

$$\mathbf{x}^* = V\frac{1}{\mathcal{H}}(1 - \frac{1}{\mathcal{H}}) \times \mathbf{c}$$

where the G-specific centrality is defined by

$$\mathbf{c} \equiv (\mathbf{I}_n + \beta\mathbf{A}^+ - \gamma\mathbf{A}^-)^{-1} \times \mathbf{h}$$

- Contribution of group i to total fighting is equal to its relative centrality

$$\frac{x_i^*}{\sum_{j=1}^n x_j^*} = \frac{c_i}{\sum_{j=1}^n c_j}.$$

General Model - Centrality

- Centrality $\mathbf{c}$ is $\approx$ a linear combination of the Bonacich centralities $(\mathbf{b}^-, \mathbf{b}^+)$ attached to each submatrix $\mathbf{A}^-$ and $\mathbf{A}^+$
- Formally, the Bonacich centrality measures all walks arriving in i using rivalry (alliance) connections, where walks of length k are weighted by the geometrically decaying rival (alliance) externality γ^k (β^k).
- In our contest game each Bonacich centrality gauges the network multiplier effect attached to rivalry or alliance.

  $\longrightarrow$ $b_i^-(\gamma)$ measures how much group i is influenced by all its (direct and indirect) rivals.

  $\longrightarrow$ $b_i^+(\beta)$ measures how much group i is influenced by all its (direct and indirect) allies.

Context of DRC conflict - II

- Complex network of alliances
- Two major grand-alliances:
  1. Rwandan and Ugandan (US and UK supported) governments, anti-Angolan forces like UNITA and local Tutsi militias (RCL);
  2. Kabila's DRC government backed by local Mayi Mayi forces, Hutu militias and government troops from Zimbabwe, Angola, Namibia, Chad and Sudan
- Several localized conflicts involving only some actors, e.g., anti-Ugandan rebels from the Allied Democratic Forces and the Lord's Resistance Army fighting the Ugandan army

Summary Statistics

Table 1: Summary statistics.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Total Fighting	1190	5.23	22.72	0	300
Total Fighting of Enemies	1190	50.48	92.89	0	645
Total Fighting of Allies	1190	38.80	74.77	0	493
d^- (Number Enemies)	1190	2.61	3.59	0	20
d^+ (Number Allies)	1190	2.24	3.41	0	18
Foreign	1190	0.31	0.46	0	1
Government Organization	1190	0.20	0.40	0	1
Rain fall $(t-1)$	1190	125.35	26.36	58.02	197.35

Robustness Analysis

Non-classical measurement errors in Rainfall

- Local fighting could impact ground measures of rainfall. This would lead to non-classical measurement errors.
- Satellite measures of rainfall are imune. But they are less precise than ground measures (2.5 x 2.5 degree). So we cannot use them as IV.
- We take a different route: can we detect violence-induced measurement errors?

→ All Africa over 1998-2010.

→ Violence is measured with ACLED projected on a (0.5 x 0.5) grid.

$$GROUND_{k,t} = \alpha_0 \times SAT_{k,t} + \alpha_1 \times (SAT_{k,t} \times FIGHT_{k,t})$$

→ Test for $\hat{\alpha}_1 \stackrel{?}{=} 0$ (absence of violence-induced measurement errors).

Robustness Analysis

Non-classical measurement errors in Rainfall

Table 8: Measurement error in rainfall.

	Dependent variable: GPCC gauge rainfall measure							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
model	linear		log-linear		linear		log-linear	
# ACLED conflict events	0.017	0.008	0.009	0.001	-0.069	0.016	-0.016	0.005
	(0.032)	(0.012)	(0.008)	(0.003)	(0.057)	(0.014)	(0.014)	(0.004)
TRMM satellite rainfall measure	0.639***	0.513***	0.714***	0.619***				
	(0.018)	(0.012)	(0.015)	(0.013)				
GPCP satellite rainfall measure					0.790***	1.073***	0.843***	1.233***
					(0.044)	(0.081)	(0.055)	(0.100)
(0.5 x 0.5) Grid Cell FE	No	Yes	No	Yes	No	Yes	No	Yes
Annual TE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9893	9893	9893	9893	9893	9893	9893	9893
R-squared	0.578	0.667	0.604	0.684	0.555	0.601	0.541	0.587

Notes: An observation is a given cell of resolution 0.5 x 0.5 degrees in a given year. The panel contains 761 cells covering DRC between 1998 and 2010. In Columns 3,4,5,6 all rainfall variables are in log. Robust standard errors are clustered at the (0.5 x 0.5) cell level in Columns 1-4 and at the (2.5 x 2.5) cell level in Columns 5-8. Significance levels are indicated by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Robustness Analysis

Mismeasurement of links: Montecarlo

- Mismeasurement of links can lead to estimation biases toward attenuation **or** expansion (Chandrasekhar and Lewis, 2014)
- Monte Carlo approach: we rewire links in the observed network at random, and measure the robustness of our estimates in such perturbed networks
- We postulate a data generating process with $\beta = 0.14$ and $\gamma = 0.09$, and then we introduce noise in the measurement of network links
- Then, we estimate the model as if the econometrician did not know the true network, but had to infer it from data measured with error

Robustness Analysis

Mismeasurement of links: Montecarlo

Table 9: Monte Carlo simulations testing link mismeasurement.

Probability of mismeasurement		0		0.01		0.1		0.2		0.5		1	
		β	γ	β	γ	β	γ	β	γ	β	γ	β	γ
Enmity links only	Mean	0.141	0.091	0.141	0.089	0.141	0.074	0.140	0.061	0.144	0.027	0.143	0.001
	S.D.	0.001	0.002	0.003	0.007	0.006	0.017	0.009	0.026	0.012	0.032	0.007	0.019
Alliance links only	Mean	0.141	0.091	0.138	0.092	0.123	0.096	0.103	0.097	0.044	0.098	0.001	0.091
	S.D.	0.001	0.001	0.004	0.013	0.016	0.025	0.025	0.028	0.036	0.032	0.009	0.010
Alliance & Enmity links	Mean	0.141	0.091	0.139	0.091	0.126	0.080	0.106	0.065	0.044	0.023	0.001	-0.001
	S.D.	0.001	0.002	0.005	0.015	0.018	0.028	0.029	0.035	0.042	0.043	0.017	0.021

Notes: This table reports the Mean and Standard Deviations of the Monte Carlo sampling distributions (1000 draws) of the 2SLS estimates of β and γ for different probabilities of link mismeasurement. The data generating process is based on true $\beta = 0.14$ and true $\gamma = 0.09$.

Literature

- Generally linked to the literature on the economics of networks (cf. e.g. Jackson and Zenou 2014; Acemoglu and Ozdaglar 2011; Jackson 2008).
- Franke and Öztürk (2009): agents choose their fighting efforts to attack their neighbors. No alliances. Focus on (low scale) specific networks.
- Hiller (2012): a model of network formation where having more "friends" makes a player "stronger"
- Most previous work is theoretical.
- Exception: Acemoglu, Garcia-Jimeno and Robinson (2014) estimate a structural politico-economic model of public good provision using a network of Colombian municipalities.
- Key player analysis: Ballester et al. (2006), Liu *et al.* (2011), Lindquist and Zenou (2013). Focus is not on civil conflicts.

Centrality

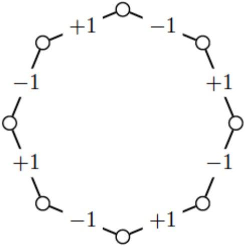
- Ignore for a moment the shifters ($\mathbf{Z}_{it} = e_i = \varepsilon_{it} = 0$).
- Solving for the fixed-point yields a closed form characterization of the equilibrium fighting efforts

$$\mathbf{x}^* \approx \mathbf{c}$$

  where centrality $\mathbf{c}$ is a linear combination of the Bonacich centralities $(\mathbf{b}^-, \mathbf{b}^+)$ attached to each submatrix $\mathbf{A}^-$ and $\mathbf{A}^+$
- In our contest game each Bonacich centrality gauges the network multiplier effect attached to rivalries or alliances.
  - $\longrightarrow$ $b_i^-(\gamma)$ measures how much group i is influenced by all its (direct and indirect) rivals.
  - $\longrightarrow$ $b_i^+(\beta)$ measures how much group i is influenced by all its (odd vs even) allies.

Theoretical Example - Regular Graph

- A *regular graph*, is a symmetric graph where each group has d^+ allied and d^- rivals



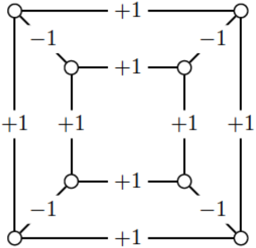


Figure: The figure shows two examples for regular graphs.

- Simple closed-form characterization of the Nash Equilibrium

Theoretical Example - Regular Graph

- The (symmetric) solution yields:

$$x_i^* = x^* = \frac{n - (1 + \beta d^+ - \gamma d^-)}{n(1 + \beta d^+ - \gamma d^-)} \times \frac{V}{n}$$

$$\pi_i^* = \pi^* = \left(\frac{1}{n} + \frac{\beta d^+ - \gamma d^-}{1 + \beta d^+ - \gamma d^-} \right) \times \frac{V}{n}$$

- Two special cases of interest:

1. "Harmonious society" [Rousseau]: $d^+ = n - 1$ and $\beta \to 1$
$\Rightarrow x^* = 0$ and $\pi^* = V/n$. No rent dissipation!
2. "Homo homini lupus" [Hobbes]:
$d^- = n - 1$ and $\gamma \to 1/\left(n^2 - 1\right)$
$\Rightarrow x^* \to V/n$ and $\pi^* \to 0$. Full rent dissipation!

- The model spans from totally destructive anarchy to a peaceful sharing without any rent dissipation.

Exogenous Network Changes

- Many local sub-conflicts
  (North Kivu, South Kivu, Uganda-Rwanda, Ituri, LRA-Uganda, Angola MPLA-UNITA, various local rebellions)
- Not all subconflicts are hot at the same time.
  Many groups are only active in subperiods.
- Baseline: when a group is not active, its effort level is zero.
- Alternative: Unbalanced sample with an exogenous time-invarying network (using an iterative procedure)

$$x_{i,t}^* = -\beta \sum_j a_{ij}^+ x_{j,t}^* + \gamma \sum_j a_{ij}^- x_{j,t}^* - \underbrace{\mathbf{Z}_{it}\delta}_{\text{OBS.}} + \underbrace{\frac{\Lambda^{\beta,\gamma}(G)\left(1-\Lambda^{\beta,\gamma}(G)\right)V}{1+\beta d_{i,t}^+ - \gamma d_{i,t}^-}}_{\text{TIME-VAR. NETWORK}} - \underbrace{e_i}_{\text{FE}} - \varepsilon_{it}$$