Environmental Impacts of Violent Conflict:

Evidence from the paramilitary expansion in Colombia

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Outline

Research questions

- What are the environmental implications of violent conflict? (Today)
- What channels explain the relationship between conflict and environmental distress? (Ongoing work)

This paper

- Case of Colombia
- Dependent variable: Forest cover from 1990 to 2010
- Two empirical strategies:
  1. Panel regressions with municipality fixed effects and differential trends parametrized as functions of municipality characteristics.
  2. Exploit a natural experiment: expansion of the paramilitaries in the late 1990s after creation of AUC
     - Constituted a dramatic increase in conflict activity

Theory

Ambiguous effect of conflict on deforestation *a priori*

- Conflict may stop deforestation: it disrupts economic activity, and makes the forest (even more) impenetrable.
- But conflict may also lead to deforestation...
  1. Increases incidence of illegal crops.
  2. In Colombia, may be linked to transition to extensive agriculture.
  3. Increases internal forced displacement, which may push population to frontier lands (and also open lands for extensive agriculture and cattle herding).

$\Rightarrow$ Effect of conflict on deforestation is an empirical question

Our contribution [RESULTS]

- "Reduced-form": effect of paramilitary activity on deforestation [POSITIVE]
- Explore mechanisms (ongoing work):
  - Forced displacement [YES]
  - Coca crops [?]
  - Extensive agriculture (oil palm) [?]
  - Cattle herding, mining [?].

Related literature

- Large body of empirical papers examines link conflict-environment, **But**:
  1. Most use cross-country data:
     - → Finding an instrument to address endogeneity concerns is challenging
  2. Most look at the other direction of causality: environment → conflict
     - E.g recent special issue of *Journal of Peace Research*
     - Plus similar methodological shortcomings (e.g Homer-Dixon 1991, 1999)
- We address these concerns:
  - Look at sub-national variation
  - Solve endogeneity problems
  - Look at relationship: conflict → environment
  - + a BONUS: Disentangle channels

Empirical strategy I

Panel regressions

$$forest_{m,t} = \beta_1 Para_{m,t} + \beta_2 X_{m,t} + \delta_m + \delta_t + \epsilon_{m,t}$$

- $forest_{m,t}$ is the ratio of forest to total area in municipality m at time t (=1990, 2000, 2005, 2010)
- $Para_{m,t}$ are alternative measures of paramilitary presence or actions (attacks) in municipality m during the years leading up to period t
  - Check robustness to alternative time-windows
- $X_{m,t}$ are time varying, municipal-specific controls
- δ_m and δ_t are municipality and time fixed effects respectively

Empirical strategy I

Panel: robustness

- We can also include differential time trends depending on fixed characteristics of municipalities (like the presence of natural resources, e.g. oil or gold; presence of protected areas; initial socio-economic indicators)

$$forest_{m,t} = \beta_1 Para_{m,t} + \beta_2 X_{m,t} + \delta_m + \delta_t + \sum_t \kappa'_m \bar{\omega}_t + \epsilon_{m,t},$$

- where κ_m are time invariant characteristics of municipality m and $\bar{\omega}_t = 1$ in year t.

Empirical strategy II

IV specification

- Potential omitted factors that can affect
  - Paramilitary activity
  - Deforestation

→ We instrument paramilitary activity

  - Distance from every municipality to Córdoba, epicenter of the paramilitary expansion in the second half of the 1990s
  - Geography-based fixed municipality characteristic unlikely to affect changes in forest cover

- First stage:

$$Para_m = \gamma_1 Dist_m + \gamma_2 X_m + v_m$$

- Second stage:

$$forest_m = \rho_1 \widehat{Para_m} + \rho_2 X_m + u_m$$

Empirical strategy

Estimation of potential channels

- Explore potential mediating mechanisms
- Run "twin" specifications of the form:

$$forest_{m,t} = \bar{\beta}_1 Channel_{m,t} + \bar{\beta}_2 X_{m,t} + \delta_m + \delta_t + \psi_{m,t}$$

$$Channel_{m,t} = \bar{\gamma}_1 Para_{m,t} + \bar{\gamma}_2 X_{m,t} + \delta_m + \delta_t + u_{m,t}$$

- $Channel_{m,t}$ is:
  - Coca cultivation
  - Forced displacement
  - Extensive agriculture (Oil palm)
  - Cattle herding
  - Mining.

Data

Treatment and mechanisms

- **Conflict data:**
  - Event-based, 1988-2009. Each event records type, date, location, perpetrator, and victims.
  - Source: CERAC/URosario
- **Forced displacement:**
  - Inflows and outflows
  - Source: *Acción Social*
- **Coca cultivation:**
  - Satellite-based amount of land with coca bushes (since 1999 by municipality)
    - Source UNODC
- **Cultivation of oil palm:**
  - Number of hectares
    - Source FEDEPALMA

Data

Dependent variable

- **Forest cover:** Satellite-based images on forest cover at the municipal level, for the entire country
  - Four observations: 1990, 2000, 2005 and 2010.
  - Source: IDEAM/Moore Foundation

Descriptive Statistics

Table: Aggregate net forest change 1990-2000

	1990		2000		2005		2010	
	Km^2	%	Km^2	%	Km^2	%	Km^2	%
Forest	643,757	56.5	617,460	54.2	601,494	52.8	585,842	51.4
No Forest	471,236	41.3	500,613	43.9	508,703	44.6	516,356	45.3
No Information	24,904	2.2	21,823	1.9	29,664	2.6	37,662	3.3

Descriptive Statistics

Table: Municipal net forest change 1990-2000

		1990		2000		2005		2010	
		Level	Weighted	Level	Weighted	Level	Weighted	Level	Weighted
Forest	Mean	26.7	56.4	24.6	54.1	23	52.7	21.1	51.4
	Min	0	0	0	0	0	0	0	0
	Max	99	99	98.5	98.5	98	98	98.3	98.3
No Forest	Mean	70.6	41.3	73.3	43.9	74.1	44.6	73.8	45.3
	Min	0.3	0.3	1.3	1.3	0.7	0.7	1.4	1.4
	Max	100	100	100	100	100	100	100	100
No Information	Mean	2.7	2.2	2.1	1.9	2.9	2.6	5.2	3.3
	Min	0	0	0	0	0	0	0	0
	Max	79.4	79.4	59.8	59.8	68.5	68.5	52.1	52.1

Descriptive Statistics

Table: Inter period municipal deforestation and regeneration rates

		1990-2000	2000-2005	2005-2010
Deforestation	Mean	17.6	11.5	12.3
	Min	0	0	0
	Max	100	100	100
Regeneration	Mean	5.78	9.60	1.90
	Min	0	0	0
	Max	3.6	14.8	2.2

Baseline Results

Table: Effect of paramilitary activity on forest cover: 1990-2010 - OLS

	Dependent variable: *Forest cover*				
	(1)	(2)	(3)	(4)	(5)
Panel A: One Year Lag					
Paramilitary Attacks	0.0165*	0.0238***	0.0247***	0.0178**	-0.00419*
	(0.00883)	(0.00858)	(0.00870)	(0.00841)	(0.00228)
R-squared	0.001	0.003	0.003	0.323	0.371
...					
Panel E: Average Five Year Lag					
Paramilitary Attacks	0.0506***	0.0778***	0.0785***	0.0218	-0.0206***
	(0.0177)	(0.0188)	(0.0189)	(0.0157)	(0.00549)
R-squared	0.002	0.006	0.007	0.323	0.376
Controls					
Population		Yes	Yes	Yes	Yes
Year fixed effects			Yes	Yes	Yes
Geography				Yes	Yes
Municip. fixed effects.					Yes

Baseline Results in the Cross Sections I

Table: Cross-sectional effect of paramilitary activity on forest cover (one year lag)

Dependent variable: *Forest cover*			
	(1)	(2)	(3)
Panel A: 1990			
Paramilitary Attacks	0.00274	0.0197	-0.00215
	(0.0335)	(0.0335)	(0.0308)
R-squared	0.000	0.001	0.299
Panel B: 2000			
Paramilitary Attacks	0.0132	0.0223**	0.0198**
	(0.00954)	(0.00907)	(0.00901)
R-squared	0.001	0.005	0.327
Controls			
Population		Yes	Yes
Geography			Yes
Observations	1,116	1,082	1,013

Baseline Results in the Cross Sections II

Table: Cross-sectional effect of paramilitary activity on forest cover (one year lag)

Dependent variable: *Forest cover*			
	(1)	(2)	(3)
Panel C: 2005			
Paramilitary Attacks	0.0311*	0.0356*	0.000728
	(0.0183)	(0.0183)	(0.0179)
R-squared	0.002	0.004	0.356
Panel D: 2010			
Paramilitary Attacks	0.0632	0.0674	0.00108
	(0.0490)	(0.0488)	(0.0347)
R-squared	0.002	0.003	0.369
Controls			
Population		Yes	Yes
Geography			Yes
Observations	1,116	1,082	1,013

Instrumental Variables

Pre-Peace Process

Table: Cross-sectional effect of paramilitary activity on forest cover – IV: 1990 & 2000

Dependent variable: *Forest cover*		
	(1)	(2)
	1990	2000
Panel A: One Year Lag		
Second stage		
Paramilitary Attacks	-3.063*	-0.455***
	(1.679)	(0.157)
First stage		
Distance to Monteria	-7.41e-05*	-0.000411***
	(3.67e-05)	(0.000114)
Controls		
Population	Yes	Yes
Geography	Yes	Yes
Observations	1,013	1,013

Instrumental Variables

Post-Peace Process

Table: Cross-sectional effect of paramilitary activity on forest cover – IV: 2005 & 2010

Dependent variable: *Forest cover*		
	(3)	(4)
	2005	2010
Panel A: One Year Lag		
Second stage		
Paramilitary Attacks	-8.533	-4.847
	(27.32)	(7.998)
First stage		
Distance to Monteria	-1.86e-05	-2.65e-05
	(5.96e-05)	(4.31e-05)
Controls		
Population	Yes	Yes
Geography	Yes	Yes
Observations	1,013	1,013

Size of the effects

- Take the panel estimation for 5 years-lag: a one-standard deviation increase in paramilitary attacks leads to a reduction in forest cover by almost 1.5 percentage points (0.68*0.021).
- Take the most conservative IV estimation from 2000: similar increase in paramilitary attacks leads to a fall of 30 percentage points!

Conclusions

- What are the environmental implications of violent conflict?
- Most of the empirical literature is cross country, focuses on the opposite direction of causality, and does not explore the mechanisms
- In this paper we address these issues
  - Uses paramilitary expansion in Colombia as natural experiment of conflict upsurge
- Main result: paramilitary forces reduced the share of forest cover in Colombian municipalities
  - Robust to the inclusion of a rich set of controls and time and cross-sectional fixed effects, and IV
- Main channel thus far seems to be forced displacement
- But more to do on this front
- Findings are very policy relevant

Thanks!
(Y perdón for the spanglish)