DETERring Deforestation in the Brazilian Amazon
Environmental Monitoring and Law Enforcement

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Agenda

- Introduction
- Institutional context
- Methodology
- Key findings
- Policy implications
- CPI Rio projects
- Q&A
Introduction | The Brazilian Amazon

- The Brazilian Amazon
  - 4 million km²
    - 80% remains covered by native vegetation
  - 20% of planet’s fresh water
  - Unique biodiversity
  - Carbon sink

... combating illegal deforestation is an immense challenge!
Introduction | The Brazilian Amazon

Annual Amazon Deforestation Rate

- agricultural output prices
- conservation policies

<table>
<thead>
<tr>
<th>Year</th>
<th>Deforestation Rate (thousand km²)</th>
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<tbody>
<tr>
<td>2002</td>
<td>20</td>
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<tr>
<td>2003</td>
<td>25</td>
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<td>2011</td>
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</tbody>
</table>
Introduction | This Study

- Main question
  - What role did monitoring and law enforcement play in the recent deforestation slowdown?

- Our approach
  - Empirical regression-based analysis
    - Sample: 526 Amazon municipalities from 2007 through 2011
  - Explore policy implementation details to assess policy effectiveness
    - Satellite-based targeting of monitoring and law enforcement
Introduction | This Study

- **Main findings**
  - Large deterrent effect of monitoring and law enforcement
    - 2007-2011: preserved over 59,500 km² of Amazon forest
  - Estimated monetary benefits are larger than costs
  - Forest preservation occurred at no apparent cost to local agricultural production

- **Monitoring and law enforcement policy**

  effective & low-cost

  monetary agricultural
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Institutional Context | What is Ibama?

- Brazilian Institute for the Environment and Renewable Natural Resources [Ibama]
  - Environmental monitoring and law enforcement authority
  - Police force
  - Investigation of environmental infractions
  - Sanctioning of environmental crimes
Institutional Context | Policy Change

- Pivotal conservation effort of 2000s
  - Plan for the Prevention and Control of Deforestation in the Amazon [PPCDAm]

- Stricter monitoring and law enforcement
  - Real-Time System for Detection of Deforestation [DETER]
    - Satellite-based real-time monitoring
Institutional Context | How DETER Works

National Institute for Space Research + Remote Sensing Center
Institutional Context | How DETER Works

before

after
Institutional Context | How DETER Works
Institutional Context | How DETER Works

National Institute for Space Research

Remote Censing Center
Institutional Context | How DETER Works

- Targeting before DETER
  - Voluntary reports of deforestation activity

- Targeting after DETER
  - Satellite imagery: 3-day intervals, year-round
  - More timely law enforcement action

... **significant improvement** in Amazon monitoring and law enforcement capability

- DETER is incapable of capturing land cover patterns beneath cloud coverage
Institutional Context | How DETER Works

Jan 2011

Apr 2011

Jul 2011

Oct 2011
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A Word on Methodology

- Goal: identify **causal effect** of Ibama’s presence on deforestation activity
  - Environmental fines as measure of Ibama’s presence

- Challenge: address **two-way causality**

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monitoring and law enforcement ↔ deforestation
```
A Word on Methodology

- Use DETER cloud coverage as source of exogenous variation in law enforcement
  - What does this mean?
  - For a given area, systematically:
    - Greater DETER cloud coverage
      - Lower chance of DETER issuing alert
      - Lower chance of Ibama targeting the area
      - Lower intensity of monitoring and law enforcement

... unrelated to deforestation!
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Results | Key Findings

- DETER cloud coverage affects Ibama’s presence
  - Lower cloud coverage leads to greater number of fines

- Ibama’s presence affects deforestation activity
  - Greater number of fines in current year leads to lower deforestation in following year
  - Deterrent effect dissipates over time
Results | What Does This Mean?

- What if Amazon monitoring and law enforcement capability had not improved starting in 2004?

![Graph showing deforestation (thousand km²) with observed and estimated values]

- **Total deforestation, 2007-2011**
  - Observed: 59.5 thousand km²
  - Estimated: 101.1 thousand km²
Results | What Does This Mean?

- What if Amazon monitoring and law enforcement had been entirely inactive?

![Bar graph showing total deforestation, 2007-2011](image)
Results | What Does This Mean?

- Simulation 1: 59,500 km²
  - $\approx \frac{2}{3}$ area of Portugal

- Simulation 2: 122,000 km²
  - $\approx$ area of Nicaragua
  - Avoided emissions equivalency: 900 million tCO₂ per year
    - $\frac{1}{2}$ US 2011 transport sector emissions
    - 2.5–3 times average annual emissions savings from European renewables sector
Results | Worth It?

- **Cost-benefit analysis**

  - 24,500 km\(^2\)
    - average forest area preserved per year
  
  - 900 million tCO\(_2\)
    - avoided emissions per year

  - 560 million USD
    - 125 million USD annual budgets for Ibama and INPE
  
  - 685 million USD
    - annual budget for Amazon monitoring and law enforcement

  - 5 USD/tCO\(_2\)
    - common current price of carbon
  
  - 0.76 USD/tCO\(_2\)
    - break-even price of carbon

  **low monetary cost**
Results | Key Findings

- Tradeoff between economic growth and preservation?

- Ibama’s presence does not affect local agricultural production
  - Greater number of fines has no impact on local agricultural GDP or crop production

  **low agricultural cost**
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Policy Implications

- Maintain Amazon monitoring and law enforcement efforts
  - Strong deterrent effect at relatively low cost
  - Need for continuous policy action
  - Complementary nature of other conservation policies

- Promote strategic use of technology and information
  - Improve monitoring technology
  - Further enhance law enforcement capability
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CPI Rio Projects | Land Use

- **Deforestation**
  - **Prices or policies?**
    - *Conditional rural credit*
    - *Monitoring and law enforcement*
    - Net impact of protected areas
  - Socioeconomic impact of conservation policies
  - Forest clearing behavior

- **Agriculture**
  - Enhanced productivity
    - Technological adoption
    - Insurance for rural producers
Questions?

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for full paper and executive summary, click here