Conservation impact evaluation using remotely sensed data

Alberto Garcia and Robert Heilmayr

Conservation Economics Lab, University of California, Santa Barbara

Background

Question

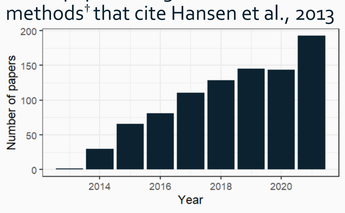
Does applying standard econometric methods to remotely sensed data generate accurate estimates of the impacts of conservation policies?

Setting

How does ____ affect deforestation?

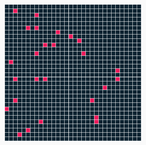
- **Protected areas**
  Herrera, Pfaff and Robalino, 2019
- **Conflict**
  Prem, Saavedra and Vargas, 2020
- **Property registration**
  Alix-Garcia et al., 2018
- **Supply chain commitments**
  Heilmayr et al., 2020

>1000 papers using econometric methods† that cite Hansen et al., 2013



To quantify impact, we often build econometric models that compare observed deforestation, against an unknowable counterfactual:

What happened with the policy: $y_i(1)$



Potential outcome of what would've happened without the policy: $y_i(0)$

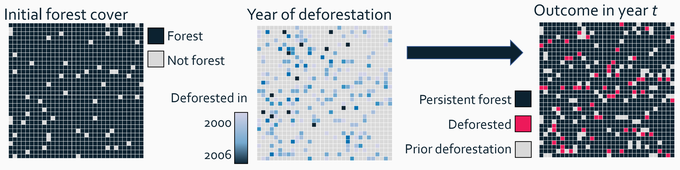
The pixel-level *treatment effect* can be expressed as:

$$E_i = y_i(1) - y_i(0)$$

We want to measure the Average Treatment Effect on the Treated (ATT):

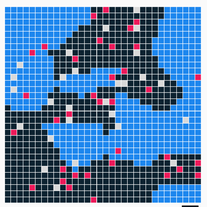
$$ATT = \frac{1}{n_{i:D_i=1}} \sum_{i;D_i=1}^{N} y_i(1) - y_i(0)$$

But remotely sensed observations of deforestation are often binary and irreversible, which is different from typical outcome variables. Prior literature hasn't grappled with how this might bias our estimates.



Methods

- Simulate landscapes with data structure similar to common remotely sensed data products (e.g. Hansen et al., 2013)
- Introduce a policy with a pre-defined impact, ATT
- Run candidate econometric models to estimate $\widehat{ATT}$
- Repeat 1,000 times with new landscapes
- Calculate average bias, root mean square error, and coverage for each candidate model



Allows us to compare commonly used models such as:

Difference in differences (DID) regression:

$$y_{i,t} = \beta_{DID} \times D_i \times T_t + \gamma D_i + \eta T_t + \mu_{i,t}$$

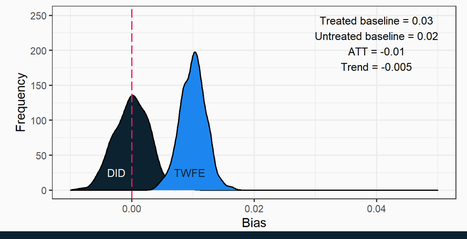
Two-way, fixed effects regression (Generalized difference in differences):

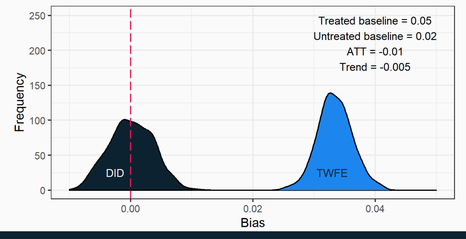
$$y_{i,t} = \beta_{TWFE} \times D_i \times T_t + \gamma_i + \eta_t + \mu_{i,t}$$

Results

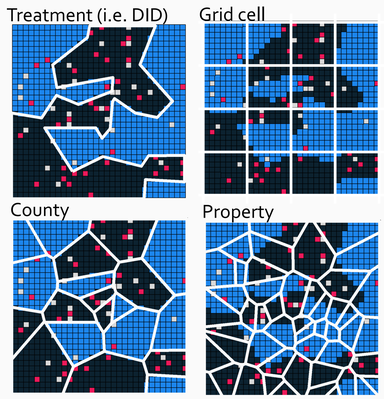
Pixel-level, two way fixed effects model is biased

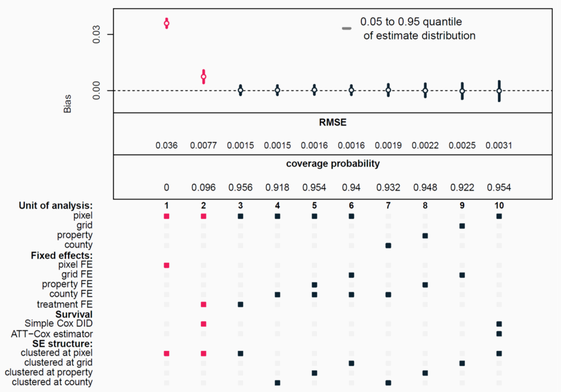
$$\hat{\beta}_{TWFE} = \left(\frac{1}{n_{i:D_i=1}} \sum_{i;D_i=1}^{N} y_{i,2}(1) - y_{i,2}(0)\right) + \left(\frac{1}{n_{i:D_i=1}} \sum_{i;D_i=1}^{N} y_{i,2}(0) - \frac{1}{n_{i:D_i=1}} \sum_{i;D_i=1}^{N} y_{i,2}(0)\right) = ATT + \text{Baseline difference in deforestation}$$





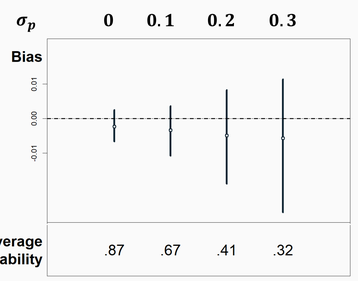
Aggregation can correct for bias

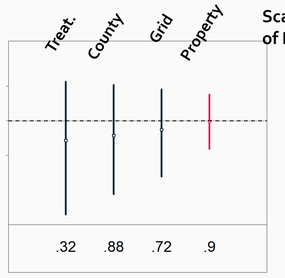




Best models match the scale of land use decisionmaking

Increasing property-level disturbances erode DID model performance

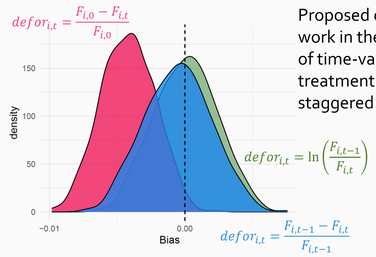




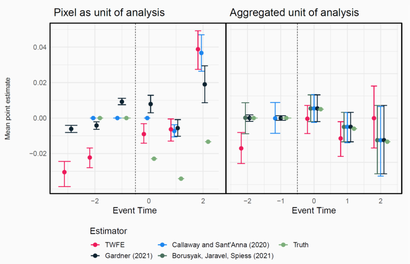
Matching unit of observation to scale of heterogeneity can recover less biased estimates

Extensions

If aggregating observations, need to think carefully about how deforestation rates are calculated



Proposed corrections work in the presence of time-varying treatment effects and staggered adoption



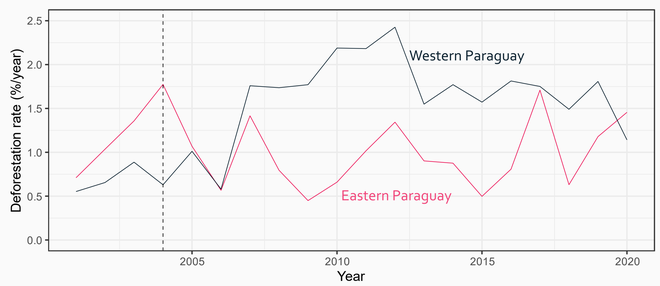
Application

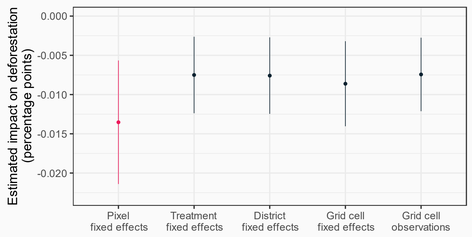
Question

How much has Paraguay's Zero Deforestation Law slowed deforestation in Eastern Paraguay?

Bias is relevant in practice

In 2004, Paraguay adopted its Zero Deforestation Law, prohibiting further clearing of forests in Eastern Paraguay. Although this is one of the first public, zero-deforestation laws, little is known about its impact.





Pixel-level fixed effects model yields effect sizes that are ~80% greater than other models. Likely represents bias in. In other projects, we've seen the direction of effect flip signs.

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Paper

Acknowledgements

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