More than just carbon: the socioeconomic co-benefits of large scale tree planting

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Overview

Motivation

Preservation and restoration of biodiversity and ecosystem services is fundamental for a sustainable economic development trajectory (Dasgupta 2021)

Large-scale tree planting could jointly address poverty and environmental concerns in developing countries and align:

- **Climate mitigation** (sequestering carbon) (Bastin et al. 2019; Griscom et al. 2017; Lewis et al. 2019)
- Climate adaptation (possibly reduce floods and landslides) (Tan-Soo et al. 2016; Van Noordwijk, Tanika, and Lusiana 2016)
- **Poverty reduction** (through job creation and asset transfers)

Philippines National Greening Program (NGP)

Established in 2011, goals:

- **1.5 billion trees in 1.5 Mha of land**
  - → 2011-2016: planted 1.6 Mha of land with over 1.4 billion trees, employed ~ 550.000 people
- **Poverty reduction** (food security, ecosystem services)

Local People's Organisations:

- **payments** for preparing, implementing and maintaining the projects
- receive all profits from the plantations
- agroforestry assets are transferred to POs

Research Questions

1. Was the NGP effective in increasing forest cover?
2. Did the NGP **reduce poverty**?
    - Were there spillover effects into surrounding villages?
    - What was the impact derived from the asset transfer (trees) and the preparation/maintenance payments?
3. Did the NGP induce any **sectoral or labor reallocation**?
4. What are the **carbon sequestration benefits** of the NGP?
    - How much CO2 was sequestered ?
    - Economic value of reducing CO2 emissions through NGP?

Preview of Paper

Exploit the staggered roll-out of the NGP by comparing earlier and later treated cohorts

Main Findings:

- 4% increase in forest cover
- **6 p.p. reduction in poverty and 8 p.p. decrease in the share of unlit settlements** (7 p.p. at the village level, significant spillovers)
- Reduction in agricultural employment and increases in unskilled manual labor and services
- No effect on labor supply (population change) → NGP created economic activity
- Cost efficient carbon sequestration

National Greening Program

National Greening Program

The Philippines have seen **continued forest loss** since the 1930s

- From 2000 - 2022, lost 1.42 million hectares of tree cover, equivalent to a 7.6 percent decrease or 848 MtCO2

NGP launched in 2011 as an executive order to plant billions of trees across the Philippines

- Budget of 31 billion PHP (~$721m), sought to plant 1.5 billion seedlings across 1.5 million hectares from 2011 - 2016
- Tree planting happens on **degraded forestlands, mangrove and protected areas** and other suitable lands

People’s Organizations

The DENR forms partnerships with People’s Organizations (local associations / cooperatives)

- They receive **payments** for their role in
  - → preparing the sites
  - → planting seedlings,
  - → maintaining and implementing protective measures for 3 years
- **All profits** generated from the plantation are directed towards the implementing PO
- Survival rate goal was 85% → from 2011 to 2016 the **survival rate was 83%**

Data

Data: National Greening Program

Data on 80,522 individual tree planting projects:

- Information on when a municipality/village received treatment
- How many hectares were planted, commodity type and species planted

Year taken: 2017

Year taken: 2020

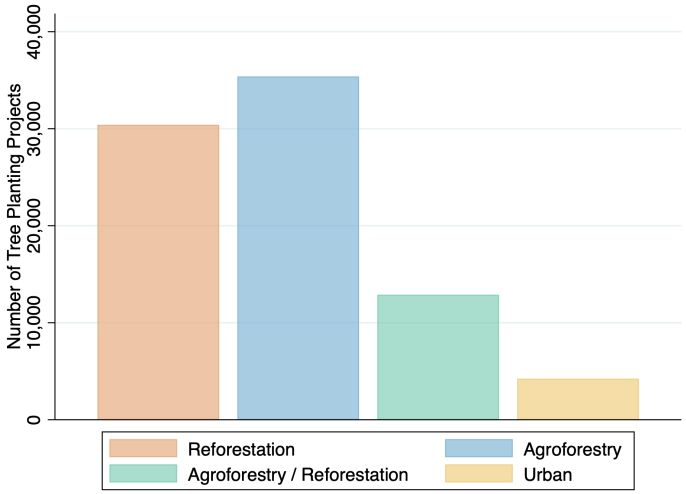
Location: Bataan, Pilar, Wawa
Area of the site: 2 has.
Site Code: 17-030804-0048-0002
Species Planted: Bakauan lalaki & Bakauan babae
Year Planted: 2017
Name of Partner: Nagkakaisang Samahang Magdaragat ng Camachile (NASAMACA)

Year taken: 2014

Year taken: 2023

Location: Davao de Oro, Monkayo, Barangay Tubo-tubo
Area of the site: _2_ ha
Site Code: 12-118207-1191-0002
Species Planted: Falcata_
Year Planted: 20_12_
Name of Partner: Barangay Tribal Council of Elders and Leaders of Tubo-tubo (BTCEL Tubo-tubo)

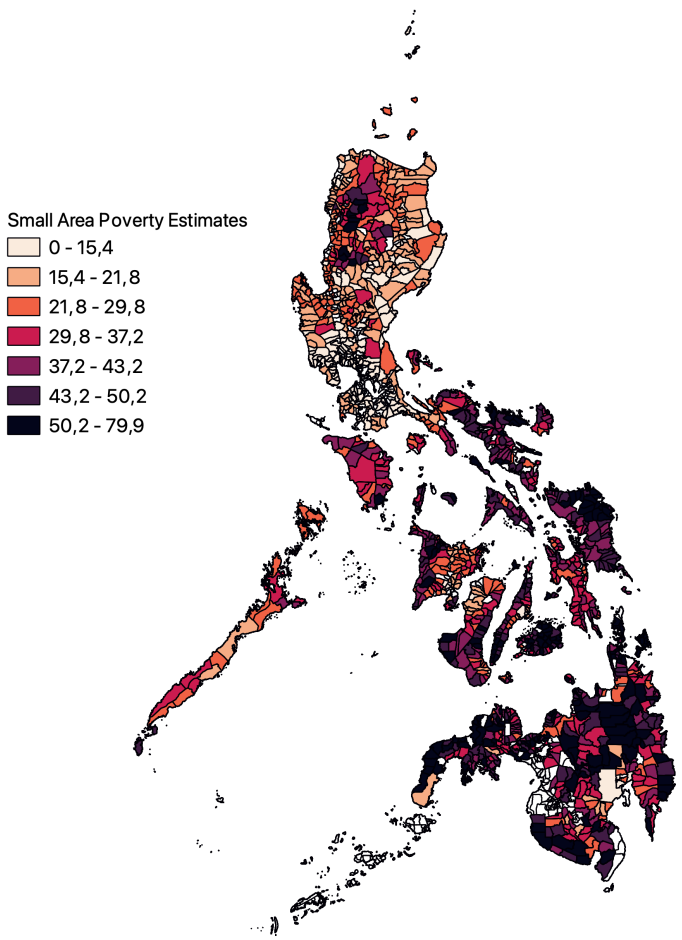
Data: National Greening Program



NATIONAL GREENING PROGRAM ACCOMPLISHMENT REPORT

Year	Target Area	Area Planted	Seedlings Planted	Employed
2011	100,000	128,558	89,624,121	47,868
2012	200,000	221,763	125,596,730	55,146
2013	300,000	333,160	182,548,862	65,198
2014	300,000	334,302	205,414,639	152,008
2015	350,000	360,357	351,014,239	123,519
2016	247,683	284,089	415,564,211	114,584
NGP	1,497,683	1,662,229	1,369,762,802	558,323

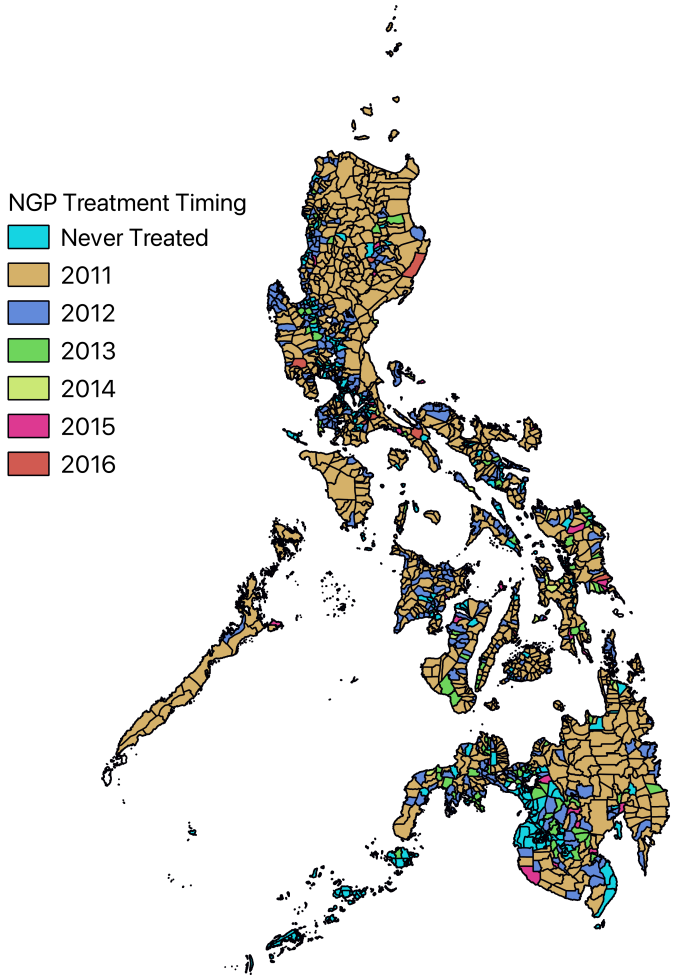
Data: municipality level



Municipality level dataset:

- Availability of Small Area Poverty Estimates from PSA
- Percentage of households that fall below the poverty threshold
- DHS data on individual employment for 2008 and 2017
- Climatic controls (Terraclimate)
- Landcover data from ESA

Data: municipality level

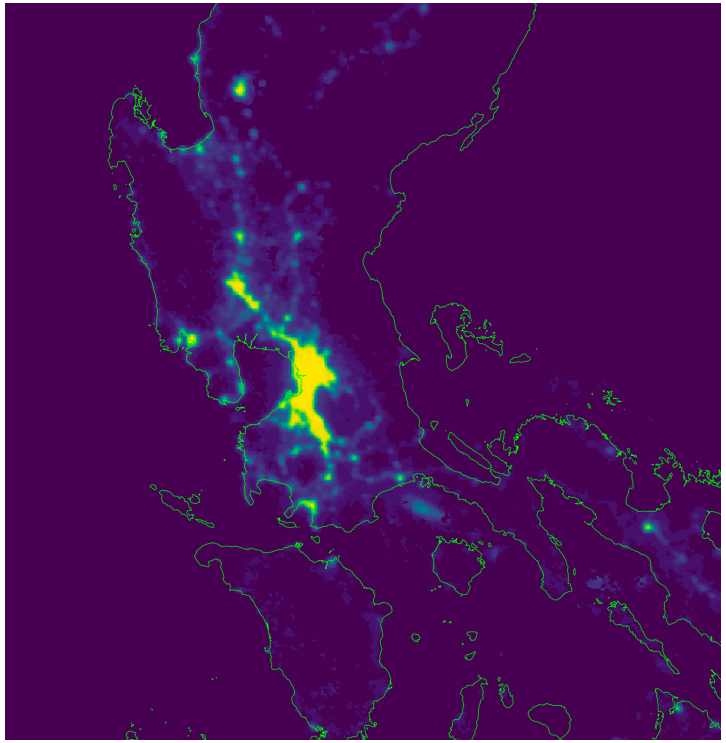


NGP Timing by Treatment Pool

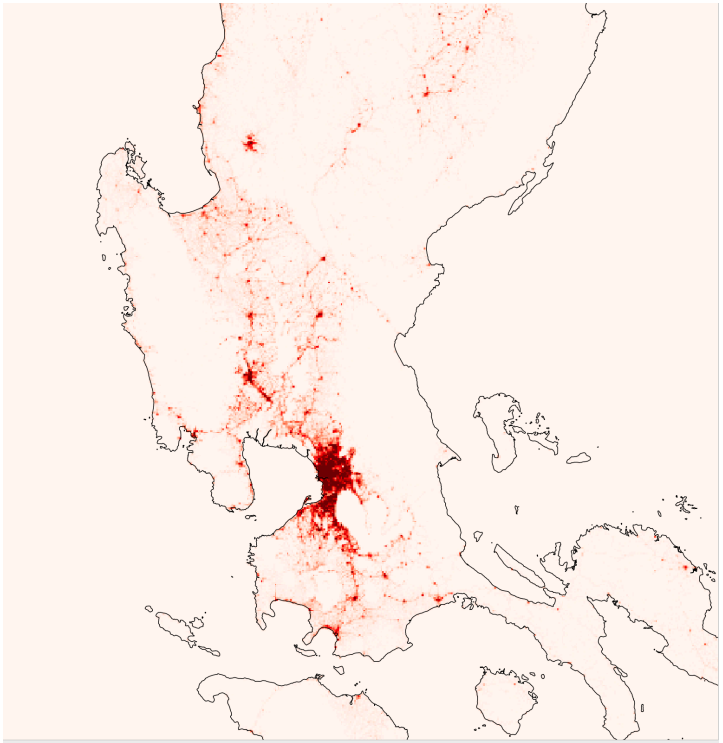
Timing	Frequency	Percent	Cumulative
Never Treated	322	19.77	19.77
2011	837	51.38	71.15
2012	301	18.48	89.63
2013	99	6.08	95.7
2014	27	1.66	97.36
2015	31	1.9	99.26
2016	12	0.74	100
Total	1,629	100	100

Measuring extreme poverty at the village level

We create the first time series of the percentage of settlements associated with no nighttime radiance, extending work by McCallum et al. (2022)

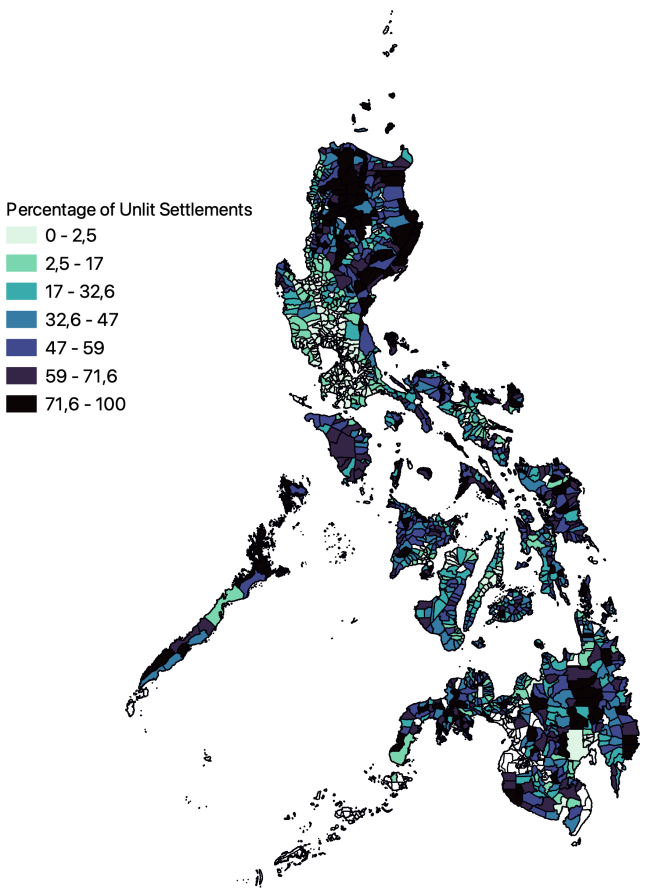


Harmonised NTL (Li et al. 2020)



Global Human Settlement Layer 2010

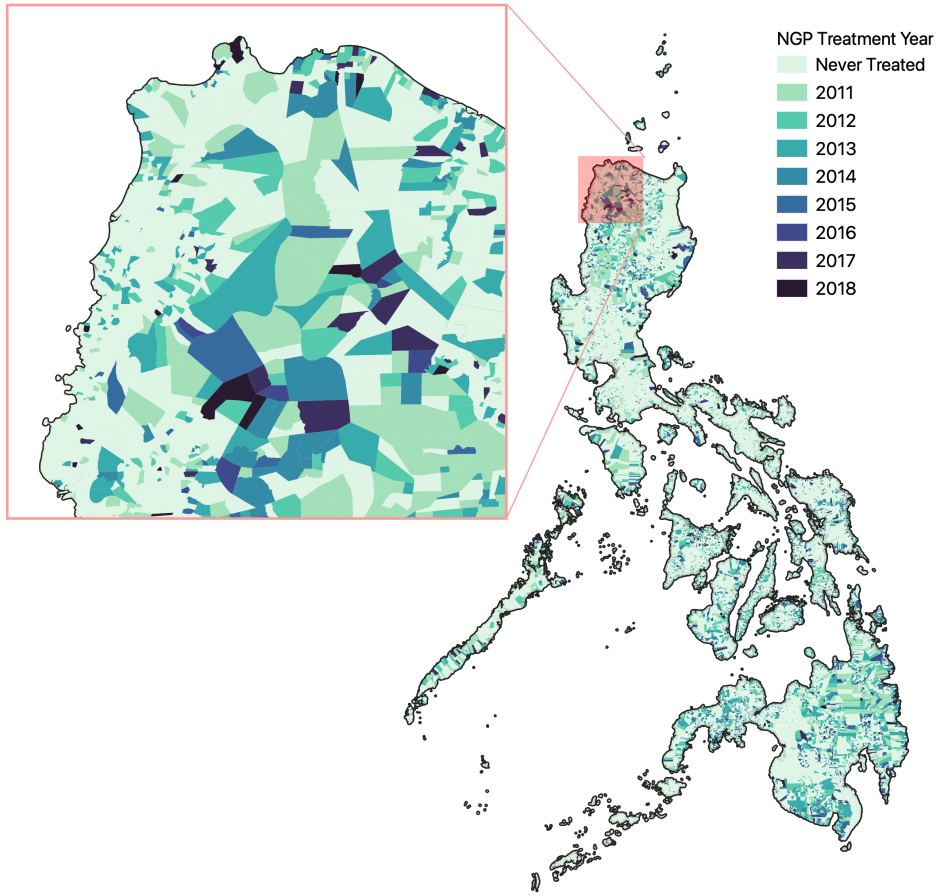
Data: village level



Village-level dataset:

- **Unlit settlements**
- Climatic controls (Terraclimate)
- Landcover data from ESA
- Sparser treatment status
  - → Spatial spillovers?

Data: village level



Village Level NGP Timing by Treatment Pool

Timing	Frequency	Percent	Cumulative
Never Treated	32,472	78.75	78.75
2011	2,523	6.11	84.87
2012	2,427	5.89	89.24
2013	1,803	4.37	93.54
2014	721	1.75	95.26
2015	909	2.20	97.43
2016	378	0.92	100
Total	41,233	100	100

Empirics

Empirics

- Staggered roll-out: **dynamic DID** à la Callaway and Sant'Anna (2021)
- Outcome $Y_{m,t}$ is estimated separately for the log of forest cover, small area poverty estimates, and the share of unlit settlements m at time t.
- We aggregate the coefficient of interest β_ϕ in an event study-type ATT plot for each outcome

  → Doubly robust standard errors following Sant'Anna and Zhao (2020) clustered at the municipality level

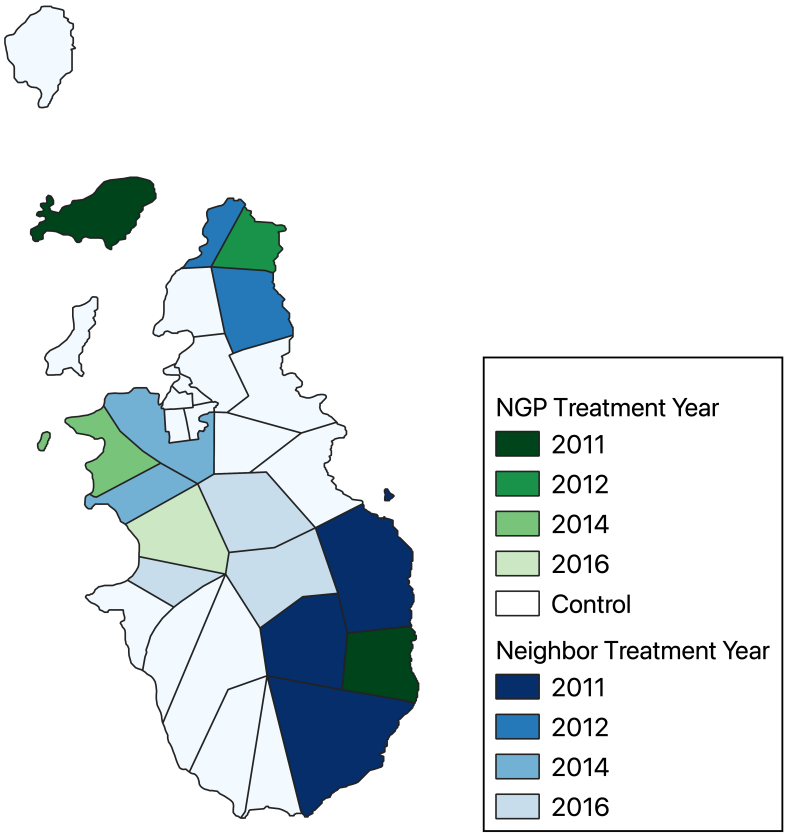
Empirics

Replicate the main dynamic DID specification for the percentage unlit settlements at the village level

Estimate spatial spillovers:

- Ferraro and Simorangkir (2020): whether a never treated village shares an administrative boundary with a treated village (contiguity)
- Adopt similar strategy within dynamic DID framework to assess whether economic activity spills over into neighboring villages

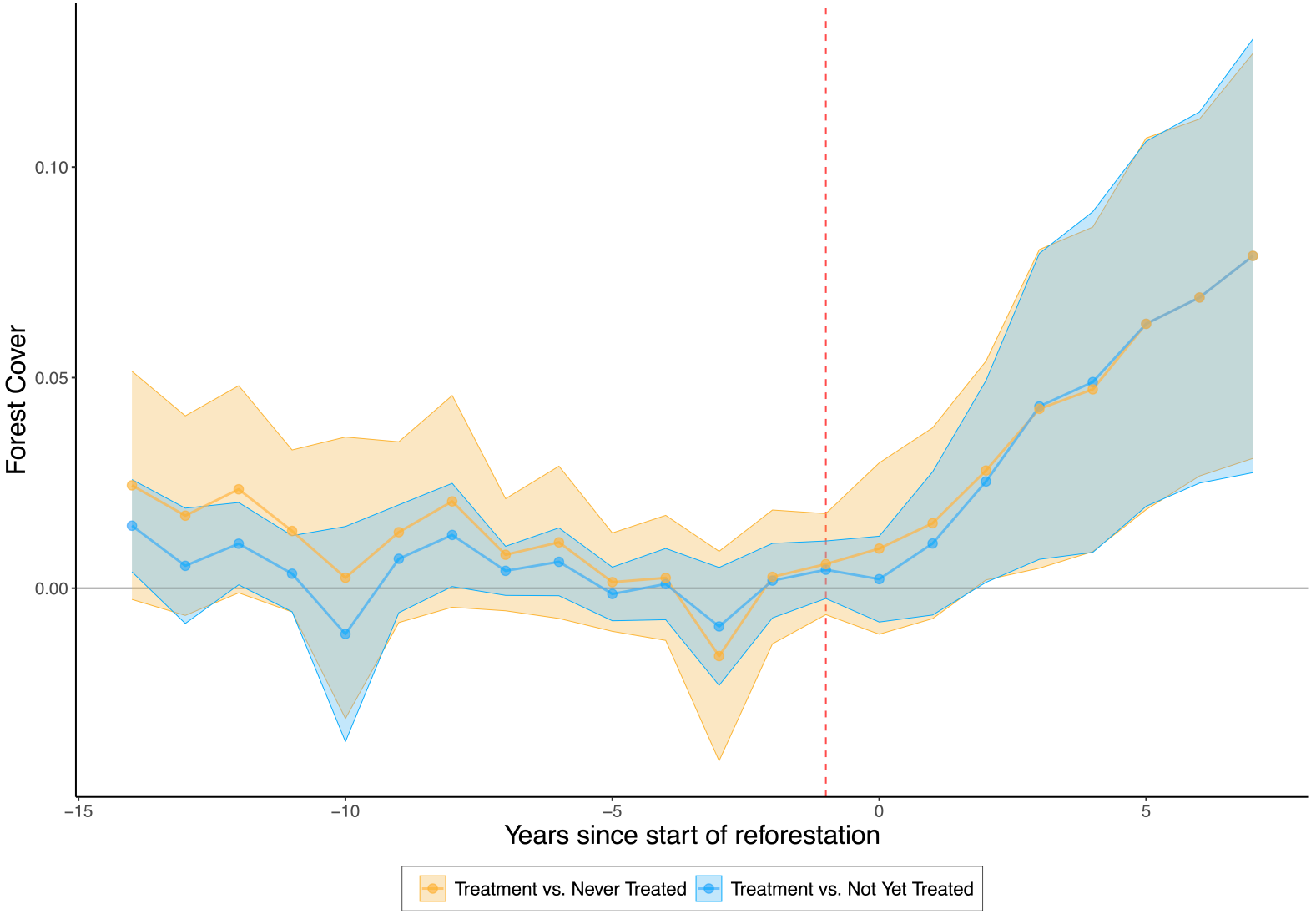
Empirics



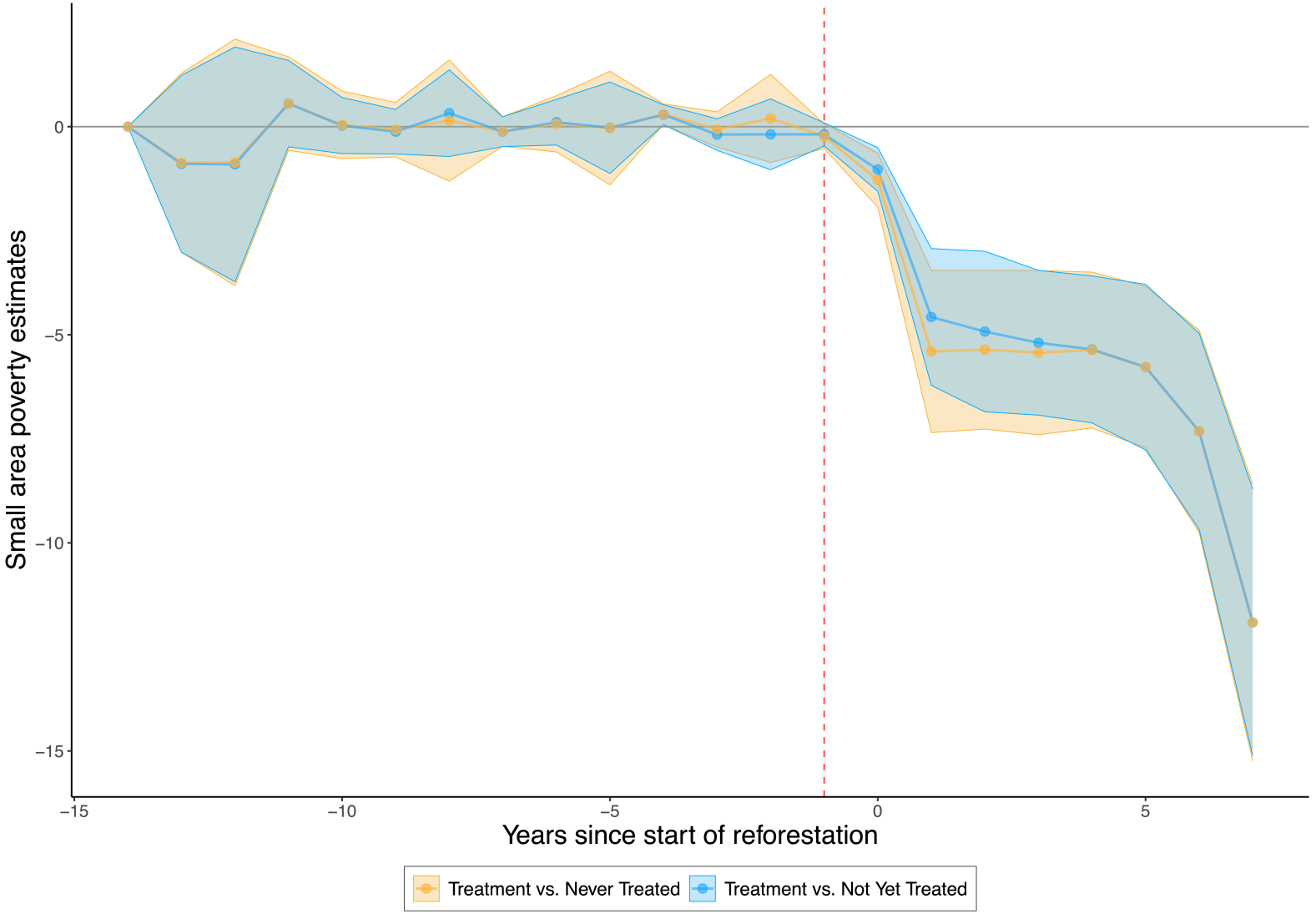
- Limit the sample to 32,472 never treated villages and exploit whether their neighbors are treated by the NGP
- We consider a never treated village as first treated when one of its neighbors is treated by the NGP
- Treatment vs spillover vs pure controls

Results

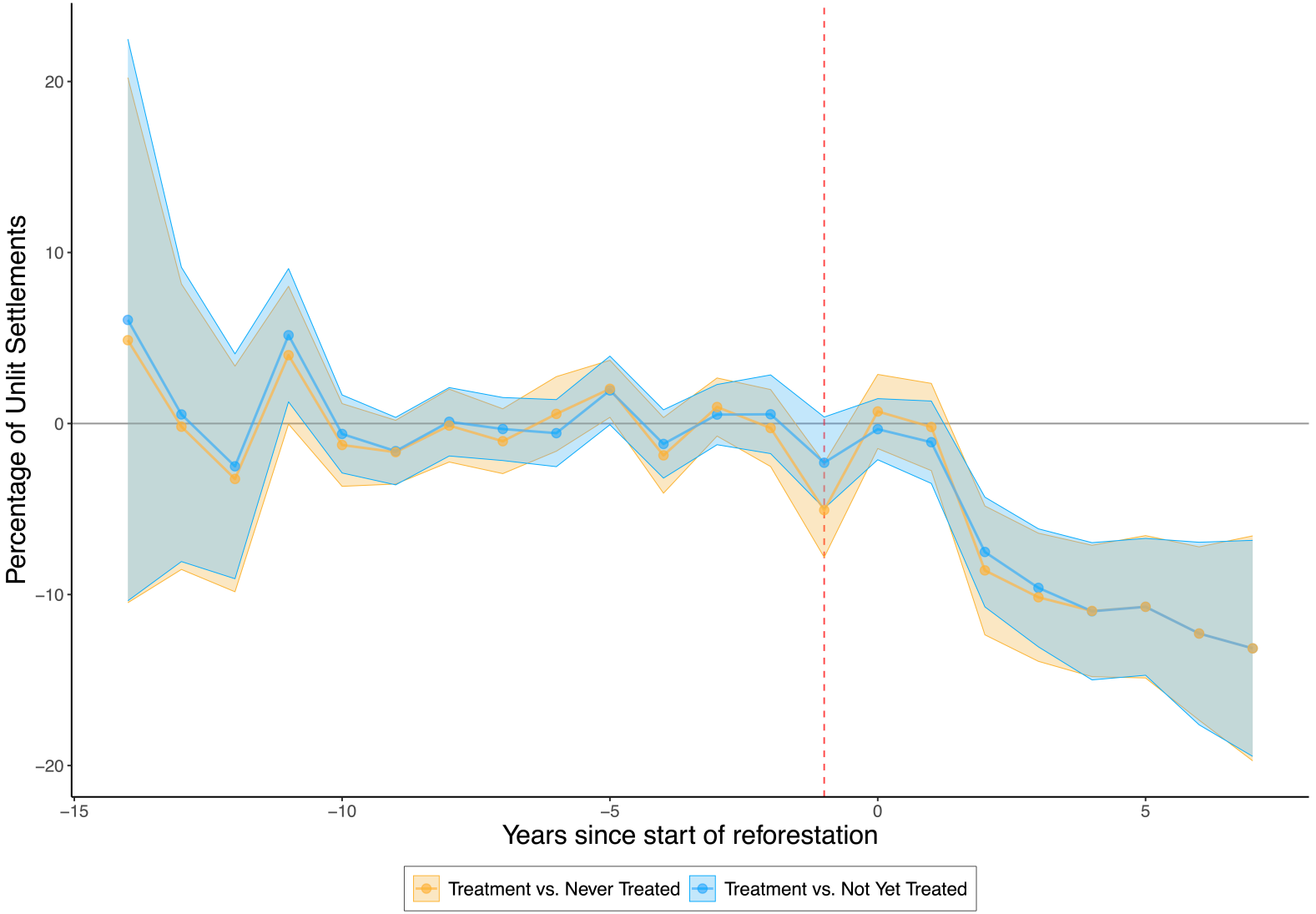
Forest cover: +4%



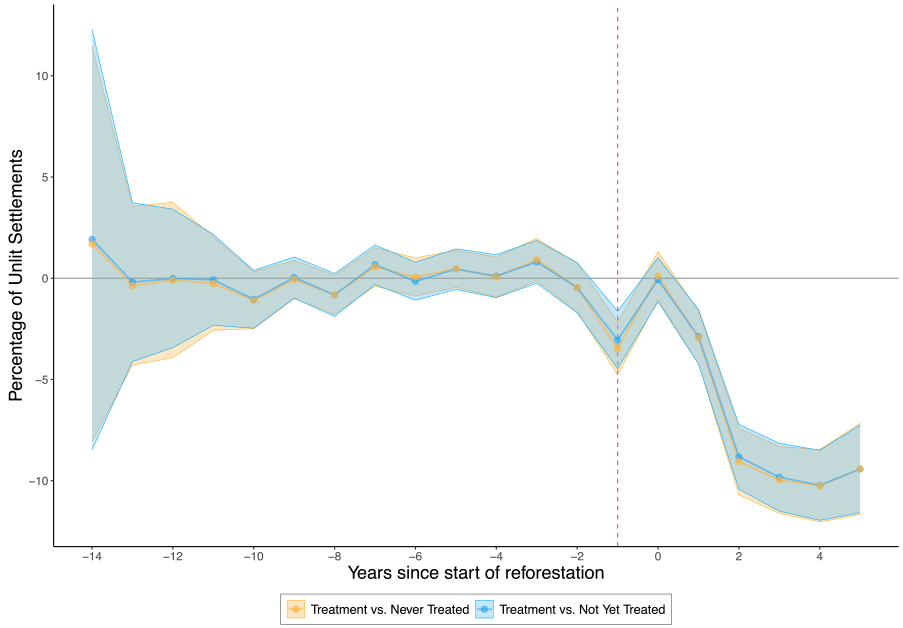
Small area poverty: -6 percentage points

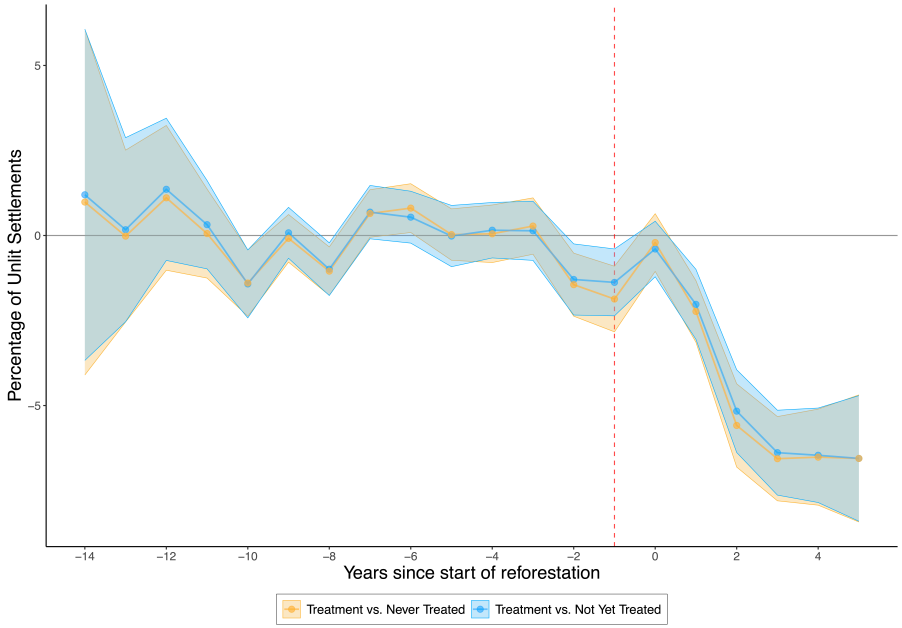


Unlit settlements: -8 percentage points



Village unlit settlements





"Clean": -6.7 percentage points

Spillovers: -4.5 percentage points

- Dip: checking for pre-trends using Rambachan and Roth (2023)
- "Naive" DID: -5.5 percentage points (contaminated control)

▶ Robustness

Sectoral and Labour Reallocation

Sectoral Reallocation

- An increase in labor productivity could be achieved through (Diao, McMillan, and Rodrik 2019):
  - → Existing economic activities capital accumulation or technological changes
  - → Labor moving from low-productivity to high-productivity activities
- We employ a two period TWFE-DID specification:

$$Sector_{imt} = \beta_0 + \beta_1 NGP_{m,t} + \tau_t + \gamma_m + \epsilon_{m,t}$$

- Where $Sector_{imt}$ is estimated separately for the percentage of individuals not working, working in services, working in agriculture, working in unskilled manual labor, or working in skilled labor for municipality m at time t

Sectoral Reallocation

Impact of NGP on Employment in Different Sectors

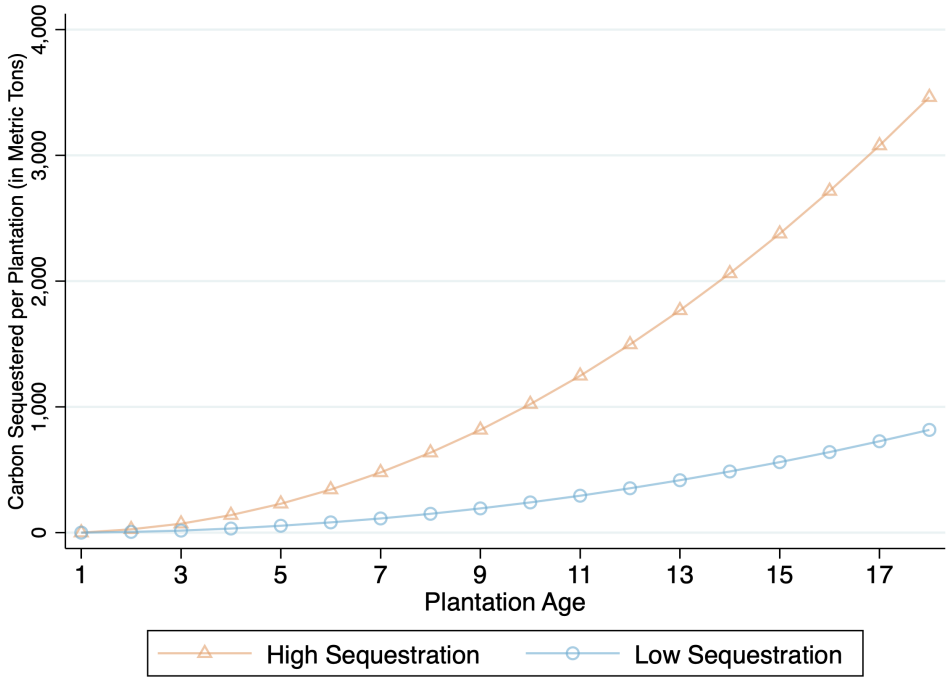
	Not Working	Services	Agriculture	Unskilled	Skilled
NGP	0.0342	0.0258*	-0.0379*	0.0564***	0.00221
	(0.0259)	(0.0150)	(0.0198)	(0.0196)	(0.0127)
Observations	976	976	976	976	976
Treated Municipalities	370	370	370	370	370
Control Municipalities	118	118	118	118	118
R-squared	0.611	0.594	0.741	0.603	0.634

- Sector definitions - Services: housekeeping and restaurant services, finance and sales associates and administrative professionals. Unskilled manual labor: manufacturing labor, building caretakers, mining and construction laborers. Skilled: textile, garment and related trades, assemblers, wood treaters and food processing.

▶ Labour Reallocation

Valuing the Sequestration Benefits of the NGP

CO2 sequestration

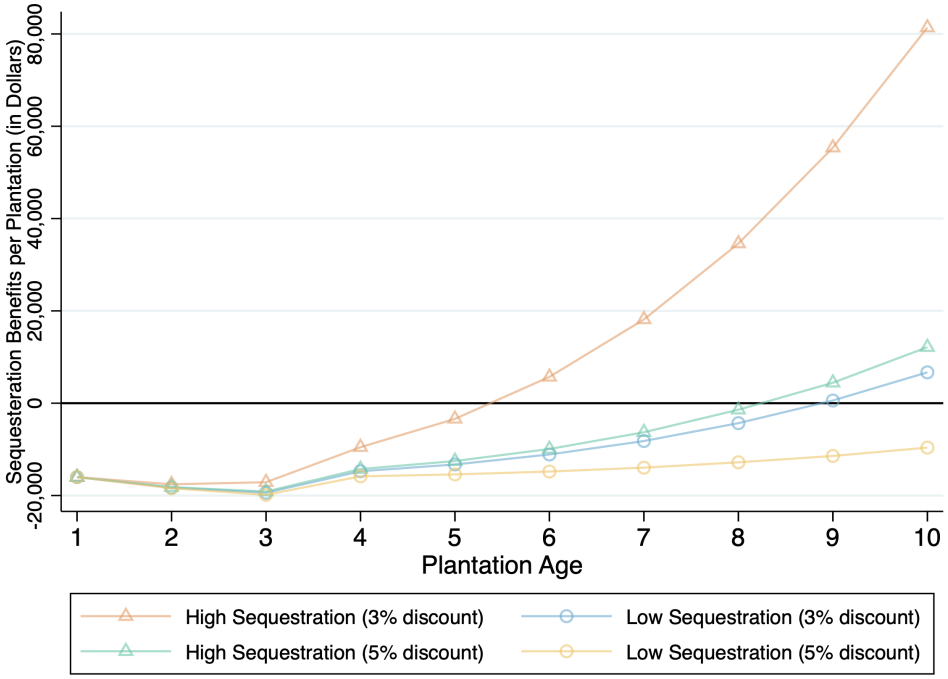


- The NGP sequestered between 72.7 MtCO2 and 308 MtCO2 over 10 years
  - → Depending on sequestration assumptions (Balangue 2016)
- Equivalent to 16.2M cars/year or 19.5 coal-fired power plants/year

- For policymakers focused exclusively on carbon emissions, the NGP reduces CO2 emissions at a cost ranging from $2.3 to $10 per ton

CO2 sequestration

- Calculate the economic value associated with a permanent reduction of CO2 in the atmosphere - US EPA estimates (2016)



- Annual benefits (social cost of carbon)
- Annual costs (3 year payments to the communities)

→ Break-even point between **6-9 years of project implementation**

Conclusion

- The NGP was effective at increasing forest cover
- The 2011 National Greening Program has resulted in a significant reduction in poverty and sizeable reductions in unlit settlements with significant spatial spillovers
- Larger impact in poor areas
- Larger tree plantations have the largest impact
- Evidence of sectoral reallocation but no evidence of population sorting
- Both the payment and tree planting asset are important aspects of the bundle reducing poverty
- Important carbon impacts

thank you!

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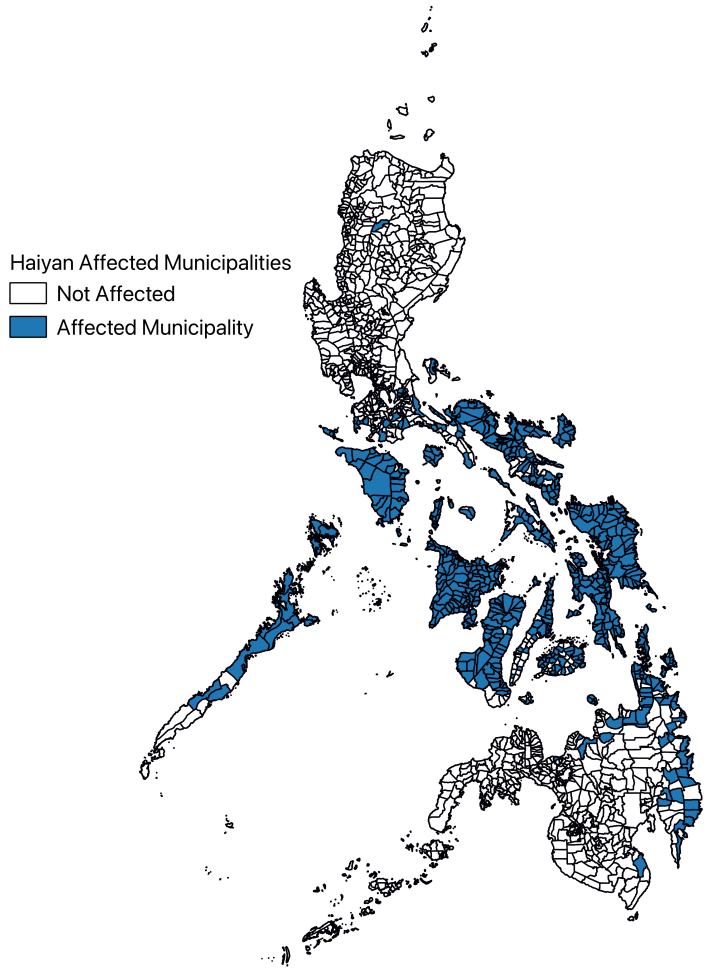
Robustness

- Run standard two-way fixed effect estimation ▶ TWFE
- Conditional parallel trends ▶ Results
  - → Time-varying controls: population, precipitation, and maximum temperature
  - → Time-invariant controls: Slope, elevation, number of villages within a municipality that have access to the national highway, number of markets, number of commercial establishments, and number of bank establishments (interacted with time-trend)
- Estimate Sun and Abraham (2021) ▶ Results
  - → Possibility that coefficients on a given lead or lag could be contaminated by the effects from other periods

▶ Back to main

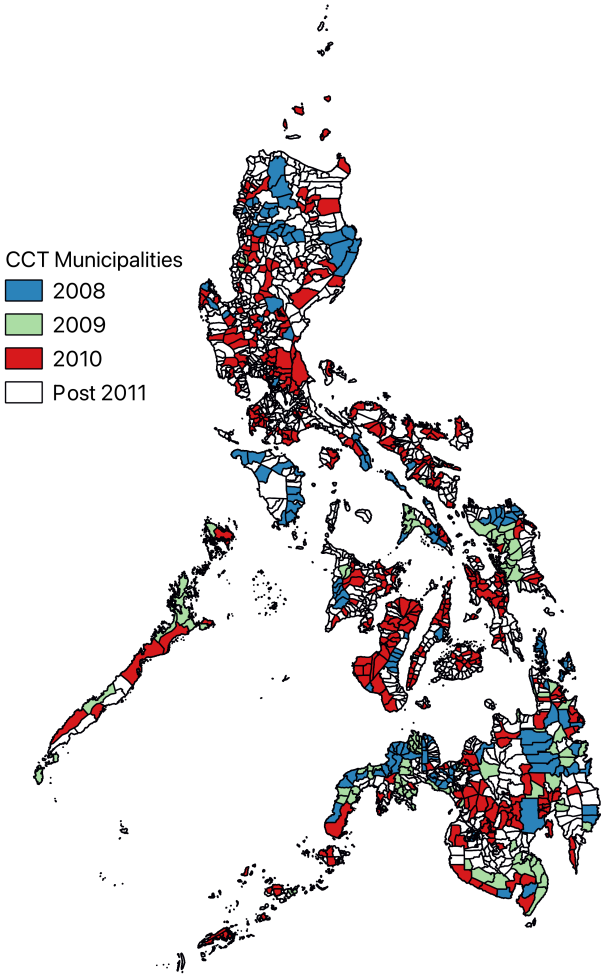
Robustness



- Typhoon Haiyan
  - → Category 5 typhoon hit in 2013 affecting 591 municipalities, 6,300 died, damage to physical assets of 3.7% of GDP
  - → Could impact ecosystems, poverty incidence and economic activity

▶ Results

Robustness



- Conditional Cash Transfer Program
  - → 2008-2010 cash grants for chronic hunger
- Conflict affected areas:
  - → Moro Islamic Liberation Front - Islamist separatist movement in Mindanao

▶ Results

▶ Heterogeneous Results

TWFE

Impact of NGP on Socio-Economic Measures: Standard TWFE-DID

	Small Area Poverty Estimates		**Percentage of Unlit Settlements**	
DID_{TWFE}	-4.636***	-3.522***	-8.301***	-5.301***
	(0.4602)	(0.4414)	(0.8810)	(0.9131)
Controls		✓		✓
Municipality FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Observations	28,907	25,827	29,322	26,028
Adjusted R^2	0.86529	0.86588	0.91762	0.91991

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Conditional parallel trends

Impact of NGP on Socio-Economic Measures

	Small Area Poverty Estimates		Percentage of Unlit Settlements	
NGP	-3.125***	-2.861***	-4.348**	-5.583**
	(0.619)	(0.708)	(2.186)	(2.659)
Controls	✓	✓	✓	✓
Treatment	NYT	NT	NYT	NT
Observations	24984	24768	21546	21546

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Sun and Abraham (2021)

Impact of NGP on Socio-Economic Measures

	Small Area Poverty Estimates		**Percentage of Unlit Settlements**	
DID_{SA}	-6.388***	-5.685***	-7.542***	-5.772***
	(0.6056)	(0.6272)	(1.110)	(1.204)
Controls		✓		✓
Municipality FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Observations	28,907	25,827	29,322	26,028
Adjusted R^2	0.86695	0.86702	0.92043	0.92201

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Robustness: concurrent shocks

Impact of NGP on Small Area Poverty Estimates: Robustness

	Excluding Haiyan		Excluding Mindanao		Excluding CCT	
NGP	-6.892***	-7.063***	-2.048***	-2.051***	-5.421***	-5.582***
	-0.808	-0.811	-0.449	-0.461	-0.691	-0.703
Observations	17010	17010	21780	21780	17910	17910
Treatment	Not Yet Treated	Never Treated	Not Yet Treated	Never Treated	Not Yet Treated	Never Treated

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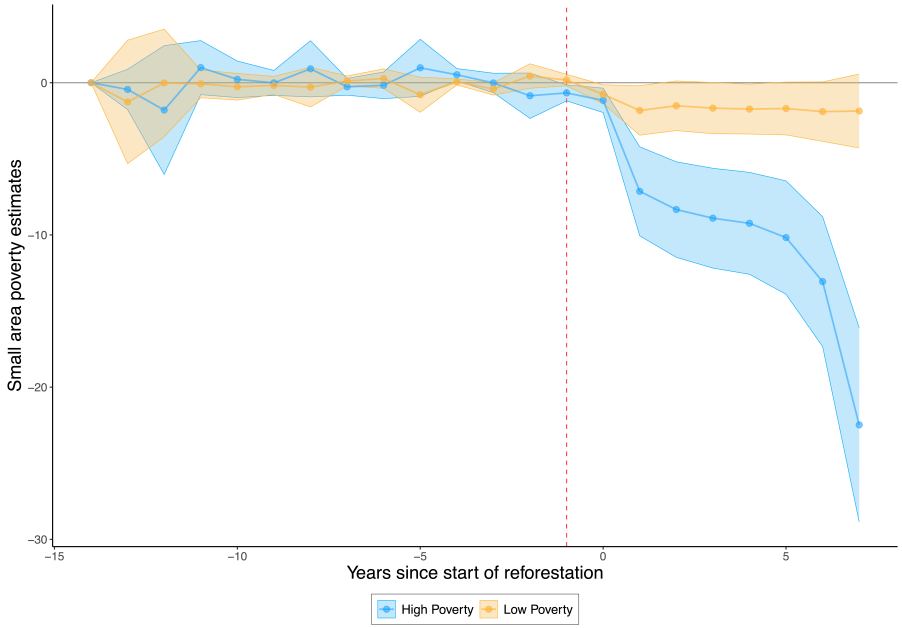
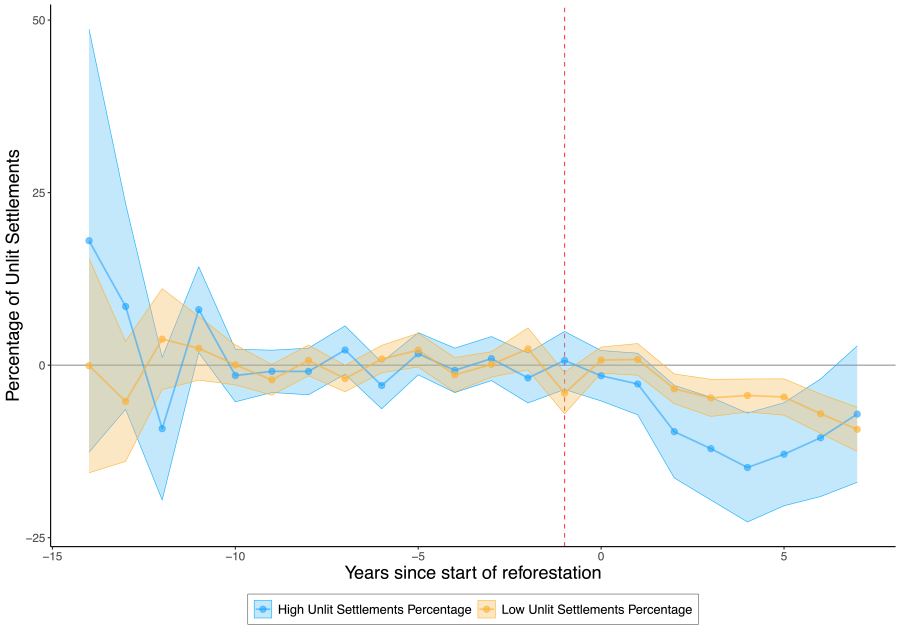
Heterogeneity: municipality

- Heterogeneity based on above median and below median levels of 2010 small area poverty estimates and unlit settlements
  - → High poverty: -10 p.p.; Low poverty: -1.6 p.p.
  - → High share unlit settlements -9 p.p.; Low share - 4 p.p.





Heterogeneity: plantation

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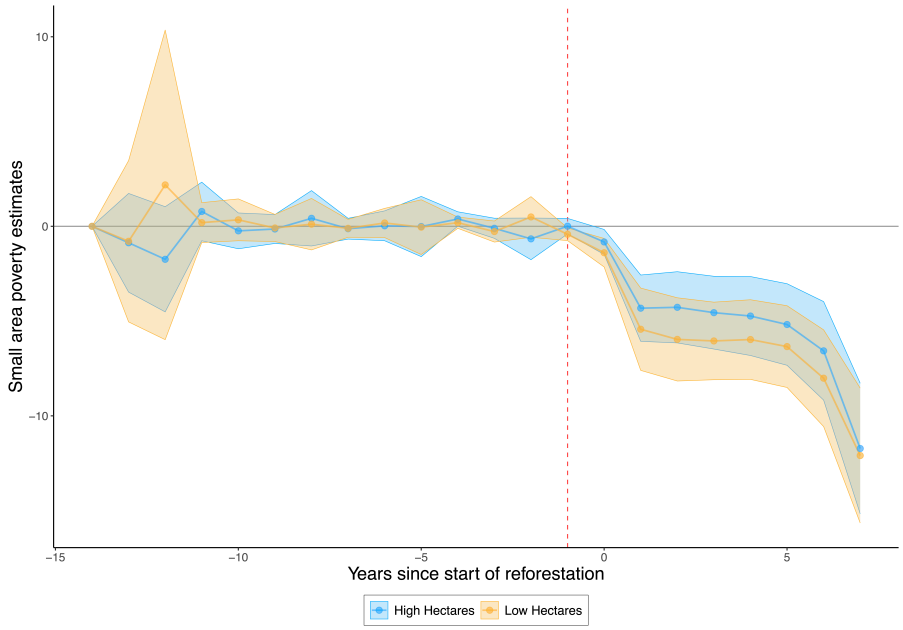
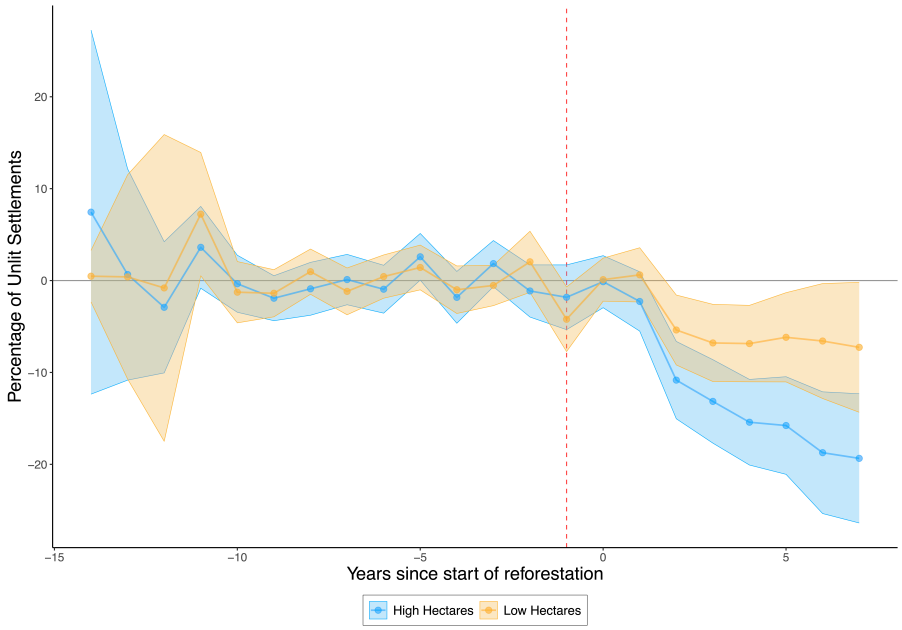
- Small scale vs large scale plantations
  - → Small ratio = a multitude of small plantations
  - → Higher ratio = a small number of larger tree plantations





Poverty: high ratio -5.3 p.p.; low ratio: -6.4 p.p.

Unlit: high ratio -12 p.p.; low ratio - 4.7 p.p.

Labour reallocation

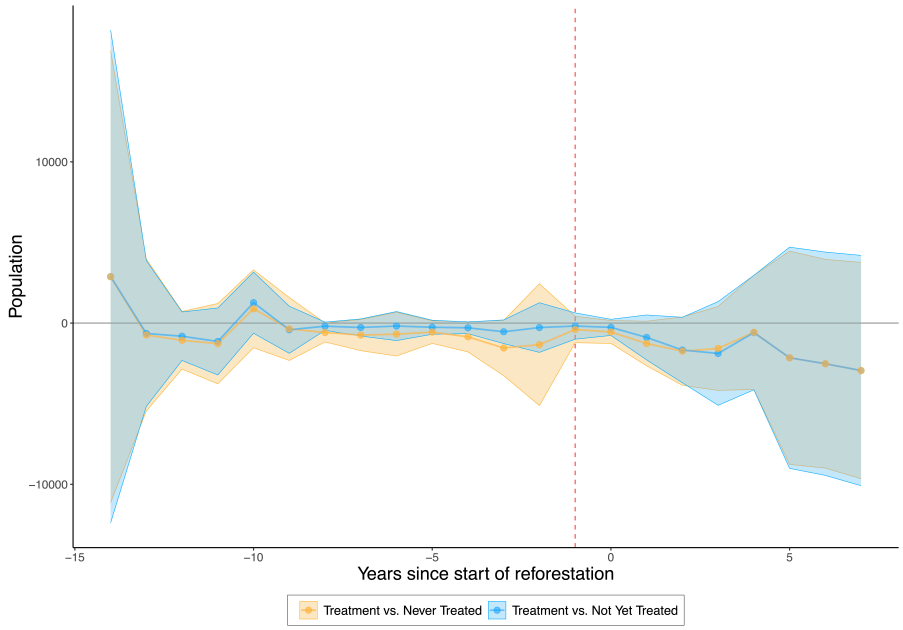
Did the NGP lead to broader changes in labor supply?

We investigate whether the increased economic activity is the result of population growth or migration

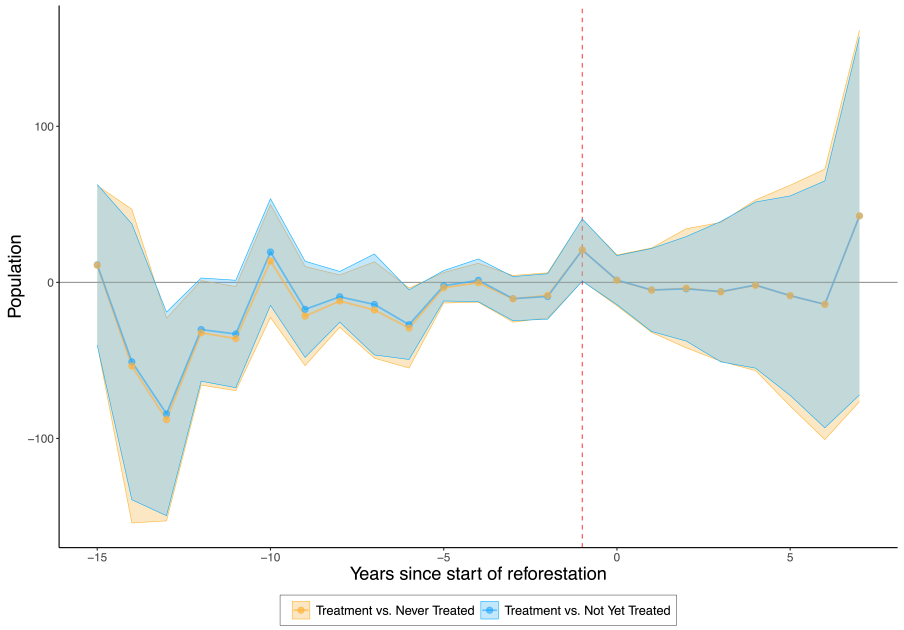
- Use high-resolution disaggregated census counts
- Captures the full potential activity space of people throughout the course of the day and night (Sims et al. 2022)

Labour reallocation

- No significant effects on labour reallocation



Municipality-level



Village-level

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