Does Conservation Work in General Equilibrium?

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Local solutions to a global problem

- Tropical deforestation causes global problems
  - → Carbon emissions (instantaneous)
  - → Loss of carbon sinks (permanent)
  - → Biodiversity loss
- Avoided deforestation is a major component of all IPCC emission reduction pathways compatible with 1.5 or 2 degree warming
- Avoided deforestation projects were excluded from Clean Development Mechanisms
  - → largely due to concerns about leakage.

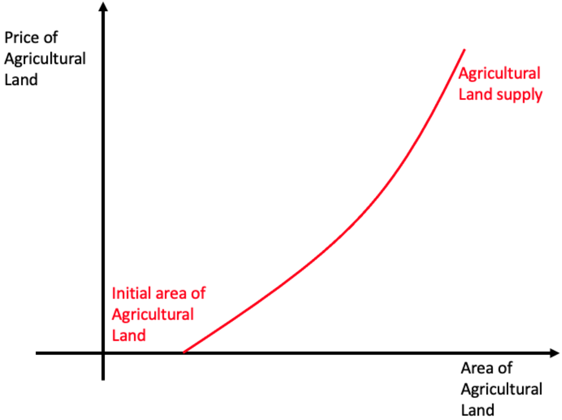
Leakage as a General Equilibrium Effect

- UN Definition

  The unexpected loss of anticipated carbon benefits due to the displacement of activities in the project area to areas outside the project, resulting in carbon emissions. (UN-REDD programme glossary)

- As a General Equilibrium effect
  - Deforestation clears area for agricultural use
  - Conservation policy restricts supply of agricultural land; leaves demand unaffected
  - Leakage: excess demand leads to increased deforestation in non targeted areas

Aggregate Agricultural Land Market



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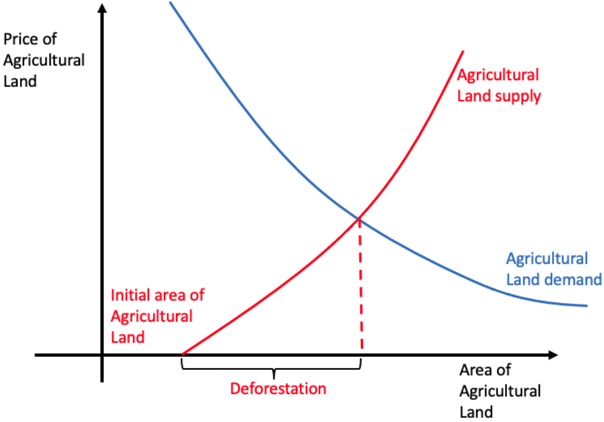

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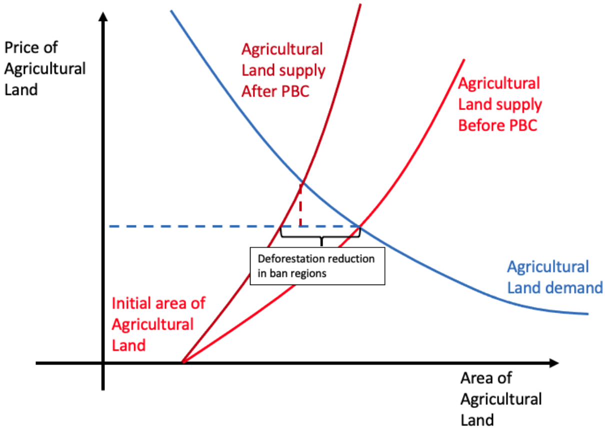

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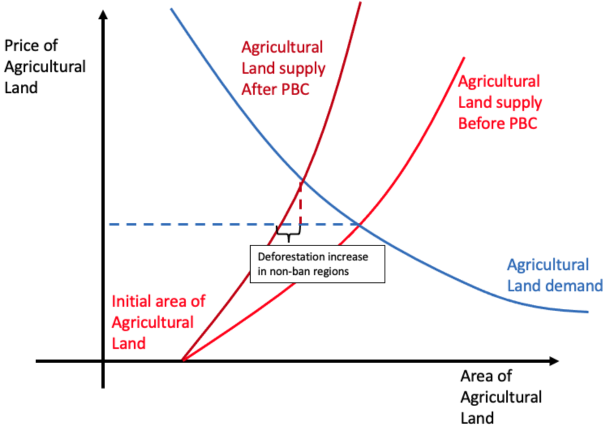

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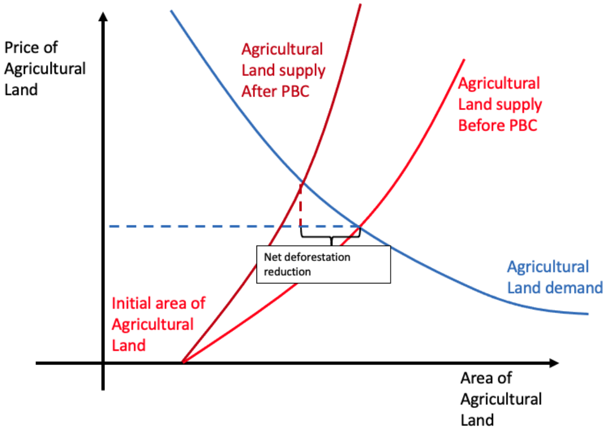

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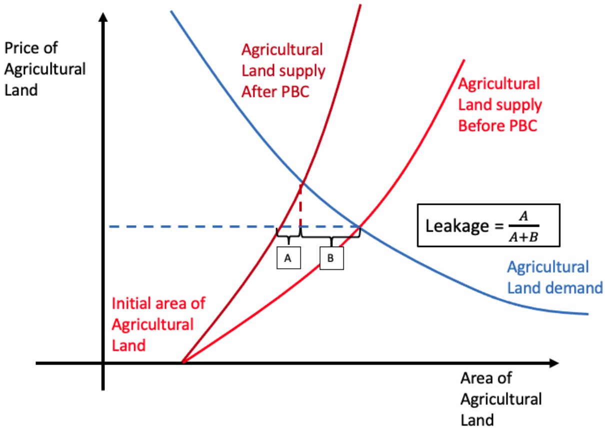

dynamics of land market

This paper

- How much does place-based conservation "leak" outside targeted areas?

→ Calibrate a Quantitative Spatial Equilibrium model of Brazilian economy with trade and migration and endogenous deforestation supplying land to the agricultural sector

+ Simulate place-based conservation policies to quantify leakage

Why Brazil?

- Brazil has one third of the world's rainforests
- Average (1985-2021) yearly forest loss: 20,000 km^2 $\approx$ Wales trends

Figure: Green: forest as of 2019, Orange: deforestation between 2000 and 2019, White: non-forest in 2000

Leading conservation policies are spatially targeted

Preview of results

- Regions with higher deforestation rates have low demand for agricultural land
  - Due to lower agricultural productivity, lower market access, and lower population density
  - Large comparative advantage in deforestation
- Leakage of policies implemented since 2002 has been relatively small, and it increases over time
  - Protected Areas reach 15% over 2002-2019
  - Priority List municipalities reach 10% over 2008-2019
- Priority List municipalities avoid more deforestation and have similar amounts of leakage
  - Due to differences in targeting criteria

Contribution

- **Evaluation of anti-deforestation policies** Alix-Garcia, Sims, and Yañez-Pagans (2015); Burgess, Costa & Olken (2019), Assunção et al. (2019), Souza-Rodrigues (2019), Pfaff and Robalino (2017)
- **Carbon Leakage** Aichele and Felbermayr (2015), Baylis, Fullerton and Karney (2014), Chen et al (2021), Cherniwchan, Copeland and Taylor (2017), Greenstone (2002), Taylor (1998)
- **Structural modelling of deforestation** Hsiao (2023), Dominguez-Iino (2022), Farrokhi et al (2022), Araujo, Costa and Sant'Anna (2023), Souza-Rodrigues (2019)

$\Rightarrow$ Quantify the leakage of conservation policies accounting for domestic trade and migration

Roadmap of Talk

Reduced form evidence

Motivate features of the model

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Counterfactual Results: Protected Areas

Counterfactual Results: Priority List

Conclusion

Place-Based Conservation Policies

Priority List Municipalities and Conservation Units

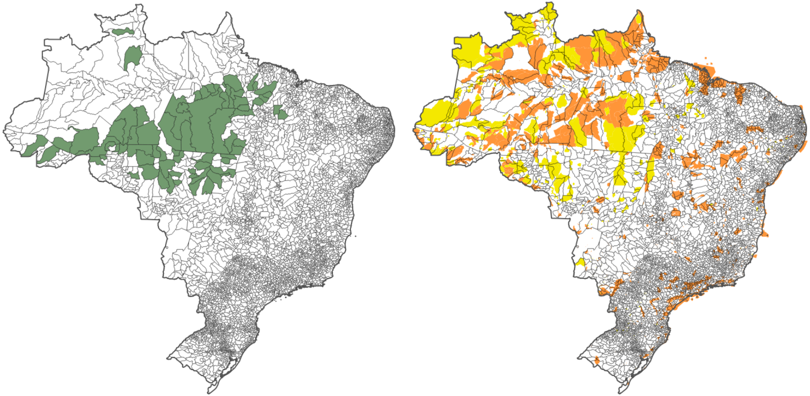
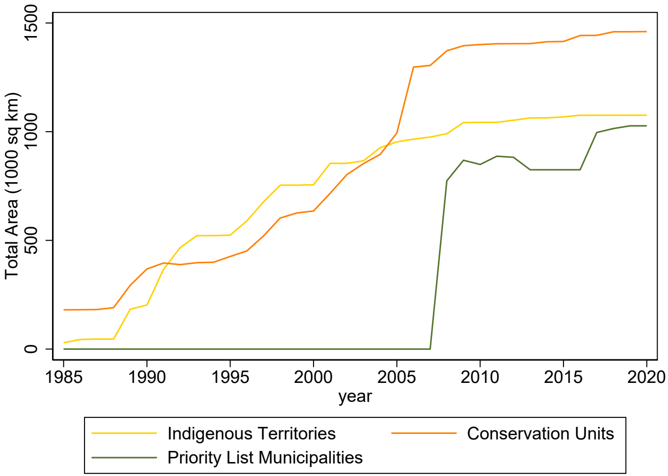


Figure: Left: Priority List municipalities in green, Right: Conservation Units in orange and Indigenous Territories in yellow.

Timeline of Place-Based Conservation Policies



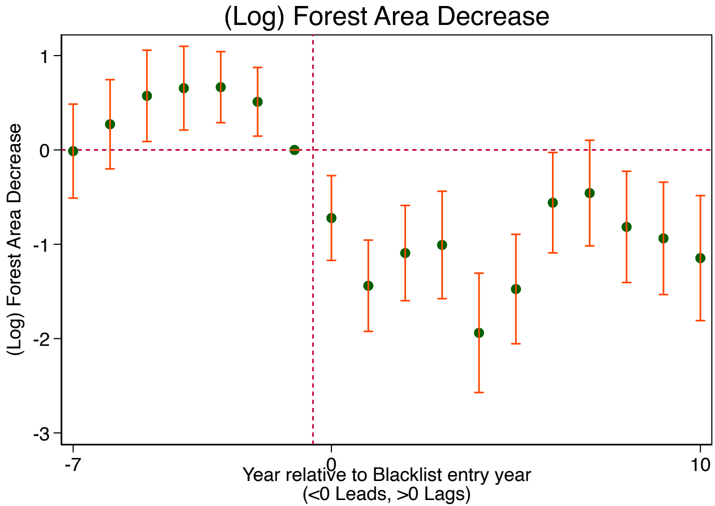
Pritority List: Identification Strategy

- Event Study Regression

$$\log(\text{Deforestation})_{rt} = \delta_t + \gamma_r + \sum_{\tau=-N_L}^{N_F} \beta_\tau \text{Priority}_{r,t-\tau} + \epsilon_{rt}$$

- Restrict attention to municipalities blacklisted in 2008 and drop those blacklisted afterwards to avoid capturing anticipatory effects of the policy

Pritority List: Results



Protected areas: Identification strategy

- Unit: 10km wide hexagons (100,000+) in all of Brazil
- Time period: 1985-2019
- Regression discontinuity

$$\text{log(ForestArea)}_{rt} = \delta_{mt} + f(\text{DistanceToBorder}_{rt}) + \beta\text{Protected}_{rt} + \epsilon_{rt}$$

Protected areas: Results

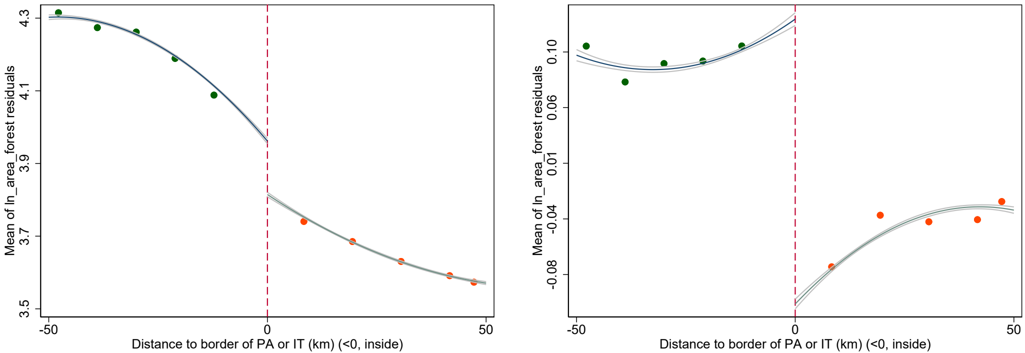


Figure: Left: without controls, Right: with municipality-year fixed effects

Summary of reduced form results

- Place-Based conservation cause large decreases in deforestation rates *in the areas they target relative that those they do not*
  - Priority List causes municipalities to decrease deforestation rates by 50% more than non-priority counterparts
  - Protected Areas cause a reduction in deforestation rates of about 20% (near the border)
- These could be due to:
  1. large deforestation reductions inside
  2. large deforestation increases outside (leakage)

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How much leakage is there? It depends

- on the elasticity of demand for agricultural land, which in turn depends
  - on the elasticity of demand for agricultural goods
  - on the substitutability of agricultural land across space, determined by
    - trade
    - migration
    - comparative advantage
- on the elasticity of supply of agricultural land, i.e. deforestation, which is heterogeneous

Key features of model

- Deforestation is a costly activity that produces a durable factor of production, land
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- Locations differ in productivity, amenities, and trade links
  - $\Rightarrow$ Multi-region economic geography model (Eaton & Kortum 2002)
- Empirical evidence shows that trade and migration frictions are important
  - $\Rightarrow$ Imperfect mobility of goods and workers

Regions with high deforestation look different from the rest of Brazil

- Poor and remote see correlation
- With lower agricultural productivity see correlation
- Agricultural and sparsely populated see correlation
- With high migration shares see correlation

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Model setup

- 557 micro-regions r, over 17 years t (2002-2019) , costly internal trade and migration
  - Sectoral TFPs (Z_{rt}^{Ak}, Z_{rt}^{NA}, Z_{rt}^{D}), land endowments (T_{0r}^{A}, T_{0r}^{F}), and amenities (B_r)

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- Non-ag. and 3 ag. sectors: temporary crops, permanent crops, and pasture (k)
  - Agricultural goods: Cobb-Douglas, land and labour as inputs
  - Ag. activities have different land shares (α_k)
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- Consumer preferences
  - Non-homothetic between agriculture and non-agriculture (η)
  - CES between agricultural products (θ)
  - CES between origins of products (σ)

Deforestation

- Agricultural land is a stock

$$T_{rt}^{A} = \underbrace{T_{rt-1}^{A}}_{\text{already ag land}} (1 - \underbrace{\rho}_{\text{regen. rate}}) + \underbrace{T_{rt}^{D}}_{\text{deforested land}} .$$

dynamics of land market

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dynamics of land market

- Deforestation sector has decreasing returns to scale

$$T_{rt}^{D} = \underbrace{Z_{rt}^{D}}_{\text{TFP of deforestation}} (\underbrace{I_{rt}^{D}}_{\text{investment}})^{\delta}, \quad 0 < \delta < 1$$

$\Rightarrow$ Equivalent to convex costs

Deforestation

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$$T^A_{rt} = \underbrace{T^A_{rt-1}}_{\text{already ag land}} (1 - \underbrace{\rho}_{\text{regen. rate}}) + \underbrace{T^D_{rt}}_{\text{deforested land}} .$$

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- Z^D_{rt} depends on the remaining amount of unprotected forested land in a region T^F_{rt}

$$Z^D_{rt} = \overline{Z}^D_{rt}(T^F_{rt})^{\delta_F}$$

Equilibrium

- Land rental rates v_{rt}, deforestation T^{D}_{rt}, and agricultural land use $\{T^{Ak}_{rt}\}_k$
  - Deforesters sell agricultural land at $q_{rt} = \frac{1}{1-\beta} v_{rt}$ to maximize profits
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- Laws of motion
  - For agricultural land: $T_{rt}^{A} = T_{rt-1}^{A}(1-\rho) + T_{rt}^{D}$.
  - For local population: $L_{rt} = \sum_{o=1}^{R} \mu_{rt}^{o} L_{ot-1}$, migration flows μ_d^o follow gravity equation

Optimal level of deforestation

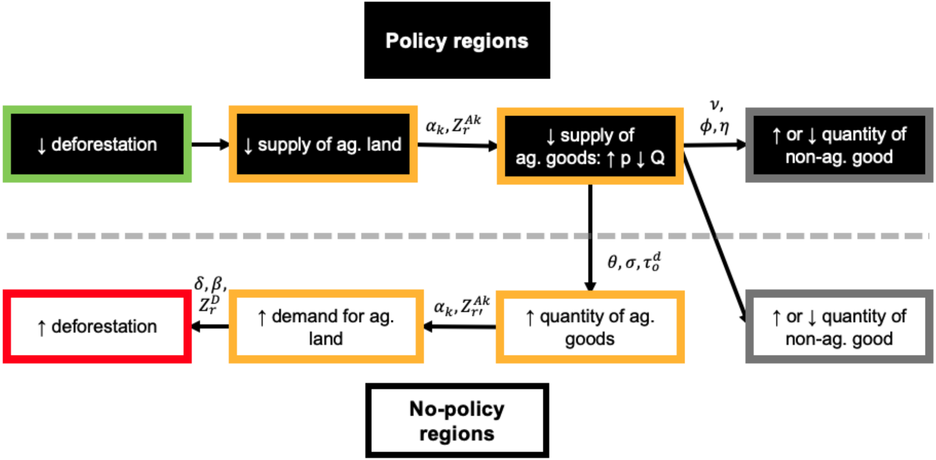
- Solving for the optimisation problem

$$T^D_{rt} = \underbrace{\left(T^F_{rt}\right)^{\frac{\delta_F}{1-\delta}}}_{\text{endowments}} \underbrace{\left(\overline{Z}^D_{rt}\right)^{\frac{1}{1-\delta}}}_{\text{supply (policy)}} \underbrace{\left(\frac{\delta q_{rt}}{p_{rt}}\right)^{\frac{\delta}{1-\delta}}}_{\text{land market eqm}}$$

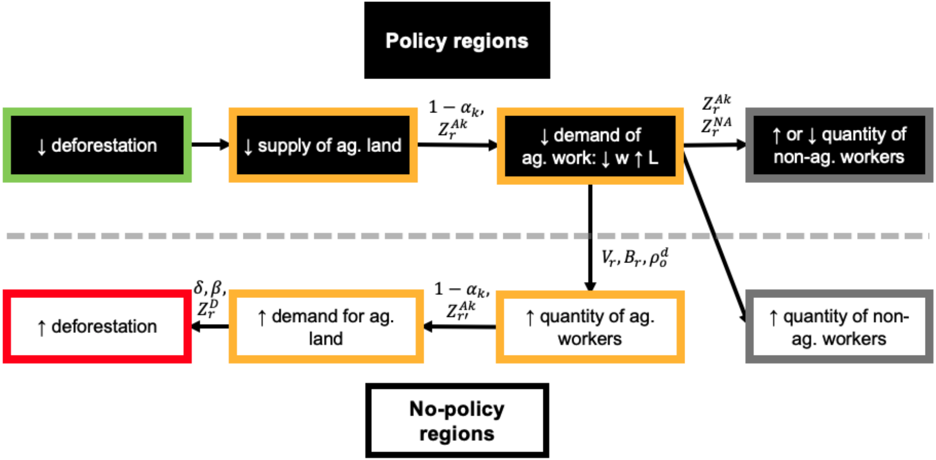
$\Rightarrow$ Use yearly deforestation changes vs. yearly changes in q_r to estimate δ Equation estimating δ

$\Rightarrow$ Use cross-sectional differences in the share of area forested under a steady state condition to estimate δ_F Equation estimating δ_F

How does leakage happen in the model? Goods market



How does leakage happen in the model? Labour market



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Parameter Estimation

Parameter		Value	Source/Method
	Preference Parameters		
β	Discount rate	0.9	
ϕ	Ag. share in price index	0.1	Eckert and Peters (2023)
ν	PIGL Preference parameter	0.5	Eckert and Peters (2023)
η	Non-homotheticity	0.506	Expenditure Survey Data (2017/18)
	Elasticities of substitution		
σ	Between origins	9	Eckert and Peters (2023)
θ	Between ag. goods	2	Costinot et al. (2016), Dominguez-lino (2023)
	Production Function		
$\{\alpha_k\}_k$	Land share in ag. activities	(0.36;0.54;0.71)	Factor shares from 2006 ag. census
χ_A, χ_{NA}, ψ	Individual sector productivity shocks	(2;1.6;12.8)	Alvarez (2019)
δ	Deforestation returns to scale	0.5	Two-way fixed effect on lagged land prices
δ_F	Dependence on natural area left	0.32	Steady-state deforestation equation
ρ	Forest regeneration	0.003	Observed reforestation rates
	Trade and Migration parameters		
$\{\mu_d^o\}_{o,d}$	Bilateral migration utilities	Migration calibration	Migration flows between 2005 and 2010
ϵ	Dispersion of idiosyncratic tastes	14.08	
κ	Trade costs distance elasticity	0.11	State trade flows in 1999 and 2017

Model inversion

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  - Population (interpolation 2000 and 2010 Census)
  - Share of Labour in Agriculture (interpolation 2000 and 2010 Census)
  - Deforestation rates 2003-2018 (MapBiomas)

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- Prices and TFPs come from solving the spatial trade model

  → disentangle the role of technology and geography in regional specialization

- Amenities are backed out from discrepancy between migration rates (2010 Census) and model-derived consumption utility levels in 2010

Calibrated TFPs | Deforestation Correlation with Fundamentals | Land values | Wages | Ag wages | Ag Value Added | Ag VA growth

Non ag Value Added | Non ag VA growth | Migration shares | Migration shares vs. distance

Counterfactual exercises

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$$(Z^{D}_{rt})^{np} = (\overline{Z}^{D}_{rt})^{np}((T^{F}_{rt})^{np})^{\delta_F}$$

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3. Simulate each year 2003-2018, updating the land endowment with $(Z^D_{rt})^{np}$

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4. Calculate a “no leakage” counterfactual that has no-policy prices, and baseline Z^D_r

$$(T^D_{rt})^{noleakage} = \left(\delta\frac{(q_{rt})^{np}}{(p_{rt})^{np}}\right)^{\frac{\delta}{1-\delta}}((Z^D_{rt})^p)^{\frac{1}{1-\delta}}$$

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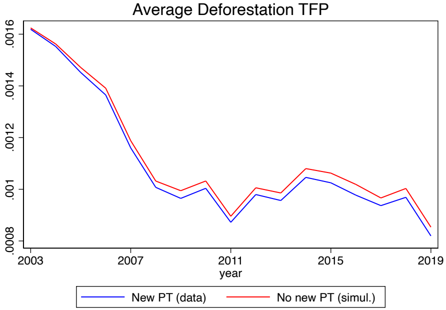
Counterfactual exercise I: Protected areas

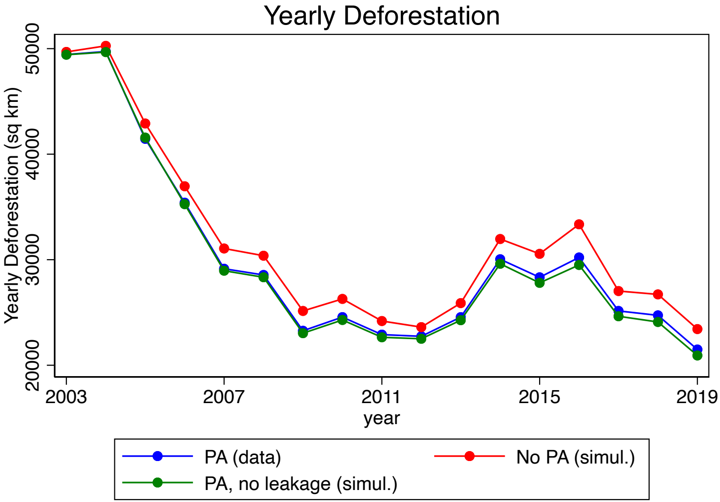
- Construct $(Z^D_{rt})^{np}$ as if all the protected areas were unprotected

$$(Z^D_{rt})^{np} = \overline{Z}^D_{rt}(T^F_{rt} + T^{PT}_{rt})^{\delta_F}$$

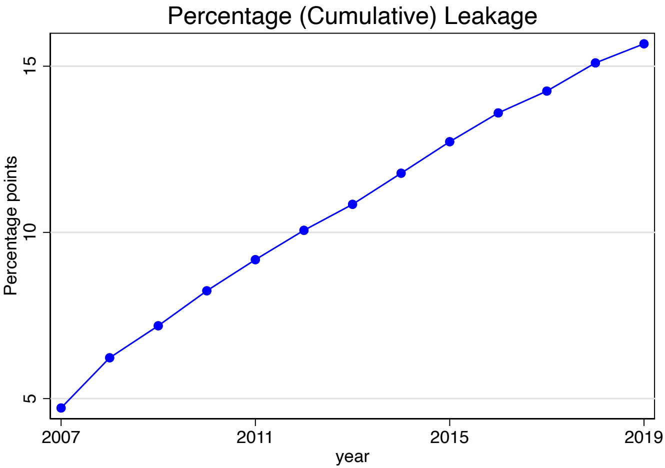
- where T^{PT}_{rt} is the area protected in region r at time t.



Counterfactual: deforestation rates



Counterfactual: cumulative leakage over time



yearly

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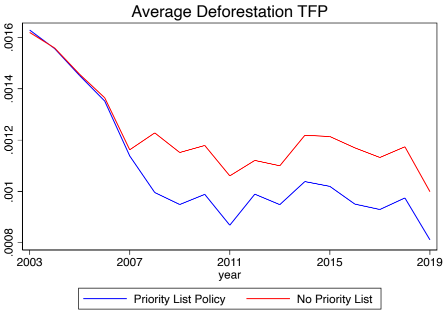
Counterfactual exercise II: Priority List

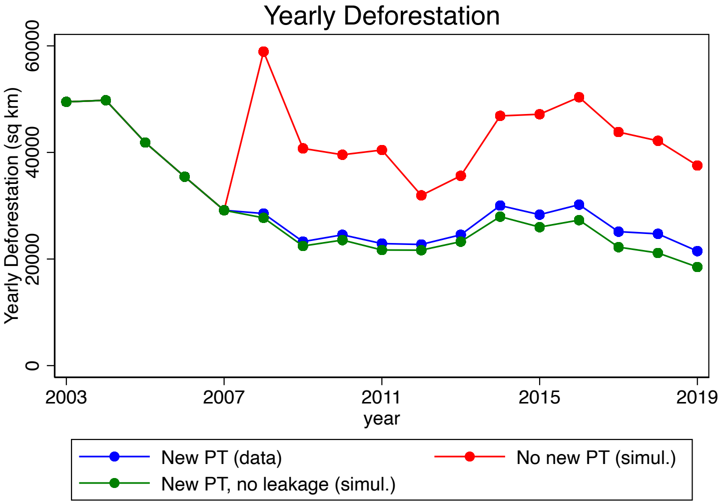
- Construct $(Z^D_{rt})^{np}$ as if there was no Priority List Policy
- Fitted values of Poisson quasi-maximum likelihood equation below, setting Priority=0

$$\mathbb{E}(\overline{Z}^D_{rt} | r, t, \text{Priority}_{rt}) = \exp(\alpha_r + \delta_t + \beta \text{Priority}_{rt} + \epsilon_{rt})$$

$$(Z^D_{rt})^{np} = (\overline{Z}^D_{rt})^{np} (T^F_{rt})^{\delta_F}$$



Counterfactual: deforestation rates



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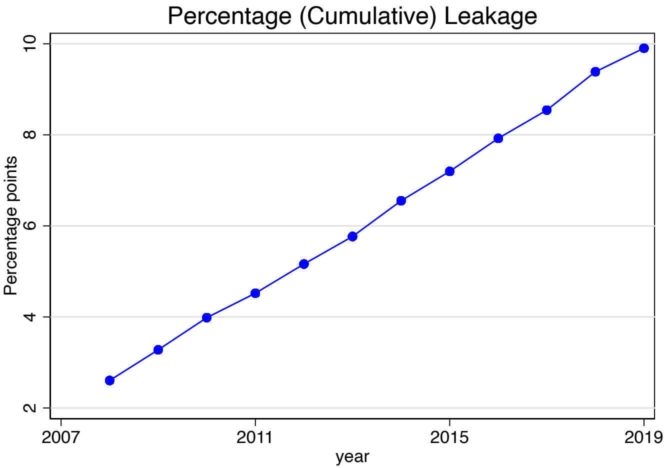

yearly

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- We find strong correlation between deforestaton rates and
  1. Lower agricultural productivity
  2. Lower market access
  3. Lower population density

  $\rightarrow$ High deforestation TFP (residual)

- Place-Based Policies targeting highest offenders cause relatively small leakage
  - It increases over time: around 2% after 1 year, less than 10% after 10 years
  - Main mechanism dampening leakage: Shift towards more labour intensive agricultural activities
    - Pasture $\rightarrow$ Crops

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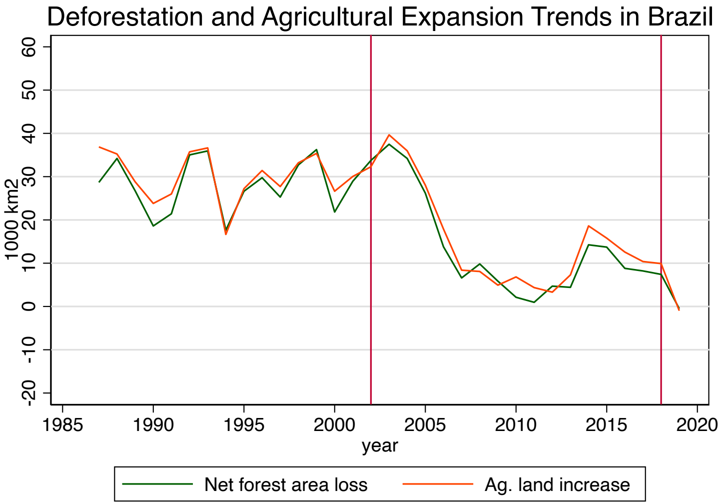
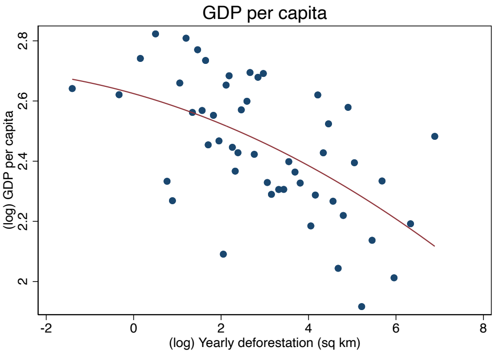
Back-up slides

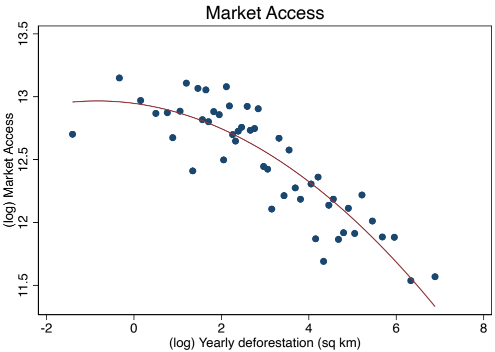
Deforestation trend 1985-2020



back to motivation

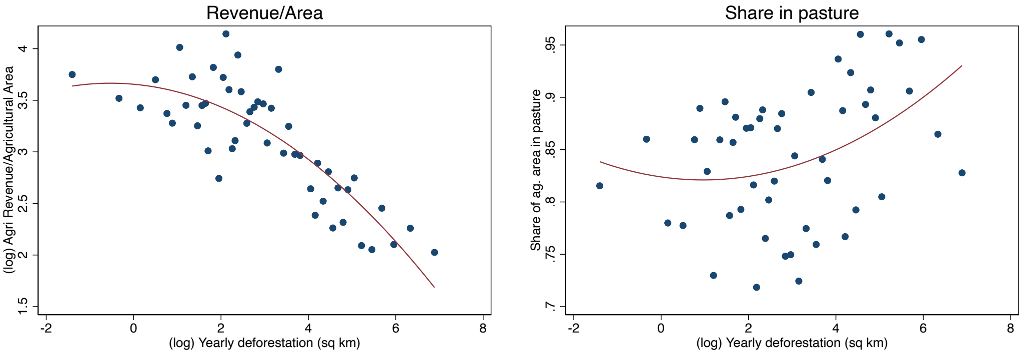
Deforestation happens in poor and remote regions





back

Lower agricultural productivity: more land for less cows



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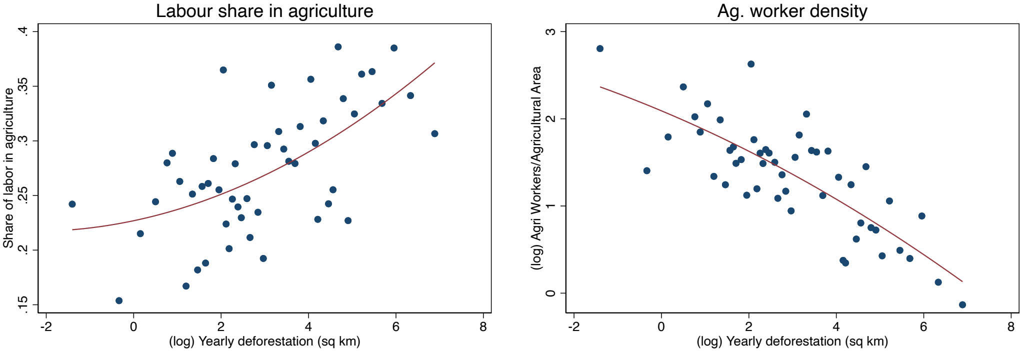
Agricultural and Sparse



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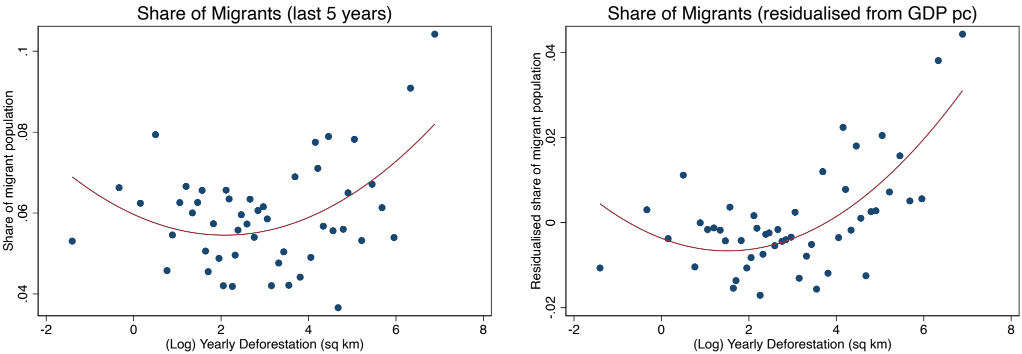
High migrant populations



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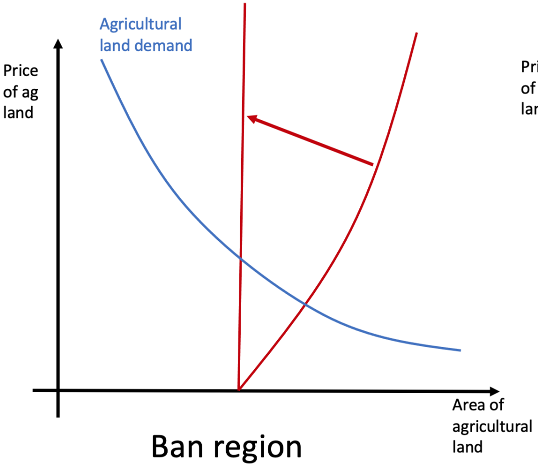
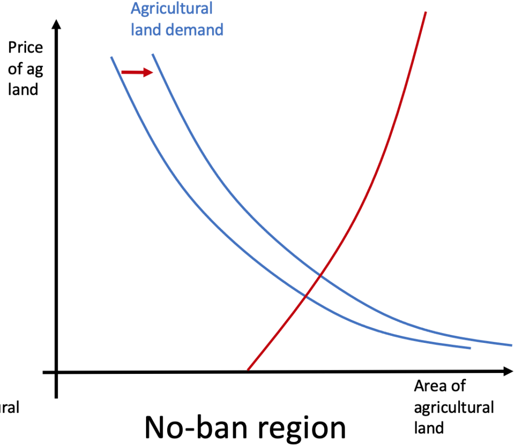
Agricultural land market: with ban and without ban





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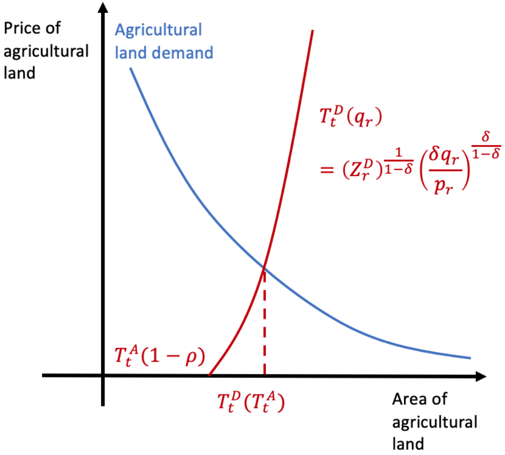
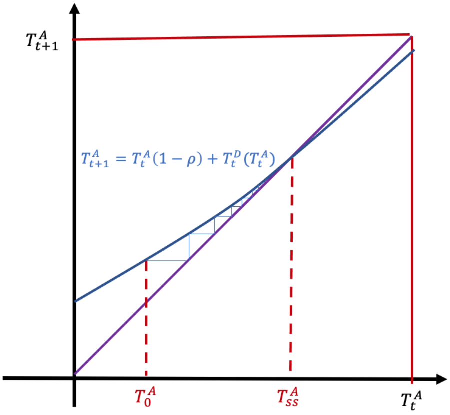
Agricultural land dynamics with regeneration





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Investment good

- The investment good is a Cobb-Douglas composite of the agricultural and non-agricultural final good

$$I = \phi^{-\phi}(1-\phi)^{-(1-\phi)}(X^A)^{\phi}(X^{NA})^{1-\phi}$$

- Therefore it has price $p_I = (p^A)^{\phi}(p^{NA})^{1-\phi}$.
- This assumption means that it does not depend on local labour markets
- Instead, investment in deforestation is perfectly substitutable with consumption, since $p_I = p$.

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Model inversion: Regional fundamentals

Table: Summary statistics of calibration results

	mean	sd	p10	p25	p50	p75	p90
TFP - temp. crops	1.75	2.38	0.10	0.20	0.64	2.43	5.16
TFP - perm. crops	0.03	0.05	0.00	0.01	0.01	0.03	0.08
TFP - pasture	5.74	5.95	1.23	2.02	3.67	7.77	12.10
TFP - non-agri	0.91	1.41	0.08	0.14	0.38	1.14	2.28
ZDr_F	0.02	0.01	0.00	0.01	0.01	0.02	0.04
TFP - deforestation	0.40	0.51	0.02	0.09	0.19	0.54	1.03
Local Amenities	0.38	0.34	0.14	0.19	0.32	0.49	0.63

ag TFP maps non ag TFP map defor TFP map amenities map
back to structural parameters

Estimating δ: deriving equation

- Recall optimal deforestation level condition

$$T_{rt}^{D} = (T_{rt}^{F})^{\frac{\delta_F}{1-\delta}} (\overline{Z}_{rt}^{D})^{\frac{1}{1-\delta}} \left(\frac{\delta q_{rt}}{p_{rt}}\right)^{\frac{\delta}{1-\delta}}$$

- Take logs

$$\begin{aligned}\log(T_{rt}^{D}) =& \frac{1}{1-\delta}\log(\overline{Z}_{rt}^{D}\delta^{\delta}) + \frac{\delta_F}{1-\delta}\log(T_{rt}^{F}) \\ &+ \frac{\delta}{1-\delta}\log q_{rt} - \frac{\delta}{1-\delta}\log p_{rt}\end{aligned}$$

- Regression specification

$$\boxed{\log(T_{rt}^{D}) = \alpha_r^1 + \alpha_t^2 + \frac{\delta}{1-\delta}\log v_{rt} + \epsilon_{rt}}$$

- Instrument for $\log v_{rt}$ with $\log v_{rt-1}$ and $\log v_{rt-2}$ (Anderson-Hsiao)

back to optimal deforestation back to parameters

Estimating δ: results

Table: Dep. var: ihs(Forest Decrease)

	(1) OLS	(2) OLS	(3) IV	(4) IV
Ihs(vr)	0.391***	0.253***	1.091***	0.606***
	[0.025]	[0.038]	[0.056]	[0.078]
Mun. FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Instrument			Lags	Lags
Weight	None	Agri. Area	None	Agri. Area
R2	0.240	0.346	-0.002	0.001
Observations	89072.000	89072.000	77938.000	77938.000

- Implied δ: 0.28-0.52

back to optimal deforestation back to parameters

Estimating δ_F: deriving equation

- Steady state condition

$$T^D_{r,ss} = \rho T^A_{r,ss}$$

$$\iff \frac{T^F_{r,ss}}{T^A_{r,ss}} = \rho(\overline{Z}^D_{r,ss})^{\frac{1}{\delta-1}}\delta^{\frac{\delta}{\delta-1}}\left(\frac{q_{r,ss}}{p_{r,ss}}\right)^{\frac{\delta}{\delta-1}}(T^F_r)^{1-\frac{\delta_F}{1-\delta}}$$

- Take logs

$$\log\left(\frac{T^F_{r,ss}}{T^A_{r,ss}}\right) = \log\left(\rho(\overline{Z}^D_{r,ss})^{\frac{1}{\delta-1}}\delta^{\frac{\delta}{\delta-1}}\right) - \frac{\delta}{1-\delta}\log\left(\frac{q_{r,ss}}{p_{r,ss}}\right) + \left(1-\frac{\delta_F}{1-\delta}\right)\log(T^F_{r,ss})$$

- Regression specification

$$\boxed{\log\left(\frac{T^F_{rt}}{T^A_{rt}}\right) = \alpha_{s(r)t} - \frac{\delta}{1-\delta}\log(v_{rt}) + \left(1-\frac{\delta_F}{1-\delta}\right)\log(T^F_{rt}) + \epsilon_{rt}}$$

Estimating δ_F: results

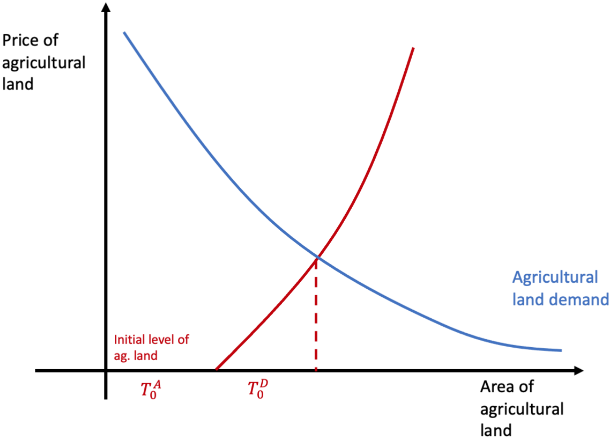
Table: Dep. var: log((Forest Area)/(Agri. Area))

	(1)	(2)	(3)
log(Unprotected Forest Area)	0.668***	0.589***	0.571***
	[0.004]	[0.004]	[0.004]
log(vr)		-0.419***	-0.357***
		[0.005]	[0.007]
State X Year FE	Yes	Yes	Yes
Weight	Agri. Area	Agri. Area	Agri. Area
Sample			Low deforest.
R2	0.735	0.793	0.805
Observations	28244.000	27875.000	16899.000

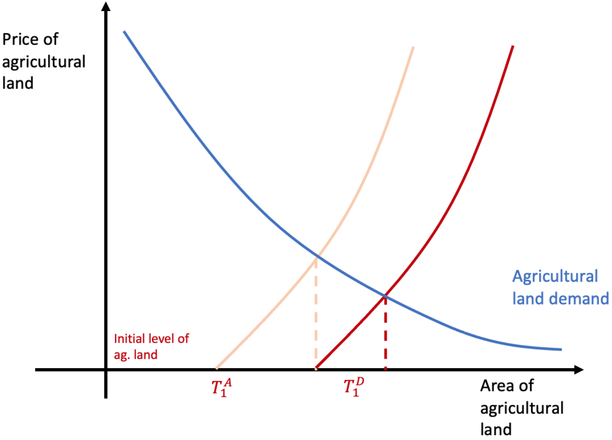
- Implied δ: 0.26-0.29
- Implied δ_F: 0.30-0.32

back to optimal deforestation back to parameters

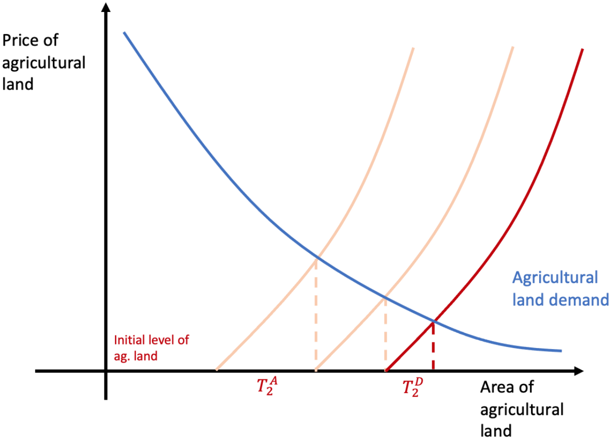
Supply of deforestation is more elastic in the long-run



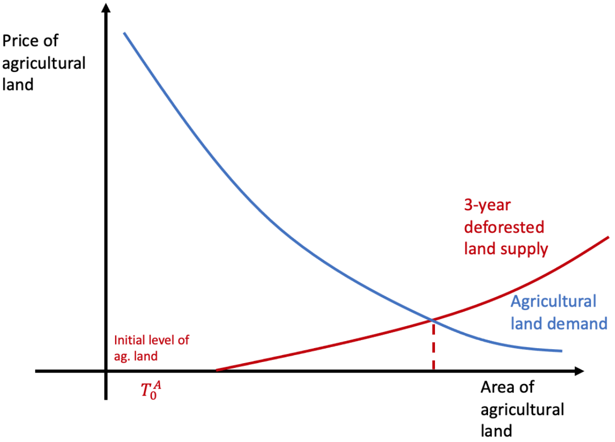
Supply of deforestation is more elastic in the long-run



Supply of deforestation is more elastic in the long-run



Supply of deforestation is more elastic in the long-run



With some forest regeneration | back to deforestation definition | back to aggregate land market

Land shares by crop

crop k	land share α_k
banana	.033
tobacco	.051
cotton	.062
palmoil	.071
coffee	.080
coconut	.085
orange	.096
rubber	.116
tea	.116
cocoa	.127
rice	.152
sugar	.206
groundnut	.297
soy	.357
maize	.378
barley	.461
wheat	.808
sorghum	.840
all crops	.3

back

Engel Curve - regression

Table: Dep var: log Share of Expenditure or Income spent on Food

	(1)	(2)
Log(Non-durable Expenditure)	-0.506***	
	[0.005]	
Log(Income)		-0.575***
		[0.008]
Constant	0.914***	0.632***
	[0.025]	[0.056]
R^2	0.309	0.195
Dep. Var. Mean	-1.730	-3.229
Observations	45322	45322

Note: *p<0.1, **p<0.05, *** p<0.01.

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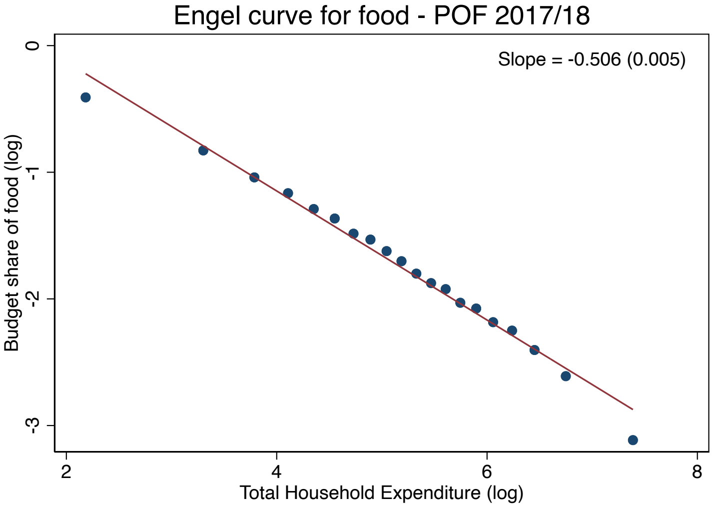
Engel Curve



back

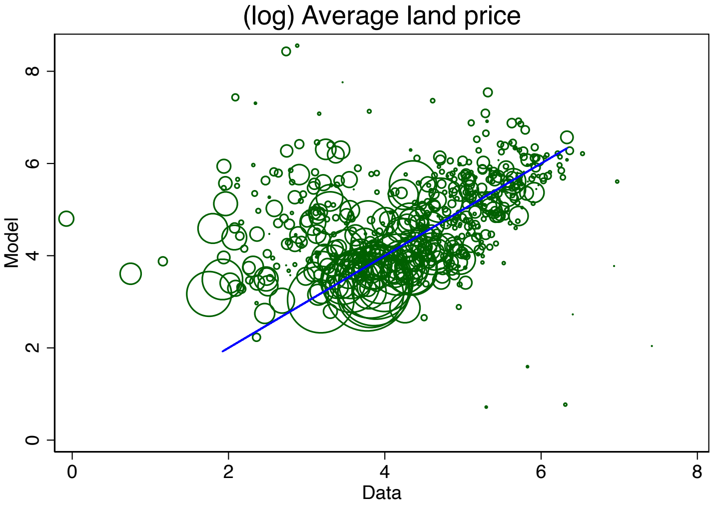
What explains deforestation in the model?

Table: Dep. var. (log) Deforestation

	(1)	(2)	(3)	(4)
(log) Area Natural	0.72***	0.63***	0.16***	-0.00*
	[0.01]	[0.01]	[0.01]	[0.00]
(log) temp. crops TFP	-0.26***	-0.20***		0.10***
	[0.03]	[0.03]		[0.00]
(log) perm. crops TFP	-0.11***	-0.03		0.00
	[0.02]	[0.03]		[0.00]
(log) pasture TFP	-0.27***	-0.38***		1.14***
	[0.04]	[0.04]		[0.01]
(log) non-ag TFP	0.62***	0.57***		-0.39***
	[0.03]	[0.03]		[0.00]
(log) Market acces		-0.32***		0.26***
		[0.03]		[0.00]
(log) Deforestation TFP			1.26***	1.90***
			[0.01]	[0.00]
R^2	0.455	0.463	0.823	0.987
Dep. Var. Mean	2.69	2.69	2.69	2.69
Dep. Var. SD	1.95	1.95	1.95	1.95
Observations	8587	8587	8587	8587

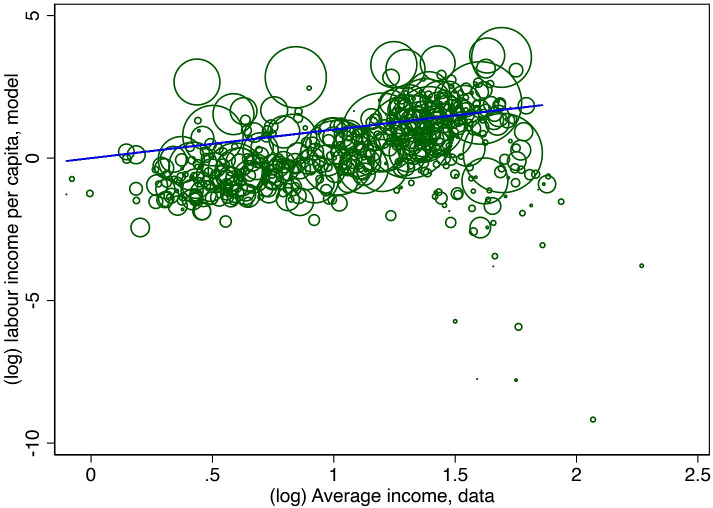
back to model inversion

Model validation: land rental rates



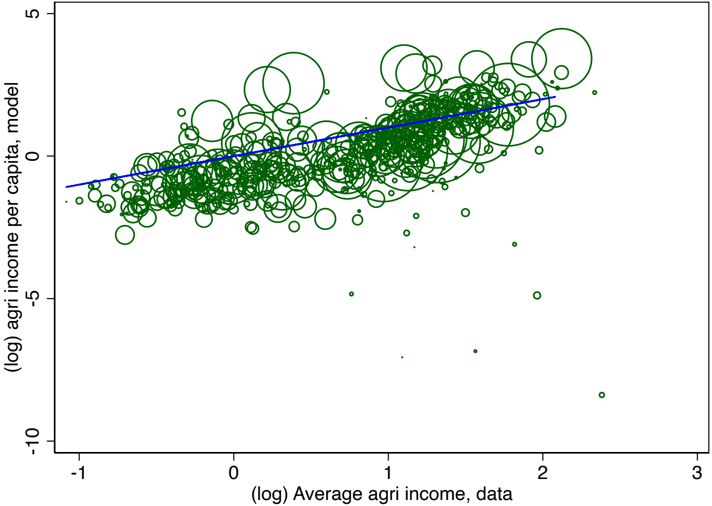
back to model inversion

Model validation: wages



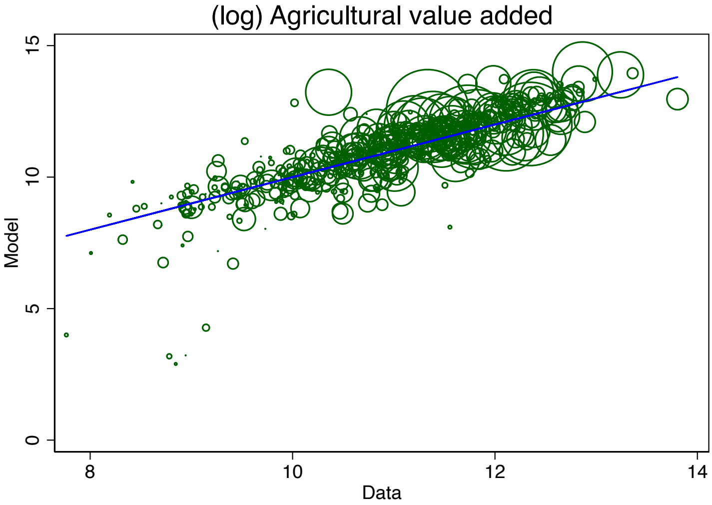
back to model inversion

Model validation: wages (agriculture)



back to model inversion

Model validation: agricultural value added

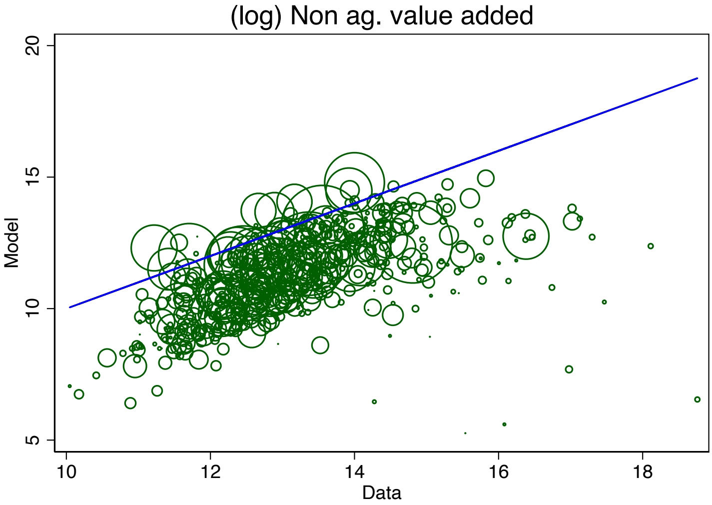


back to model inversion

Model validation: agricultural value changes

back to model inversion

Model validation: non-agricultural value added

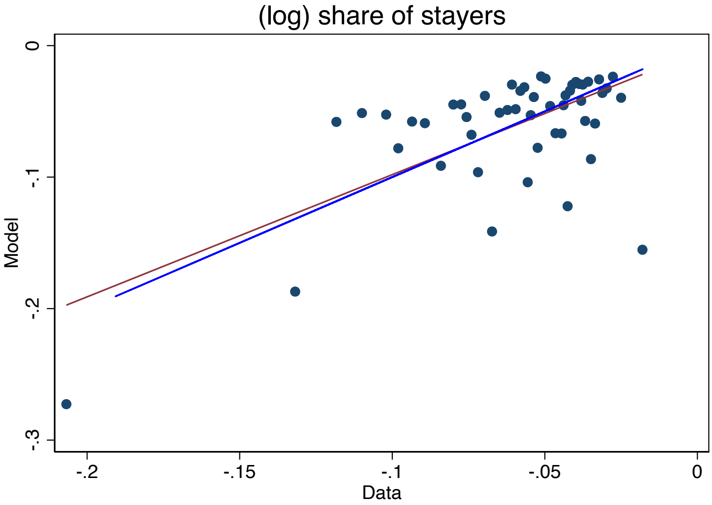


back to model inversion

Model validation: non-agricultural value changes

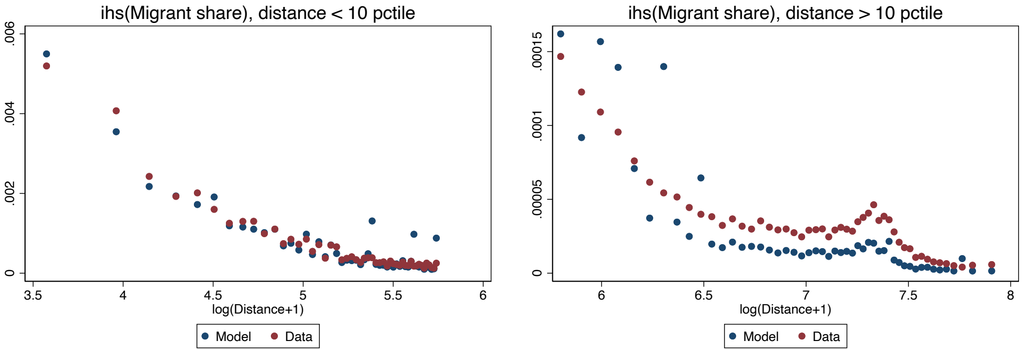
back to model inversion

Model validation: migration shares



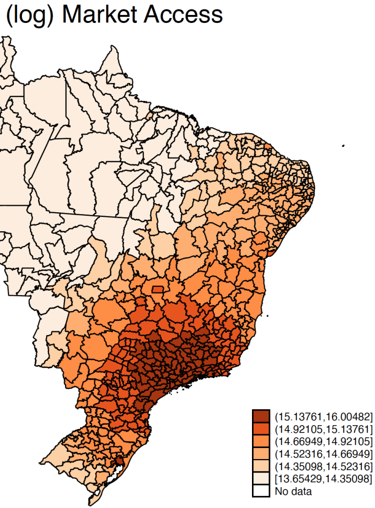
back to model inversion

Model validation: migration shares as a function of distance



back to model inversion

Market access: $\approx \sum_d \tau_d^r L_d$



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Policy counterfactual: GDP

Percentage change in GDP relative to no-policy scenario

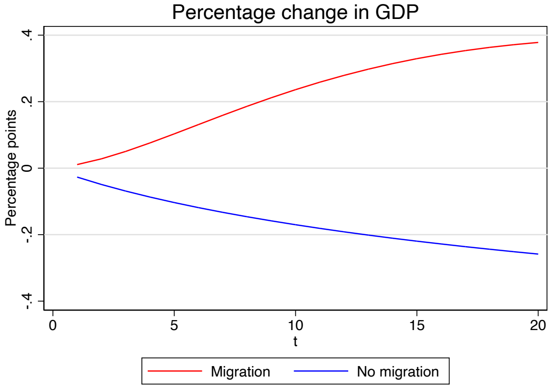

Figure: Changes in real GDP (1994 prices) Right: in absolute terms, Left: percentage change with respect to no-policy baseline

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Policy counterfactual: Changes in agricultural share

- Even though there is less agricultural land, the employment in the sector goes up
- Switch towards more labour-intensive activities (pastures $\rightarrow$ crops)

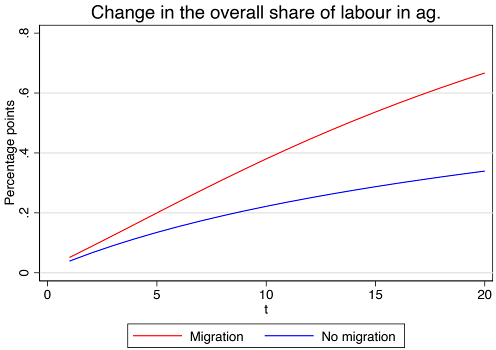

Figure: Changes in share of labour in agriculture

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Policy counterfactual: Crops-pasture substitution

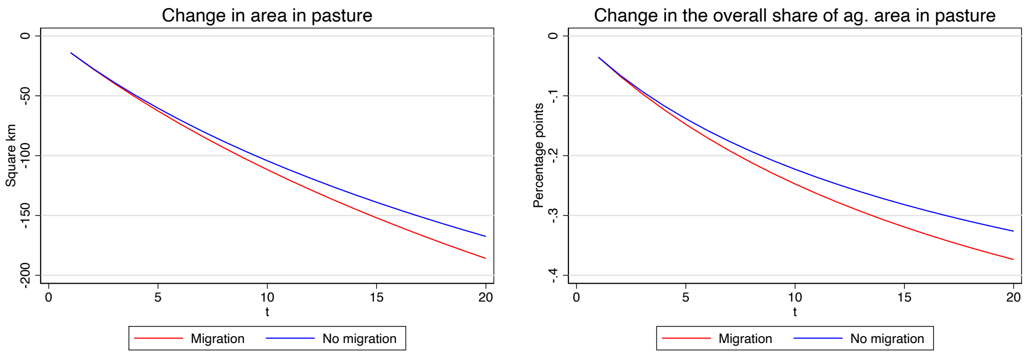

Figure: Changes in the agricultural land in pasture. Right: in absolute terms (sq km), Left: change in the share of agricultural land in crops

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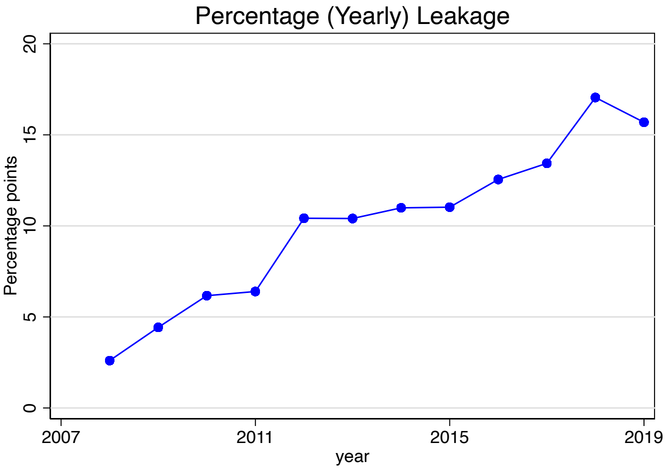
Counterfactual: yearly leakage over time



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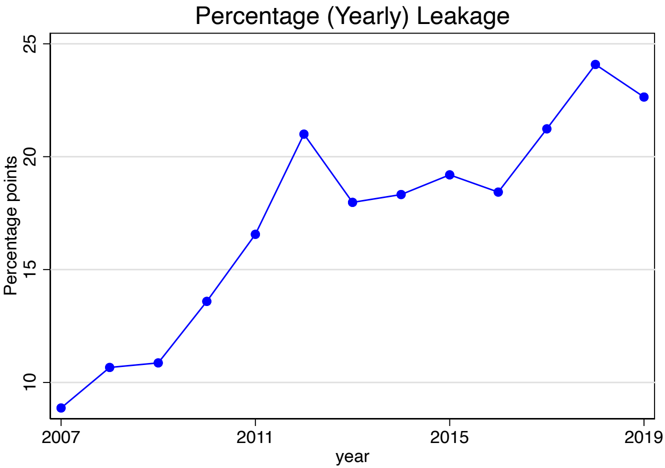
Counterfactual: yearly leakage over time



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Overall robustness and sensitivity to δ

- Preference parameters: $\phi = 0.1$; $\nu \in \{0.3, 0.5, 0.7\}$; $\eta = 0.506$; $\gamma \in \{0.7, 0.9\}$; $\sigma \in \{2, 4, 8, 10\}$; $\theta \in \{2, 4, 8, 10\}$
- Migration parameters: $\kappa \in \{1, 10, 100\}$
- Production parameters: $\alpha_{crops} \in \{0.3, 0.4\}$; $\alpha_{pasture} \in \{0.6, 0.8\}$
- Deforestation elasticity $\delta \in \{0.3, 0.5, 0.66, 0.8\}$

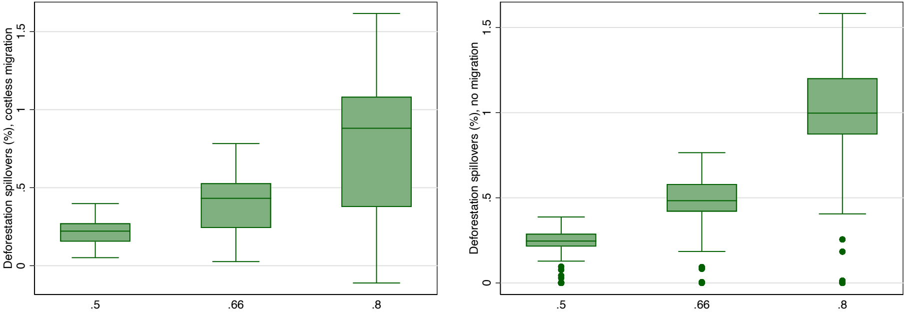

Figure: Spillovers for all values of the parameters described above, as a function of the deforstation elasticity δ. Right: no migration allowed. Left: costless migration.

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Sensitivity to θ and σ

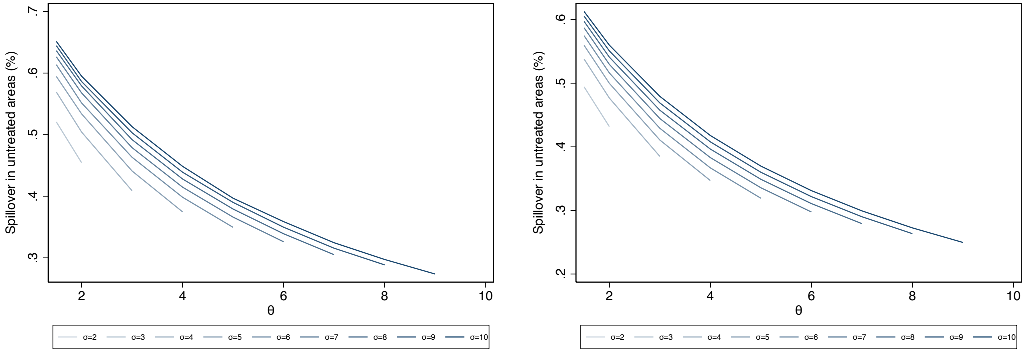

Figure: Spillovers for all values of the parameters as in baseline specification, varying the elasticities of substitution between origins σ and between agricultural commodities θ. Right: no migration allowed. Left: costless migration.

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Parameter effects on leakage

- Larger ϕ leads to smaller leakage.
- Larger ν tends to lead to larger leakage.
- Larger η leads to smaller leakage.
- Larger γ tends to lead to larger leakage. This makes sense because it means that relative crop prices have a larger effect on the share of expenditure in each crop
- Larger σ tends to lead to larger leakage. This makes sense as it means that products from different regions are closer to being perfect substitutes for one another.
- Smaller θ tends to lead to larger leakage. This makes sense as it means that pastures, which is the main agricultural product from regions with a lot of deforestation, is not easily substitutable for crops, which require less land for their production.
- Larger κ tends to lead to larger leakage.
- Larger α_k tends to lead to larger spillovers, all else equal, as this makes agriculture more “land thirsty”.
- Larger δ, unsurprisingly, tends to lead to larger spillovers. This means that when deforestation is more responsive to land prices, there are more GE effects.

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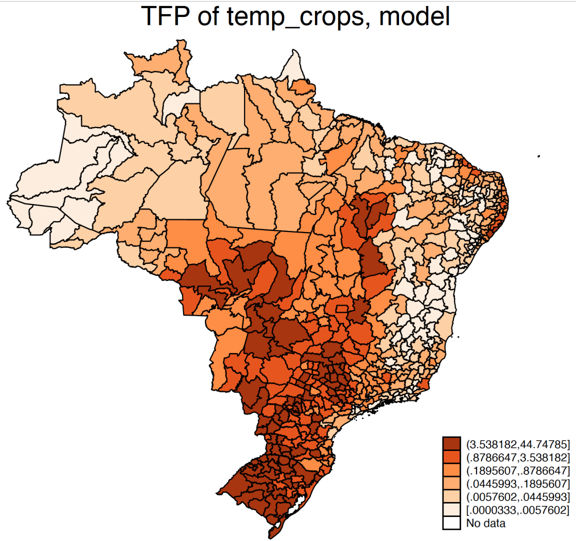
Agricultural TFP - temporary crops



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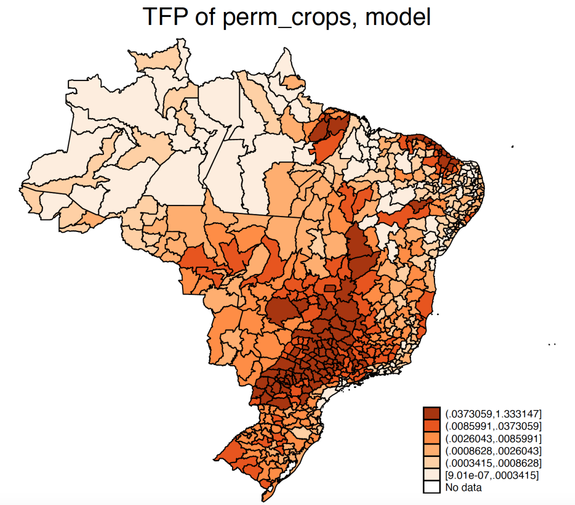
Agricultural TFP - permanent crops



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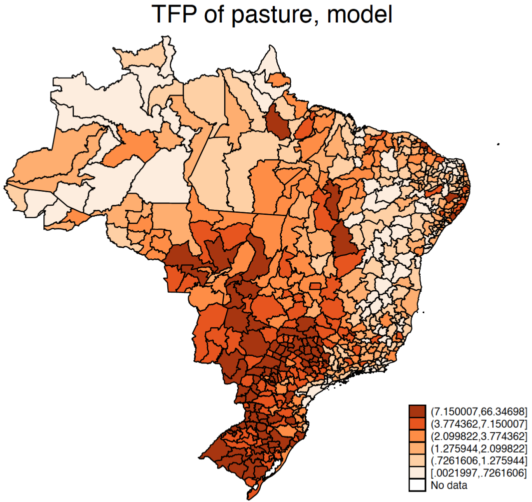
Agricultural TFP - pastures



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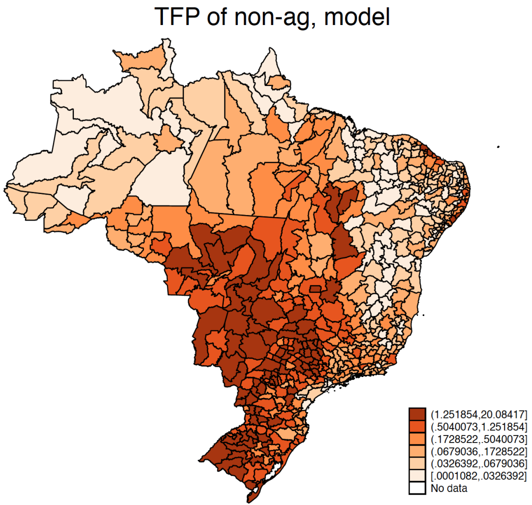
Non agricultural TFP



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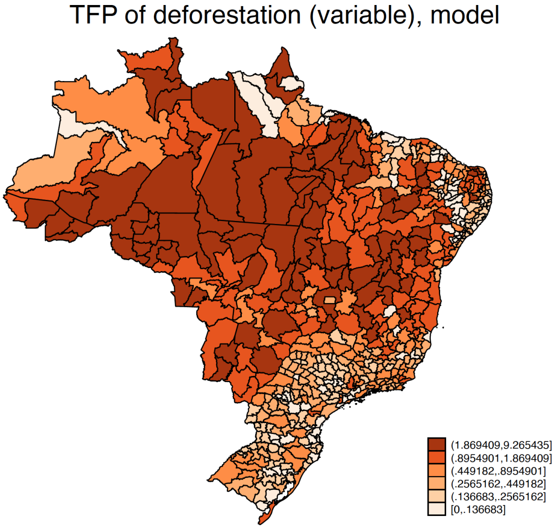
Deforestation TFP



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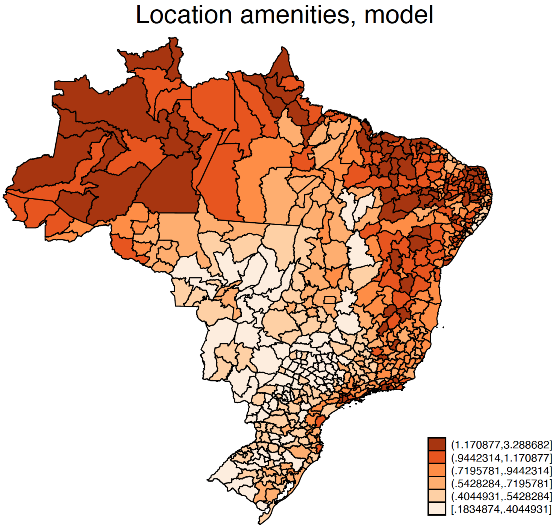
Amenities



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