Carbon prices and reforestation in tropical forests

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Based on work with Juliano Assunção (Climate Policy Initiative and PUC-Rio), Lars P. Hansen (University of Chicago), and Todd Munson (Argonne National Laboratories)

Motivation I

- Brazilian Amazon occupies 60% of the 2.7 million square miles that comprise the Amazon.
- Area the size of Texas has been deforested in Brazilian Amazon.
- 85% of deforested and not yet abandoned land dedicated to low productivity beef cattle.
- Destruction of forest has not helped to alleviate poverty in Brazil
  - Income of agricultural workers in legal Amazon was 829 reais/month in 2019, only 83% of Brazilian already low minimum wage.
  - 85% informal
- In Amazon, trees can store 500/550 tons of CO_2 per hectare.
- Low and declining productivity has led to 20% of deforested land being abandoned and are experiencing large-scale reforestation.
- Highlights opportunity for (passive) reforestation.
- Deforestation was ecological and economic disaster, but now great opportunity.

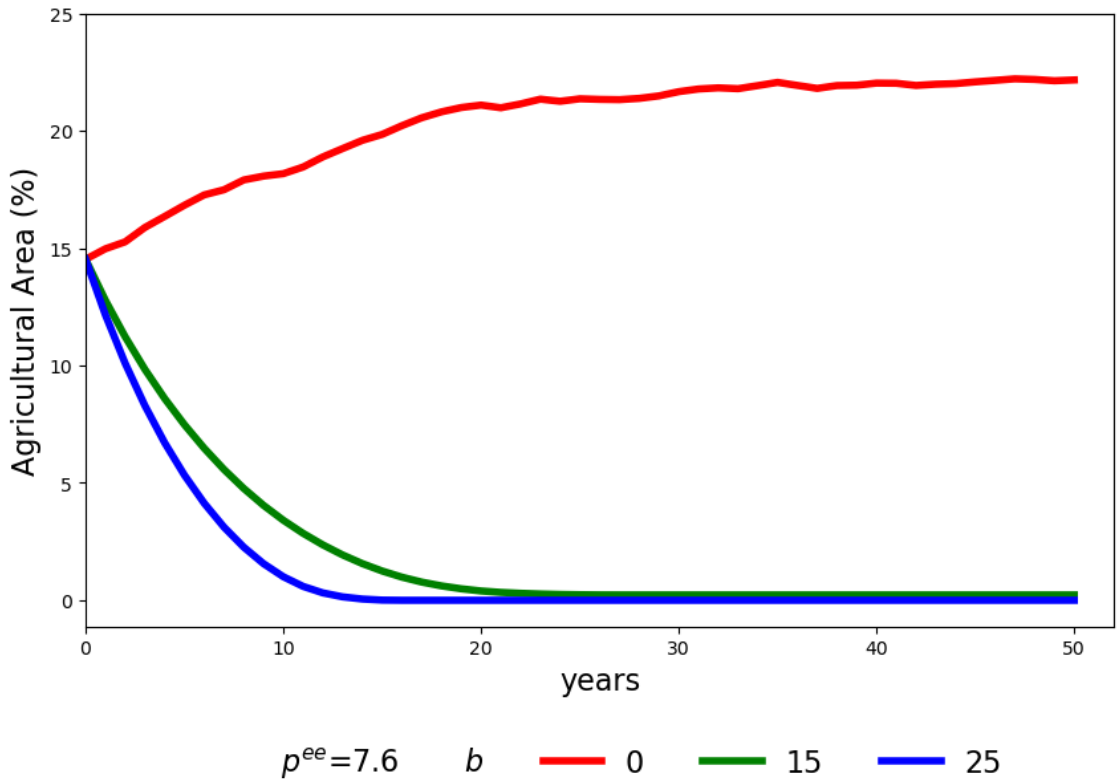
Carbon prices and reforestation I

- Assunção, Hansen, Munson and S. [2023]
- Investigate potential social gains of preservation and reforestation in the Brazilian Amazon through lens of a a dynamic and spatial optimization model that considers the trade-off between cattle production and carbon capture.
- Model is quantitative and uses detailed spatial information from multiple data sets.
- To account for cross-sectional variability, model considers detailed division of the Amazon into various sites.
- In paper model accounts for uncertainty in crucial parameters (sometimes referred to as deep uncertainty)
- Bottom line: With modest prices for CO_2, Brazilian Amazon would produce noticeable CO_2 capture.

Brazilian shadow price

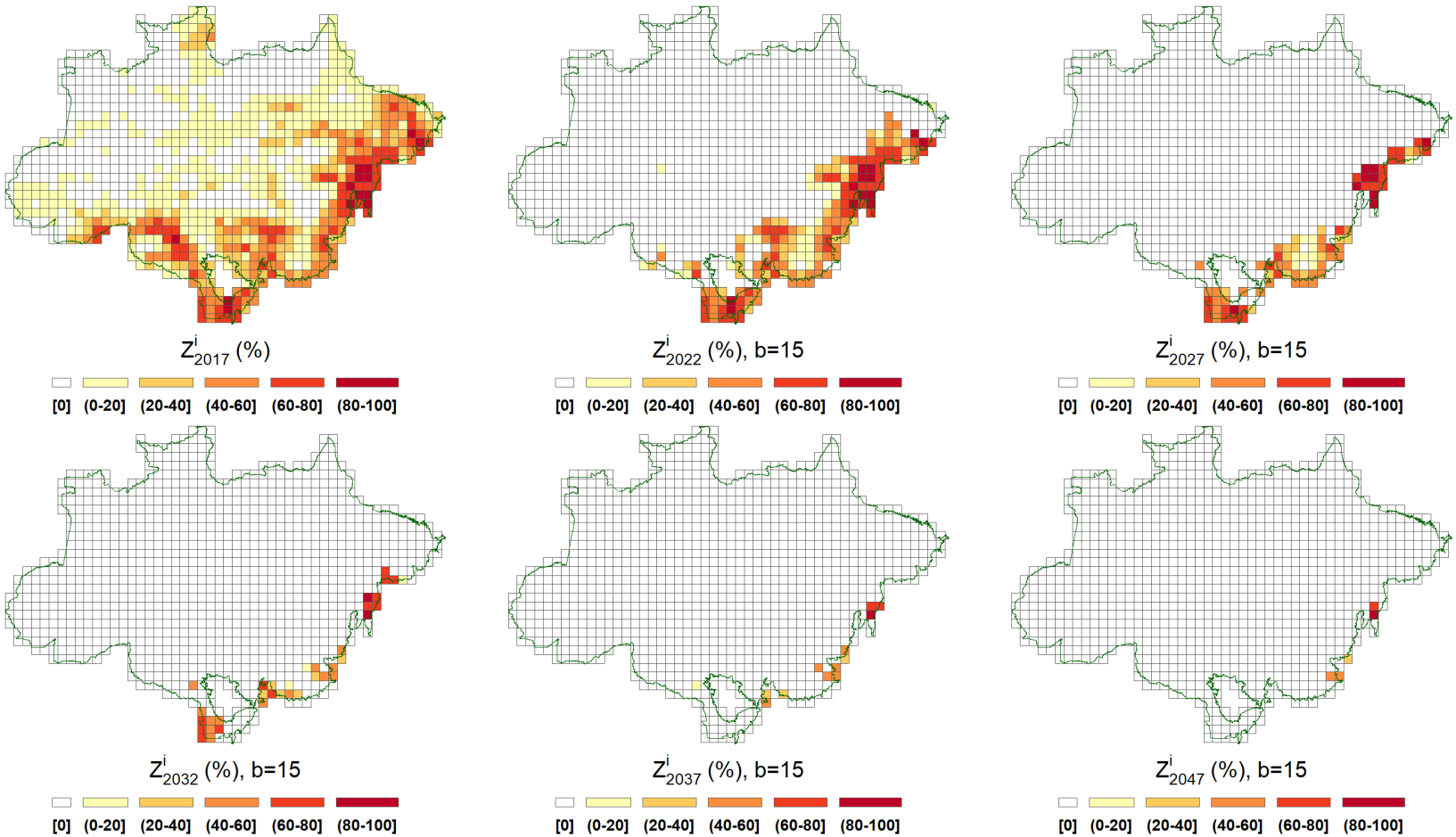
- First use model to elicit an estimate of the "shadow price" of CO_2 emissions revealed by the deforestation that actually occurred in 1995-2008.
  - "Revealed preference"
  - Shadow price also reflects value of forest services.
- Shadow price $\sim$\$7.
- Use this shadow price to predict *business-as-usual* trajectory.
- Then consider the effect of adding payments of $\$b$ per **net** ton of CO_2 captured, $b = 10, 15, 25...$
  - **No payment for simply preserving.**

Effect of transfers



- Business-as-usual causes deforestation sufficient for hydrological cycle of Amazon becoming unable to support rain forest in certain areas. (Flores et al. [2024])
- In contrast, even $b = 15$ produces substantial reforestation.

Evolution of occupation by agriculture, $b = 15$



Planner Value Decomposition (200 years)

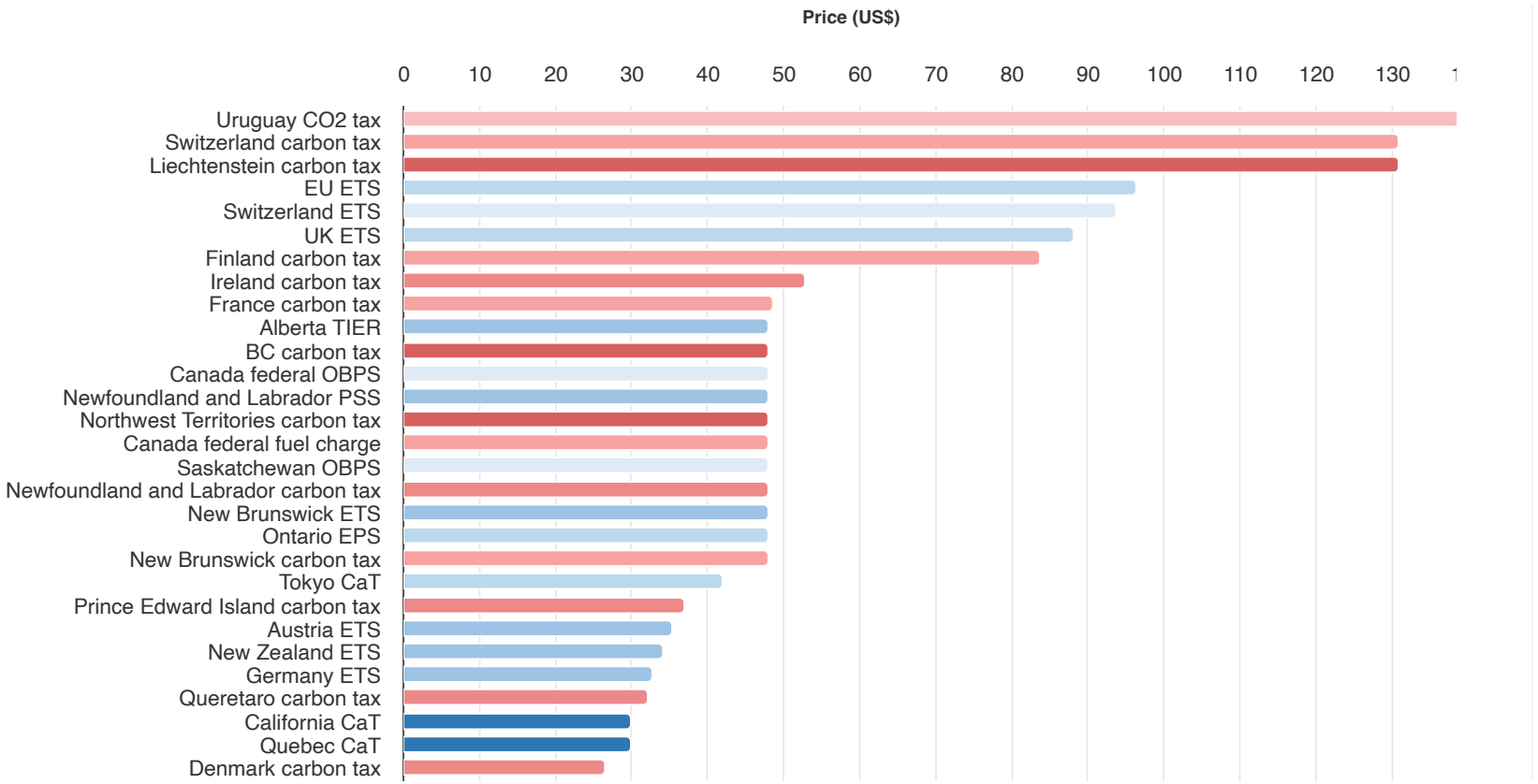
b ($)	Agricultural Output Value ($ billion)	Net Transfers ($ billion)	Forest Services ($ billion)	Adjustment Costs ($ billion)	Planner Value ($ billion)
0	372.86	0.00	-139.75	7.69	225.42
5	133.26	30.43	46.26	5.64	204.31
10	57.72	116.05	88.20	11.73	250.24
15	33.29	197.21	99.92	17.63	312.78
20	23.60	274.68	104.38	22.49	380.16
25	18.69	350.92	106.68	26.63	449.67

Notes: Forest services are calculated using baseline shadow price ($b = 0$)

Gains from trade

- Business as usual would **emit** 18 Gigatons of $C0_2$ in 30 years.
- If $b = 25$ would **capture** 15 Gigatons.
- Emissions Δ of -33 Gigatons when b changes from 0 to 25.
- Effective cost \$8.7 per ton
- 2/3 of change in first 15 years.
- Compare with current $1.5^{\underline{o}}$ budget $\sim$ 250 Gigatons (Lamboll et al. [2023])

Carbon prices above $25 (World Bank)



- Economic efficiency implies all carbon prices should be the same.
  - Rationale behind ETS

Implementation

- Implementation should be done in scale.
  - Minimize edge effects caused by contact of preserved areas with human activity.
    - No large natural fires in Amazon.
  - Experience in Brazil shows that using satellite data allows for deterrence at low cost (Assunção et al. [2022]).
- Values table shows Brazil would sign agreement to receive (pay) $b = 25$ dollars for each ton of CO_2 captured (emitted) in the Brazilian Amazon.
- However mature forests reach an equilibrium, and value of transfers eventually converge to zero.
- To avoid defection for next 50 years:
  - Payers could add a bond of \$8.2 billion payable if no deviation in land use trajectory in 50 years.
  - Brazil could post a bond of \$8.2 billion payable if deviation occurs within 50 years.
  - Payers should commit to boycott Amazonian agriculture.

Conclusions

- With modest prices for CO_2, Brazilian Amazon would produce noticeable CO_2 capture.
  - Compared to IPCC budget
  - Compared to Griscom et al. [2017] that identify and quantify natural climate solutions.
- Prices are modest when compared to carbon markets or with other CCS schemes (US IRA, \$60/ton)
- Results here ignore
  - Findings in Araujo, Assunção, Hirota and S. (PNAS, 2023) that show that deterioration of forest in an area of Amazon causes deterioration in other areas that, on average, double the damage.
  - Impact on biodiversity
- Most probably similar results for other tropical forests.

References I

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