Deforestation

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Deforestation is a major source of global carbon emissions

1. **Agricultural production** is the main driver
2. **Firm-level modeling** should inform policy analysis
3. **Trade and migration** shape the impacts of regulation
4. **Political challenges** constrain regulation

Global context

- 2.5 million km^2 of tropical forest lost (2001–2024)
  - Area comparable to France, Spain, Germany, Italy combined
  - 14% of global carbon emissions (Friedlingstein et al. 2019)

- The consequences go beyond carbon emissions
  - Biodiversity loss, air pollution, rainfall disruption, ecosystem collapse
  - Including in lower-income countries that rely on forest ecosystems

Hotspots: Brazil and Indonesia

- Top two countries for annual forest loss (2001–2024)
  - The DRC is also important and understudied
- Brazil: cattle ranching and soy
  - Forest Code protects the Legal Amazon (*Amazônia Legal*)
  - From 2004, PPCDAm and satellite monitoring cut deforestation in half
  - From 2012, weakened enforcement reversed progress
- Indonesia: palm oil
  - Central government controls the forest estate (*kawasan hutan*)
  - 15% of total land area cleared for palm plantations, often with fire
  - Widespread destruction of carbon-rich peatland forests

1. Agricultural production is the main driver

- **Productivity improvements** can lead to intensification or expansion
  Assunção et al. (2016), Abman et al. (2020), Abman & Carney (2020), Carreira et al. (2024), Farrokhi et al. (2025)

- **Policy interventions** reshape incentives and enforcement
  Assunção et al. (2013, 2019, 2022, 2023), Gandour et al. (2019), Harding et al. (2021), Burgess et al. (2023), Ferreira (2023), Reynaert et al. (2024)

- Poverty-reduction programs can increase or decrease deforestation
  Alix-Garcia et al. (2013), Jayachandran et al. (2017), Simonet et al. (2019), Cisneros et al. (2022), Linsenmeier (2024) Jack et al. (2025), Pagel & Sileci (2025), Saavedra (2025), Wong et al. (2025)

The productivity debate

- **Borlaug Hypothesis:** higher productivity → less land clearing (intensification)
- **Jevons Paradox:** higher productivity → more land clearing (expansion)

- Theoretically, depends on the elasticity of demand (Farrokhi et al. 2025)
  - With inelastic demand, higher productivity reduces prices and reduces expansion

- Evidence aligns with theory
  - Intensification: smallholders, local markets (Abman et al 2020, Abman & Carney 2020)
  - Expansion: commercial agriculture, global markets (Carreira et al. 2024)

Policy interventions in agriculture

- Brazil's policy mix under *PPCDAm* Action Plan in the 2000s
  - DETER satellite monitoring allows real-time detection (Assunção et al. 2023)
  - Credit restrictions tied to compliance with regulation (Assunção et al. 2019)
  - Protected areas have modest effects (Reynaert et al. 2024)
  - But targeted "Priority List" is effective (Assunção et al. 2022)

- Effectiveness varies with underlying pressure
  - From commodity markets (Harding et al. 2021)
  - From politics (Burgess et al. 2023)

Aligning poverty reduction and jobs with conservation

- **Direct payments** show promise
  Jayachandran et al. (2017), Simonet et al. (2019), Cisneros et al. (2022)
- Cash transfers have mixed outcomes
  - Mexico's *Oportunidades* increased deforestation (Alix-Garcia et al. 2013)
  - Brazil's *Bolsa Verde* reduced deforestation (Wong et al. 2025)
- Alternative pathways
  - Tourism and ecotourism (Linsenmeier 2024, Saavedra 2025)
  - Reforestation jobs (Pagel & Sileci 2025)

Policy takeaways and future work

- We need **productivity programs** that promote intensification, not expansion
- We need **credible enforcement tools**
  - Satellite monitoring, conditional credit, targeted enforcement
  - Credibility is key for unlocking carbon credit revenue
- We need to align **economic opportunity** with conservation
  - Steering jobs away from forest-degrading sectors
- We need **sustained political commitment**
  - Effective policies unravel quickly when support erodes

2. Firm-level modeling should inform policy analysis

- Rich models of **land-use decisions** allow us simulate hypothetical regulation
  Reis & Guzman (1992), Nelson & Hellerstein (1997), Pfaff (1999), Cropper et al. (1999), Souza-Rodrigues (2019)

- **Dynamic frameworks** capture switching costs, expectations, and persistence
  Stavins & Jaffee (1990), Stavins (1999), Scott (2013), Araujo et al. (2024), Assunção et al. (2024), Hsiao (2025), Scott et al. (2025)

- Other models integrate climate feedbacks, energy markets, and market design
  Heilmayr et al. (2020), Araujo (2024), Aronoff & Rafey (2024), Sant'Anna (2024), Araujo (2025), Aspelund & Russo (2025)

Policy takeaways and future work

- We need to consider **market incentives**
  - Conservation payments and land-use taxes can be cost-effective
- We need to incorporate **dynamic responses**
  - Firms respond differently to temporary and permanent shocks
- We need careful **program design**
  - Programs should target additionality and avoid perverse incentives

3. Trade and migration shape the impacts of regulation

- Deforestation exhibits **spatial concentration** and has **spatial spillovers**
  Asher et al. (2020), Araujo et al. (2023), Balboni et al. (2024), Gollin & Wolfersberger (2024), Leite-Mariante and Restrepo (2024), Akerman (2025), Madhok (2025)

- A **global perspective** captures impacts on international trade
  Copeland et al. (2022), Cherniwchan and Taylor (2022), Abman et al. (2024), Harstad (2024), Farrokhi et al. (2025), Hsiao (2025), Mishra (2025)

- Supply chains shape incentives by connecting local farmers to global markets
  Lambin et al. (2018), Barrozo (2024), Domínguez-Iino (2025)

Policy takeaways and future work

- We need to address **unintended consequences**
  - Infrastructure investments create spatial inertia, accelerating frontier expansion
  - Local regulation is undercut by global responses, which result in leakage
- We need stronger **coordination** across regulators
  - Regional authorities can internalize spatial spillovers
  - Trade agreements and coordinated tariffs can minimize leakage through trade

4. Political challenges constrain regulation

- Local **political incentives** and political cycles affect deforestation
  Burgess et al. (2012), Harstad & Mideksa (2017), Pailler (2018), Balboni et al. (2021), Cisneros et al. (2021), Bragança & Dahis (2022), Sanford (2023), Araujo et al. (2024), Cisneros & Kis-Katos (2024), Harding et al. (2024), Katovich & Moffette (2024), Hsiao & Kuipers (2025)

- Regulation induces **political resistance**, which can lead to repeal
  Burgess et al. (2023), Burgess et al. (2025), Costa et al. (2025)

- Dynamic problems arise because the incentives to regulate change over time
  Harstad (2016), Harstad (2023), Hsiao (2025)

Policy takeaways and future work

- We need to design policy that is **politically robust**
  - Electoral cycles, political rotation, short-term pressures, local incentives, elite capture
- We need a better understanding of **distributional effects**
  - Political distortions stem from the unequal incidence of regulation
- We need to focus on **second-best policies**
  - First-best policies are more efficient, but also infeasible

Summary

- Deforestation is central to our climate goals
  - We have made progress in understanding the key policy frictions
  - We need more work on the Congo rainforest and on biodiversity
- Important next steps for academics and policymakers
  - Achieving **economic development** alongside environmental protection
  - Leveraging **new data** to study firm choices and outcomes at scale
  - Developing **new policy tools** to ensure green trade and coordination
  - Emphasizing **political feasibility** in designing regulation