

## Banking on Forest

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## Finance Internal Seminar

May 28, 2025

## Deforestation of the Amazon rainforest

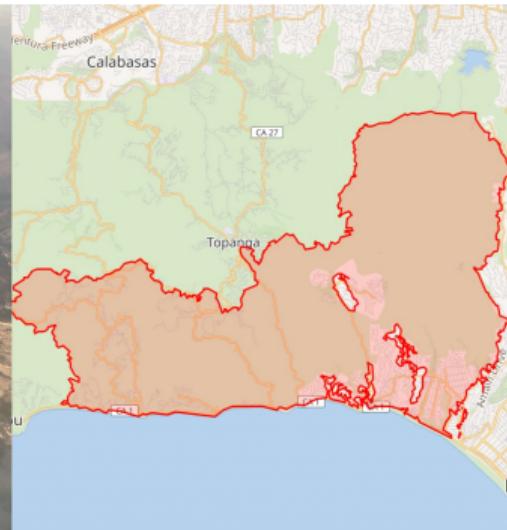
- By 2022, 26% of the Amazon was deforested 
  - Drivers: Cattle ranching & sugarcane, illegal logging, and agriculture



Sources: (1) Council on Foreign Relations; (fig 1) PARALAXIS on Shutterstock; (fig 2) Erick Caldas Xavier (Wikimedia Commons)

January 2025 Southern California wildfires

- \$135-270B economic losses; 16,000 structures destroyed; agricultural damage [▶ view case](#)



Sources: Euronews; Globaledge; Urbanland; Moody's; IQAir; (fig 1) Charles V Payne/X; (fig 2) woodlandsonline; (fig 3) Wikimedia Maps

# Forest loss and economy

- **Wildfires (natural disaster):** 23% of global forest loss
  - Hard to prevent (e.g., McWethy et al. 2019 *Nat. Sustain.*)
  - Threats to economy (e.g., 2018 CA wildfires: 1.5% state GDP damages)
  - Affect firm operation, even being insured (e.g., stated in SEC filings)
- **Human-induced factors:** 77% of global forest loss
  - A deliberate change for economic growth
  - Main factors: commodity, agriculture, forestry, urbanization<sup>1</sup>
  - Driver for carbon emissions (e.g., Houghton et al. 2012 *Biogeosciences*)
  - Regulation: European Union Deforestation Regulation. Proposed 2019; enforced 2023
  - Non-mandatory framework: e.g., REDD+ UNFCCC (2013); OECD-FAO (2016)

<sup>1</sup>Classification of forest loss follows Curtis et al. (2018 *Science*)

## What can banks do to mitigate deforestation risks?

- **Motivation: banks as a main debt holder in the capital market:**
    - Sensitive to firms' operation/performance
    - Climate change → firm losses → higher credit risk
  - **To mitigate physical risk:**
    - ① Reallocate lending to non-affected firms
    - ② Continue lending but increase pricing (e.g., Javadi & Masum 2021 *JCF*)
  - **To mitigate transition risk:**
    - ① Divest from "brown" & reallocate to "green" (e.g., Kacperczyk & Peydró 2021 *WP*)
    - ② Continue lending to "brown" → support green transition or increase pricing (e.g., Ivanov et al. 2024 *RFS*)
  - We focus on intensive margin instead of extensive (*divestment*)

## Main findings on loan pricing

- **Question:** How banks mitigate the physical risks and transition risks from forest loss
    - *Assumption:* forest-dependent firms are more affected
  - **Pricing realized physical risks**
    - After fire-induced forest loss, loan spreads for forest-dependent firms increase by 12–65 bps compared to other firms
  - **Pricing transition risks**
    - After human-induced forest loss, forest-dependent firms get higher spreads after the development of the EU Deforestation Regulation (more for EU banks and firms)

## Data and sample overview

- Key data:

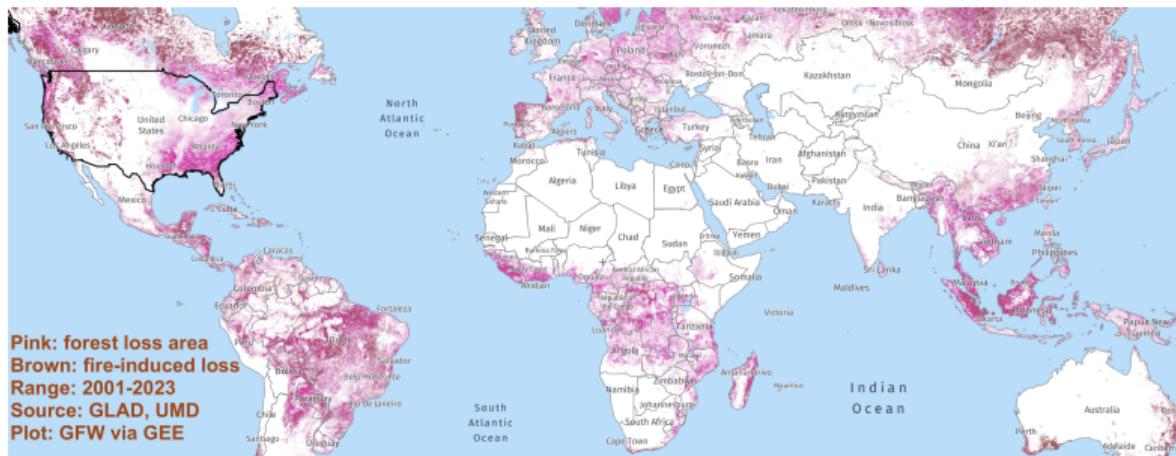
- Forest loss (geospatial): GLAD (Hansen et al. 2013 *Science*, Tyukavina et al. 2022 *Front. Remote Sens.*)
  - Forest dependency: ENCORE (UNEP)
  - Syndicated loans: DealScan
  - Supply chains & firm data: Compustat, Refinitiv
  - Reforestation (NDVI): NASA MODIS
  - Deforestation disclosures: Refinitiv AdvFil
  - Plant divestitures: EPA TRI, SDC M&A

- **Sample (loan-level):**

- 2002–2024; 42,590 obs (large-share lead arranger – deal – earliest tranche level)
  - 6,329 borrowers; 45% U.S., 13% EU, 75% OECD
  - 1,298 lenders; 25% U.S., 17% EU, 60% OECD

## Measures for firm-level forest loss

- GLAD laboratory (University of Maryland) geospatial data
    - High-resolution (30-meter) annual data: *gross forest cover loss* (Hansen et al. 2013 *Science*)
    - From 2000 to 2023, derived from Landsat (NASA) time-series imagery
    - *Definition* of loss: stand-replacement disturbance (forest to non-forest state)



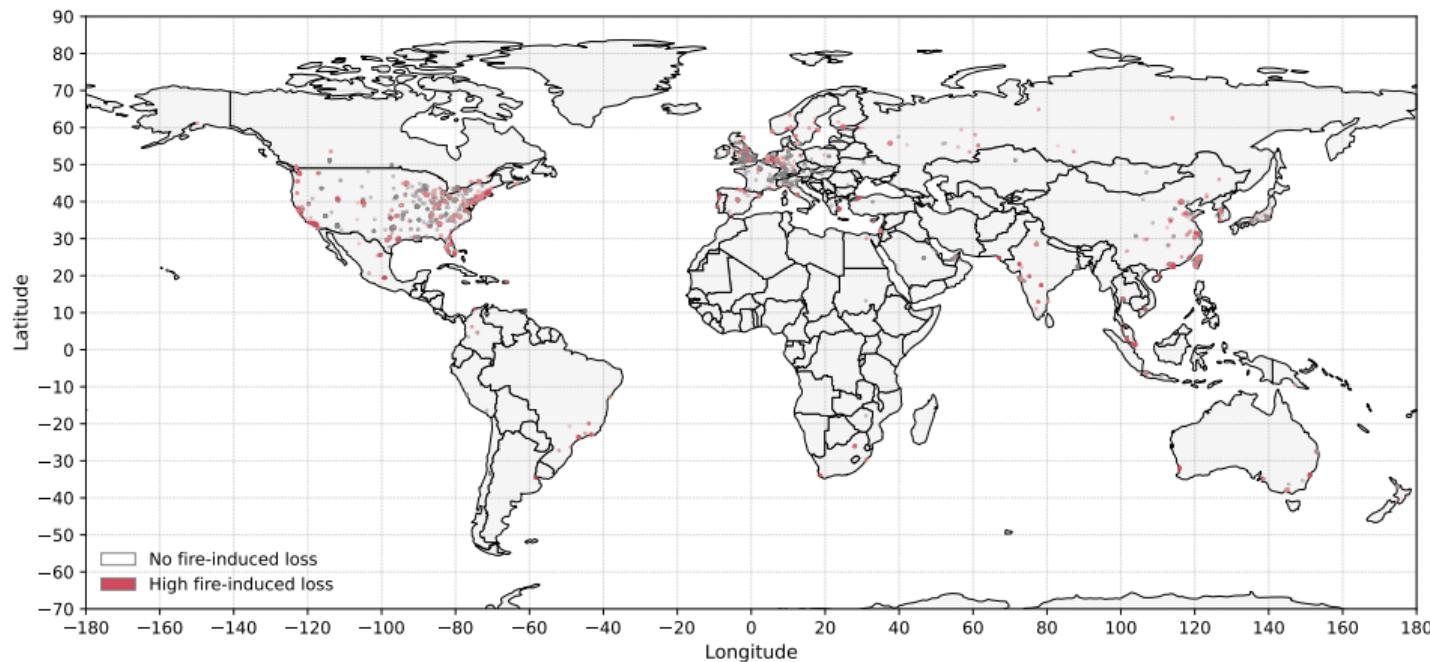
## Measures for firm-level forest loss

- Our analyses:
    - (1) Identify firm headquarters' geographic coordinates from address information
    - (2) For each firm, use *Google Earth Engine* to get annual gross forest loss area (in km<sup>2</sup>) within 10km around a firm
    - (3) Classify two types of loss: (a) forest loss from fires; (b) forest loss from human activities (*the loss area not induced by fires*)

Main drivers (global)	% of total forest loss	If external to firms	Our variables at firm-level
Wildfire	23%	Yes	<i>Fire loss</i>
Forestry	26%	No	<i>Human-induced loss</i>
Shifting agriculture	24%	No	<i>Human-induced loss</i>
Commodity-driven	27%	No	<i>Human-induced loss</i>
Urbanization	<1%	Unknown	<i>Human-induced loss</i>
<b>Total</b>	<b>100%</b>		<i>Annual gross forest loss</i>

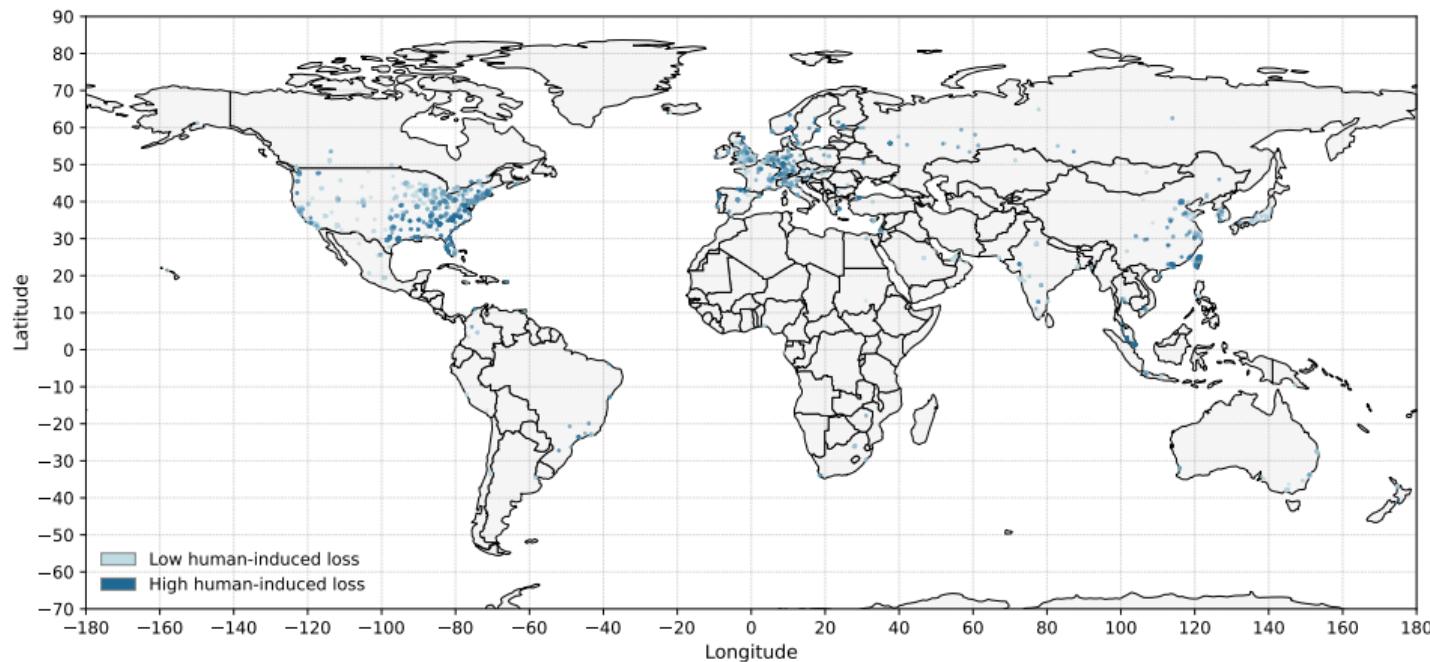
*Source for percentages:* Classifying drivers of global forest loss, Curtis et al. (2018 *Science*)

## Fire-induced forest loss of the sample firms in 2023



*Note:* The circles on the maps are visually enlarged, and do not represent the actual geographical areas

## Human-induced forest loss of the sample firms in 2023



**Note:** The circles on the maps are visually enlarged, and do not represent the actual geographical areas

## Forest dependency of production processes

- **Goal:** measure how much firms' production directly relies on forests
  - **Reason:** forest-dependent firms are more exposed/related to forest loss
    - e.g., large deforestation happened near *forestry* vs. *tech* firms
  - **ENCORE** data framework:
    - Natural capital → Ecosystem services → Industry production processes
    - *Example:* forests → plant materials → forestry production
    - Dependency rating: very low to very high (0–5)
  - **Dependency** (our main measure):
    - Select **forest-linked ecosystem services** → **Aggregate at industry** (GICS-production process)  
→ Match to borrowers via **2-digit SIC**
  - **Weighted dependency** (account for country deforestation):
    - $\text{Dependency} \times \underbrace{(1 + \text{normalized country-level forest loss})}_{= 1 \text{ for highest-deforestation country; } = 0 \text{ lowest}}$

## Baseline model: Linking forest loss and loan pricing

- **Hypotheses:** Banks care about forest loss only when—
    - Fire-induced loss triggers realized physical risk (e.g., disruption of raw materials)
    - Human-induced loss triggers transition risk (e.g., deforestation-related policy scrutiny)
  - **Identification logic:**
    - Local variation in forest loss over time (contrasting fire vs. human-induced loss)
    - Dependency varies by industry (minimal physical&transition risk if no dependence)
  - **Specification** (simplified for presentation):

$$\text{Yield spread}_{b,f,t} \sim \underbrace{\beta_3 (\text{Dependency}_i \times \text{Loss}_{f,t-1})}_{\text{differential pricing (fitted curve)}} + \underbrace{\text{Control variables}}_{\text{loan}_{b,f,t}, \text{bank}_{b,t-1}, \text{firm}_{f,t-1}} + \text{FE}$$

- If  $\beta_3 > 0$ : yield spread rises more when forest loss increases risk for high-dependency firms

## Baseline results

- At *Dependency* mean (0.91): 1 km<sup>2</sup> fire loss → 15 bps higher yield spread

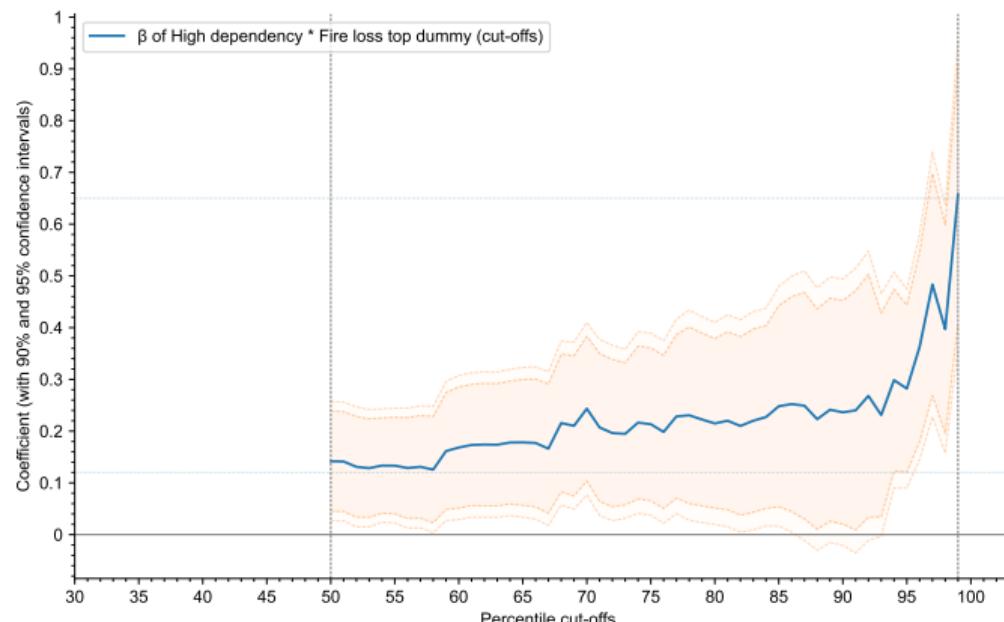
### *Dependent variable: Yield spread*

Dependency measures	Dependency				Weighted dependency	
	(1)	(2)	(3)	(4)	(5)	(6)
Dependency measure	-0.00745 (0.0740)	-0.00484 (0.0761)	-0.00721 (0.0758)	0.0000886 (0.0476)	0.0703 (0.103)	-0.0359 (0.0605)
<i>Fire loss</i>	-0.235* (0.134)		-0.238* (0.136)	-0.246* (0.129)	-0.238 (0.143)	-0.327* (0.165)
<i>Anthropogenic loss</i>		0.0349 (0.0439)	0.0373 (0.0432)	0.0570 (0.0355)	0.0574 (0.0480)	0.0265 (0.0295)
Dependency measure $\times$ <i>Fire loss</i>	0.425** (0.176)		0.424** (0.183)	0.415** (0.177)	0.527** (0.230)	0.586** (0.261)
Dependency measure $\times$ <i>Anthropogenic loss</i>		0.00219 (0.0279)	-0.00143 (0.0288)	-0.0115 (0.0278)	-0.0330 (0.0377)	-0.0140 (0.0290)
High-level industry FE	No	No	No	Yes	No	No
Bank $\times$ firm country FE	No	No	No	No	No	Yes
Adjusted R-squared	0.342	0.341	0.342	0.357	0.342	0.515

Note: (1) Obs: 42,590; (2) Year FE/Loan controls/Firm controls/Bank controls/Constant: YES

## Robustness: Fine percentile cut-offs

$$\text{Yield spread}_{b,f,t} \sim \beta_3 \underbrace{\mathbb{1}[\text{Dependency}_i > \text{median}] \times \mathbb{1}[\text{Fire loss}_{f,t-1} > \text{cutoff}]}_{\text{differential pricing (discrete effect)}}$$



## EU Deforestation Regulation: Transition risk

- **Goal:** Zero deforestation and degradation
    - Ban forest-to-agriculture conversion and unsustainable wood sourcing
  - **Due diligence:** Geolocation data, risk assessment and mitigation required
  - **Timeline:**
    - July 2019: European Commission proposed regulatory framework
    - June 2023: Entry into force, with 12-month additional phasing-in period
  - **Scope:** all firms operating/trading in the EU (products traced to origin)
  - **Identification logic:** EUDR increase transition risks for high-deforestation-risk firms
  - **Specification** (loan-level; simplified):

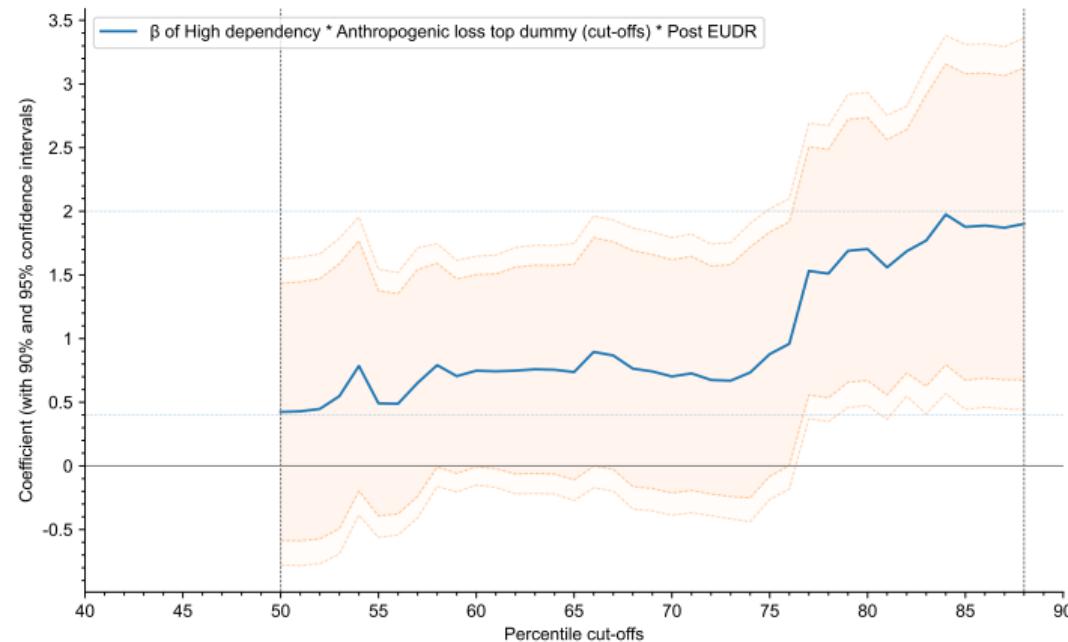
$$\text{Yield spread}_{b,f,t} \sim \beta_7 \underbrace{(\text{Dependency}_i \times \text{Loss}_{f,t-1})}_{\text{differential pricing (fitted curve)}} \times \underbrace{\mathbb{1}[\text{Period} > \text{July 2019}]}_{\text{post-EUDR effect}}$$

- If  $\beta_7 > 0$ : deforestation transition risk priced in after EUDR

EUDR policy shock: Findings

- **Global firm sample** ▶ view table
    - Include all firms, since EUDR applies to any firm operating in the EU
    - Post-EUDR: forest-dependent firms with human-induced loss face higher yield spreads
    - No effect for fire loss → reinforces transition-risk pricing channel
  - **EU lender–EU operator subsample** ▶ view table
    - Post-EUDR: Stronger differential pricing, with higher magnitude than global sample
    - No pricing response among non-EU lender–firm pairs
  - **Policy phase: Framework vs. Enforcement** ▶ view table
    - Pricing sharpens after enforcement (June 2023), compared to post-framework (July 2019)
    - Most visible for EU bank–EU firm pairs

### Robustness: Human-induced loss percentile cut-offs



*Note:* The sample is restricted to EU bank-EU firm lending pairs.

Credit supply side: Do committed banks price forest risk more?

- **Hypothesis:** Committed banks (those mentioning deforestation in disclosures) are more responsive to transition risk exposure
  - **Design:** Compare four groups: committed vs. non-committed banks, before vs. after EUDR, and re-estimate *Dependency*  $\times$  *Anthropogenic loss*
  - **Findings:** [▶ view table](#)
    - Post-EUDR, committed banks charge 17.6 bps higher spreads to forest-dependent firms (at mean 0.9) following 1 km<sup>2</sup> human-induced forest loss
    - No differential pricing pattern for non-committed banks
    - Suggests active pricing role from the credit supply side in response to transition risk

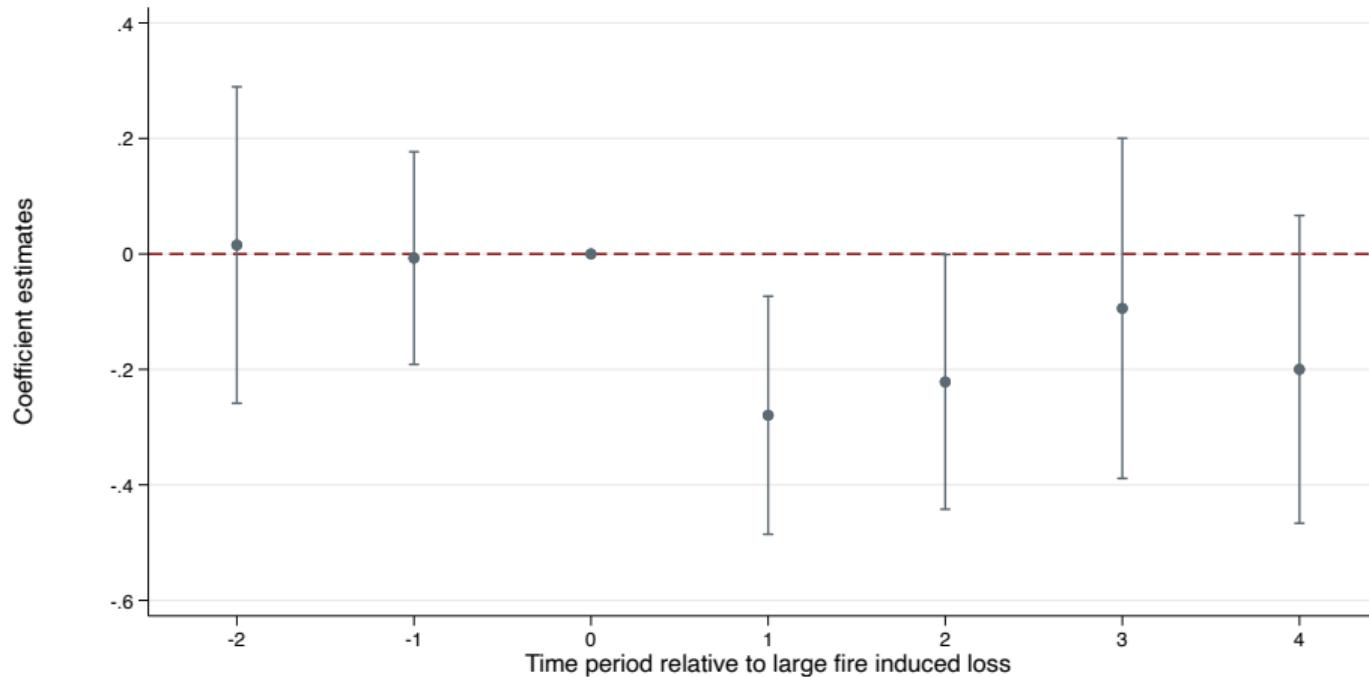
## Borrower side: Does firm commitment mitigate pricing?

- **Hypothesis:** Firms that disclose deforestation issues may be seen as more risk-aware and committed to mitigation
  - **Design:** Triple interaction — *Dependency* × *Anthropogenic loss* × *Firm commitment*
  - **Findings:** [▶ view table](#)
    - No pricing effect before EUDR
    - After EUDR: committed firms face lower yield spreads
    - Results are consistent when using E-score as an alternative commitment proxy

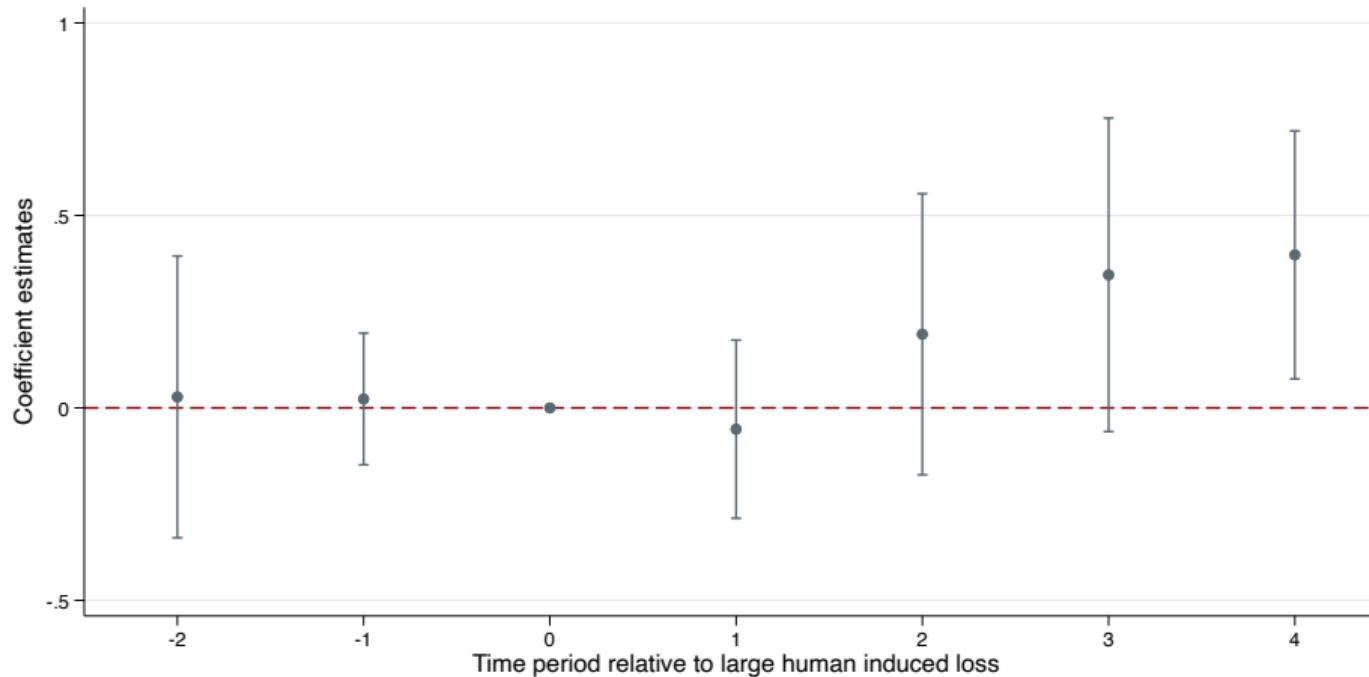
#### Mechanism: Forest loss and firm operation

- **Motivation:** Wildfires can damage assets & operations (e.g., Portugal 2017 wildfire, Lopes and Póvoa 2022 *J. Real Estate Finance Econ.*)
  - **Question:** Do banks price *real disruptions* or just *perceived risk*?
  - **Design:**
    - Compare firm operating cash flow before/after large forest loss event
    - *Top dependency* = 1 if in top 30% by forest dependency
    - *Post large loss* = 1 if after large fire or human-induced event
  - **Findings:**
    - **Fire loss** → cash flow declines for forest-dependent firms
    - **Anthropogenic loss** → no immediate operational impact
    - Suggests banks price fire loss due to **liquidity risk**, not just perception

## Dynamic effects of large fire loss on firm cash flow



## Dynamic effects of large human-induced loss on firm cash flow



## Ex-post: Do loans facilitate green transition?

- **Hypothesis:** If a high-transition-risk firm (from large human-induced loss) get loans → banks and firms might both engage in green transition → (1) **Production** shift (away from deforestation inputs); (2) **Reforestation**; (3) **Divestiture** of pollutive plants
    - No effect expected after fire-induced loss (firms do not have different effect of loan engagement in mitigating transition risk)
  - **Specification** (firm-event level; simplified):

$$\text{Outcome}_{f,t+\tau} \sim \beta_3 \underbrace{\mathbb{1}[t > \text{Large anthropogenic loss event}] \times \mathbb{1}[\text{Get loan at } t \text{ or } t+1]}_{\text{loan effect after large deforestation event}}$$

- If  $\beta_3 > 0$ : loan facilitates post-deforestation adjustment
  - Subsample or interaction tests for high *Dependency* (more exposed)
  - $\tau > 1$ : restrict timelines to: loss event → if get loan → future outcomes
  - Balanced 3-year estimation window; exclude overlapping events

### Ex-post outcomes and findings

- **Production sourcing** ▶ view details ▶ view table
    - *Supply dependency*: share of inputs from forest-dependent suppliers → **Firms maintain forest inputs — no broad production shift**
    - *Country-adj supply*: inputs from forest-dependent suppliers in high-deforestation-risk countries → **Firms redirect toward responsible sourcing**
  - **Environmental recovery** ▶ view table
    - *NDVI (NASA)* greenness index, , or disclosed *reforestation offset programs*: → **Reforestation increases after loans — stronger for high-dependency firms**
  - **Asset divestiture** ▶ view table ▶ view discussion on selection and alternative measure
    - *Divestiture of pollutive plants*: pollutive facilities sold after loan receipt → **Firms divest forest-dependent pollutive plants post-loan**

## Key takeaways

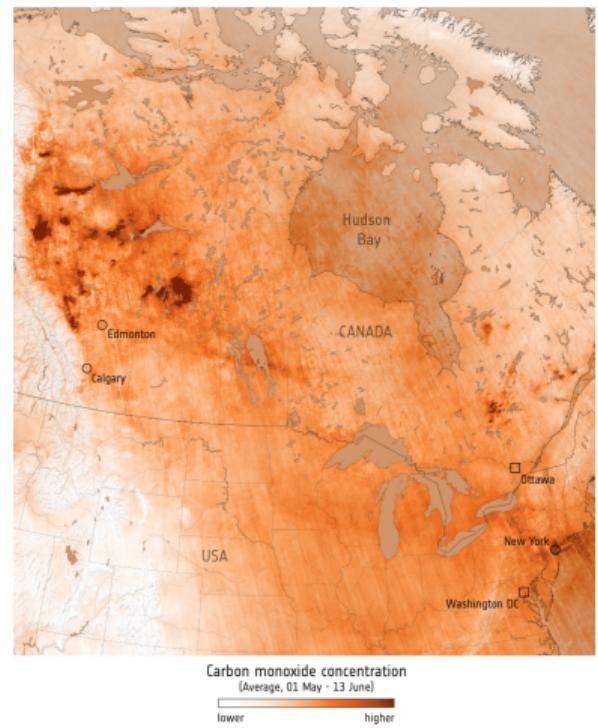
- Forest-dependent firms face higher loan spreads following fire-induced forest loss
  - Human-induced deforestation only leads to higher spreads after the EU deforestation regulation framework is proposed
  - Loan recipients with high transition risks respond by:
    - Reducing reliance on forest-based inputs from high-deforestation-risk countries
    - Engaging in reforestation efforts (e.g., NDVI or disclosure-based evidence)
    - Divesting pollutive forest-dependent plants
  - Results highlight banks' role in compliance and enabling green transition

Further discussions: Selection, and alternative outcome measure

- Selection into loan receipt
    - Question: what if firms with certain features are also more likely to get loans?
    - Univariate test: the book value of debt of firms that receive bank syndicate loans in a year is significantly higher
    - Selection model: firm-level forest dependency and human-induced forest loss are not significantly correlated with loan receipt (Probit: *If get loan ~ Firm characteristics*)
    - Results remain unchanged after controlling for IMR
  - Alternative measure of reforestation ▶ Back to summary
    - Potential concern: MODIVS NDVI is not a direct measure of firms' actual engagement in reforestation projects
    - Alternative measure: firm disclosure of reforestation activities (keyword dictionary derived from voluntary “Forestry Land Use” carbon offset classifications)
    - Filing coverage: ESG reports, SEC filings, press releases, etc.
    - Findings are robust

## **Case 1: Impact of 2023 Western Canada Wildfires on Canfor Corp**

- *Industry*: Forest products; *Country*: Canada
  - Wildfires disrupt pulp & lumber in Alberta & B.C.
    - Q2 2023 loss: \$43.9M (vs. \$373.8M profit in Q2 2022)
    - Q3 2023 lumber production down 34%
  - *Operational Disruptions*
    - 3-week shutdown at Fox Creek, Alberta
    - Severe fiber shortages, haul & harvest delays
  - *Financial Impact*
    - Revenue down to \$1.45B (from \$2.17B YoY)
    - B.C. port strike worsens supply chain
  - *Outlook*
    - Wildfire risks persist into late 2023
    - Long-term fiber supply is uncertain



## *Case 2: Deforestation of JBS*

- *Industry:* Meat and food processing; *Country:* Brazil
  - *Key impact*
    - JBS linked to large-scale deforestation in Brazil for livestock expansion
    - 1.5M hectares deforested by indirect suppliers in 15 years (size of Northern Ireland)
    - Pantanal wetlands impacted, violating environmental regulations
  - *Supply Chain & Compliance Failures*
    - JBS failed to trace indirect suppliers, despite available technology
    - Non-compliance with EU Deforestation Regulation (EUDR) → facing EU trade restrictions
  - *Consequences & Outlook*
    - EU sanctions & reputational damage threaten exports
    - Growing pressure from investors & regulators for accountability
    - Unclear if JBS will meet 2025 zero-deforestation goal

## Policy shock: The introduction of the EUDR

- Loan sample: we start with all firms, as EUDR applies for any firm operating in the EU

Dependent variable: Yield spread				
Loss measure	Fire loss		Anthropogenic loss	
	(1)	(2)	(3)	(4)
Dependency measure	-0.0257 (0.0721)	0.0469 (0.0980)	-0.0194 (0.0756)	0.0599 (0.104)
Loss measure	-0.249 (0.147)	-0.241 (0.150)	0.0622 (0.0508)	0.0818 (0.0532)
<i>Post EUDR</i>	0.0115 (0.110)	0.0558 (0.110)	0.0946 (0.140)	0.148 (0.143)
Dependency measure × Loss measure	0.455** (0.202)	0.551** (0.248)	-0.0184 (0.0374)	-0.0519 (0.0427)
Dependency measure × Loss measure × Post EUDR	-0.588 (2.136)	-1.554 (3.066)	0.261* (0.126)	0.416** (0.185)
Observations	42,590	42,590	42,590	42,590
Adjusted R-squared	0.342	0.343	0.343	0.343

*Note 1:* Year FE/Loan controls/Firm controls/Bank controls/Constant: YES

► Back to summary

**Note 2:** Dependency measure: Col (1) & (3) *Dependency*; Col (2) & (4) *Weighted dependency*

*Note 3:* Other two-way interaction terms are not presented here.

# EUDR Country heterogeneity: EU bank-EU operators lending pair

- Sample includes borrowers operating in the EU (suppliers to EU & EU firms)

<i>Dependent variable: Yield spread</i>				
<i>Bank country</i>	EU bank (1)	Non-EU bank (2)	EU bank (3)	Non-EU bank (4)
Dependency	-0.126* (0.0723)	-0.135 (0.122)	-0.149 (0.149)	-0.144 (0.200)
Anthropogenic loss	0.0696 (0.187)	-0.0716 (0.220)	0.0833 (0.191)	-0.111 (0.244)
<i>Post EUDR</i>	0.339** (0.161)	-0.952** (0.359)	0.365* (0.181)	-0.891** (0.378)
Dependency × Anthropogenic loss	0.0412 (0.176)	0.0624 (0.236)	0.0426 (0.298)	0.158 (0.415)
Dependency × Anthropogenic loss × Post EUDR	1.686** (0.643)	-0.423 (1.382)	2.568* (1.168)	-1.016 (2.796)
<i>Chi-square test</i>	3.0201*		2.7673*	
<i>P-value</i>	0.0822		0.0962	
Observations	6,171	5,671	6,171	5,671
Adjusted R-squared	0.471	0.441	0.469	0.440

Note 1: Year FE/Loan controls/Firm controls/Bank controls/Constant: YES

▶ Back to summary

Note 2: Dependency columns (1) & (3); Weighted dependency columns (2) & (4)

Note 3: Other two-way interactions are not presented

# EUDR: Phase 1 vs Phase 2

- *Post EUDR (phase 1)*: = 1 if the time is between the first deforestation policy framework (23 July 2019) and enforcement (29 June 2023), = 0 otherwise
- *Post EUDR (phase 2)*: = 1 after entering into force (29 June 2023), = 0 otherwise

Bank–Firm pair	Dependent variable: Yield spread			
	EU pair (1)	Non-EU pair (2)	OECD pair (3)	Non-OECD pair (4)
Dependency	-0.124** (0.0581)	-0.00149 (0.0791)	-0.233** (0.111)	0.0829 (0.103)
Anthropogenic loss	0.133 (0.206)	0.0504 (0.0444)	0.137 (0.206)	0.0672 (0.0495)
Dependency × Anthropogenic loss × <i>Post EUDR (phase 1)</i>	2.260*** (0.642)	0.288 (0.195)	4.201*** (1.205)	0.407 (0.255)
Dependency × Anthropogenic loss × <i>Post EUDR (phase 2)</i>	4.608*** (1.608)	0.186 (0.113)	8.662** (3.112)	0.333 (0.251)
Observations	5,518	37,072	5,518	37,072
Adjusted R-squared	0.481	0.338	0.481	0.338

Note 1: Year FE/Loan controls/Firm controls/Bank controls/Constant: YES

Note 2: Col (1)&(3): *Dependency*; Col (2)&(4): *Weighted dependency*

Note 3: Stand-alone time indicators (+sig), two-way interactions, and Chi-sq tests (sig) omitted

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# Credit supply side: Bank commitment on deforestation

- *Committed banks:* banks mentioned deforestation in disclosures

<i>Dependent variable: Yield spread</i>				
Bank subsample Subsample period	Committed Pre-EUDR	Committed Post-EUDR	Non-committed Pre-EUDR	Non-committed Post-EUDR
	(1)	(2)	(3)	(4)
Dependency	-0.018 (0.067)	0.143 (0.112)	0.040 (0.089)	0.164 (0.104)
Anthropogenic loss	0.151 (0.132)	-0.282 (0.173)	0.200 (0.141)	-0.227 (0.279)
Dependency × Anthropogenic loss	<b>-0.037</b> <b>(0.100)</b>	<b>0.196***</b> <b>(0.073)</b>	<b>-0.061</b> <b>(0.062)</b>	<b>0.214</b> <b>(0.188)</b>
<i>Chi-square test</i>	3.7972		2.1344	
<i>P-value</i>	0.0513		0.1440	
Observations	3,094	2,932	6,626	2,385
Adjusted R-squared	0.381	0.435	0.278	0.395

Note 1: Year FE/Loan controls/Firm controls/Bank controls/Constant: YES

▶ Back to summary

# Borrower engagement: Firm commitment on deforestation

- *Firm commit*: total number of disclosures mentioning “deforestation” in previous year
- Robustness: Use E-score to measure firms’ green engagement → similar results

<i>Dependent variable: Yield spread</i>				
<i>Subsample period</i>	Pre-EUDR	Post-EUDR	Pre-EUDR	Post-EUDR
	(1)	(2)	(3)	(4)
Dependency	-0.0188 (0.0765)	0.175 (0.131)	0.0662 (0.106)	0.237 (0.194)
Anthropogenic loss	0.0672 (0.0478)	-0.316* (0.136)	0.0879* (0.0500)	-0.294* (0.141)
<i>Firm commit</i>	-0.596 (0.361)	0.294 (0.493)	-0.560* (0.319)	0.323 (0.491)
<i>Dependency × Anthropogenic loss × Firm commit</i>	0.349 (0.634)	-1.113** (0.368)	0.601 (1.249)	-2.273* (0.989)
<i>Chi-square test</i>	7.4677***		8.3363***	
<i>P-value</i>	0.0063		0.0039	
Observations	5,317	37,273	5,317	37,273
Adjusted R-squared	0.405	0.342	0.404	0.343

Note 1: Year FE/Loan controls/Firm controls/Bank controls/Constant: YES

Note 2: Columns (1)-(2) use *Dependency*; Columns (3)-(4) use *Weighted dependency*

Note 3: two-way interactions are not presented here

▶ Back to summary

## *Ex-post outcome:* Production

- Examine whether syndicated loans facilitate transition away from forest dependency
- *Supply dependency:* Share of inputs sourced from forest-dependent suppliers
  - Captures **shift in production structure** (overall forest reliance)
- *Country-adj supply:* Share of inputs sourced from forest-dependent suppliers in high-risk countries
  - Captures **responsible sourcing** (shift toward lower-risk regions)
- Key idea: If a high-transition-risk firm reduces its deforestation exposure after securing loans, → lenders' engagement role in promoting sustainability
- Empirical design:
  - *Post large anthropogenic loss:* time indicator 3 years around a large human-induced loss
  - *If get loan:* = 1 if firm obtains loan in year  $t$  or  $t + 1$  (capture loans after loss) [Back to summary](#)

## Ex-post outcome: Production (*continued*)

Dependent variable Outcome window (forward)	Supply dependency		Country-adj supply	
	+3 years (1)	+4 years (2)	+3 years (3)	+4 years (4)
If get loan (t or t+1)	0.0593** (0.0273)	0.0634** (0.0295)	0.111** (0.0417)	0.115** (0.0440)
Post large anthropogenic loss	0.0423* (0.0235)	0.0396 (0.0243)	0.0613 (0.0387)	0.0577 (0.0402)
If get loan × Post large anthropogenic loss	-0.0426* (0.0225)	-0.0437 (0.0277)	-0.0703** (0.0250)	-0.0711** (0.0321)
Observations	523	523	523	523
Adjusted R-squared	0.330	0.345	0.349	0.365

Note 1: Year FE/Firm controls/Constant: YES

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Note 2: Window restriction: no other large loss event three years around a selected large loss event

Note 3: No production change around large fire loss

# Ex-post outcome: Reforestation

- *Outcome:* NDVI (Normalized Difference Vegetation Index) — greenness of vegetation
  - From NASA MODIS, primarily used to determine land use and land-cover change (LULCC)
- *Post large anthropogenic loss:* = 1 if three years after a large human-induced forest loss
- *If get loan:* = 1 if a firm obtains a loan in t or t+1 following large loss

<i>Dependent variable: NDVI</i>				
<i>Outcome window (forward)</i>	+1 year	+2 years	+3 years	+4 years
	(1)	(2)	(3)	(4)
If get loan (t or t+1)	-0.224 (0.710)	-0.184 (0.701)	-0.150 (0.697)	-0.0940 (0.696)
<i>Post large anthropogenic loss</i>	-2.271* (1.314)	-2.059 (1.360)	-1.918 (1.395)	-1.781 (1.393)
<i>If get loan × Post large anthropogenic loss</i>	<b>1.174*** (0.334)</b>	<b>1.215*** (0.359)</b>	<b>1.200*** (0.359)</b>	<b>1.126*** (0.359)</b>
Observations	4,322	4,322	4,322	4,322
Adjusted R-squared	0.178	0.176	0.170	0.163

Note 1: Year FE/Firm controls/Constant: YES

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Note 2: Window restriction: no other large loss event three years around a selected large loss event

# Ex-post outcome: Reforestation (High dependency subsample)

<i>Dependent variable: NDVI</i>				
<i>Outcome window (forward)</i>	+1 year	+2 years	+3 years	+4 years
	(1)	(2)	(3)	(4)
If get loan (t or t+1)	0.727 (1.053)	0.796 (1.045)	0.858 (1.044)	0.928 (1.053)
<i>Post large anthropogenic loss</i>	-2.230 (1.662)	-1.944 (1.690)	-1.869 (1.708)	-1.745 (1.684)
<i>If get loan × Post large anthropogenic loss</i>	<b>1.555** (0.593)</b>	<b>1.575** (0.620)</b>	<b>1.595** (0.632)</b>	<b>1.525** (0.646)</b>
Observations	2,303	2,303	2,303	2,303
Adjusted R-squared	0.193	0.189	0.183	0.177

Note 1: Year FE/Firm controls/Constant: YES

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Note 2: Window restriction: no other large loss event three years around a selected large loss event

### *Ex-post outcome: Divestiture of pollutive plants*

- Examines if firms divest pollutive forest-dependent plants after human-induced loss
  - Focus on U.S. public firms with TRI-listed plants; divestiture scaled by 100 (pp change)
  - Evidence: Firms receiving loans are more likely to divest forest-linked pollutive assets, especially with high forest dependency

### *Dependent variable: Divestiture*

Type of divested plants	Nonzero forest dependency			High forest dependency		
Outcome window (forward)	+2 yrs (1)	+3 yrs (2)	+4 yrs (3)	+2 yrs (4)	+3 yrs (5)	+4 yrs (6)
Dependency × Anthropogenic loss × If get loan	1.095*** (0.282)	1.118*** (0.304)	1.215*** (0.390)	1.090*** (0.279)	1.123*** (0.299)	1.210*** (0.384)
Observations	7,313	7,313	7,313	7,313	7,313	7,313
Adjusted R-squared	0.0129	0.0198	0.0233	0.0152	0.0223	0.0255

*Note 1:* Year FE/Firm controls/Constant: YES

Note 2: Stand-alone variables and two-way interactions are not presented here.

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