

Banking on Forest

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Deforestation of the Amazon rainforest

- By 2022, 26% of the Amazon was deforested [▶ view case](#)
- 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, urbanization¹
 - 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)

¹Classification 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

- **Question: How banks mitigate the physical risks and transition risks from forest loss**
 - *Assumption:* forest-dependent firms are more affected
- **Loan pricing**
 - *For realized physical risks:* after fire-induced forest loss, loan spreads for forest-dependent firms increase by 12–65 bps compared to other firms
 - *For 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)

Main findings (*cont.*)

- **Mechanism: forest loss and firm operation**
 - Wildfires disrupt operations of dependent firms ($\downarrow 24.5\%$ operating cash flow)
 - Human-induced loss has no short-term effect, consistent with planned expansion
- **Ex-post outcome: green transition after getting loans**
 - Firms that get loans after human-induced loss shift to inputs from countries with lower deforestation risk (responsible sourcing)
 - Evidence of reforestation
 - Evidence of divestiture of pollutive plants

Data and sample overview

- **Key data:**

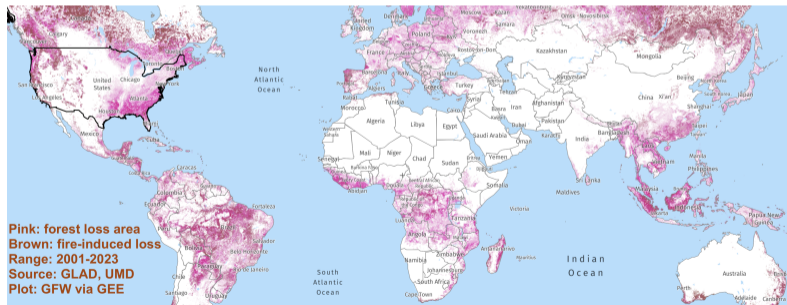
- **Forest loss (geospatial):** GLAD (Hansen et al. 2013 *Science*, Tyukavina et al. 2022 *Front. Remote Sens.*)
- **Forest dependency:** ENCORE (UNEP)
- **Syndicated loans:** DealScan
- **Supply chains & firm data:** Compustat, Refinitiv
- **Reforestation (NDVI):** NASA MODIS
- **Deforestation disclosures:**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



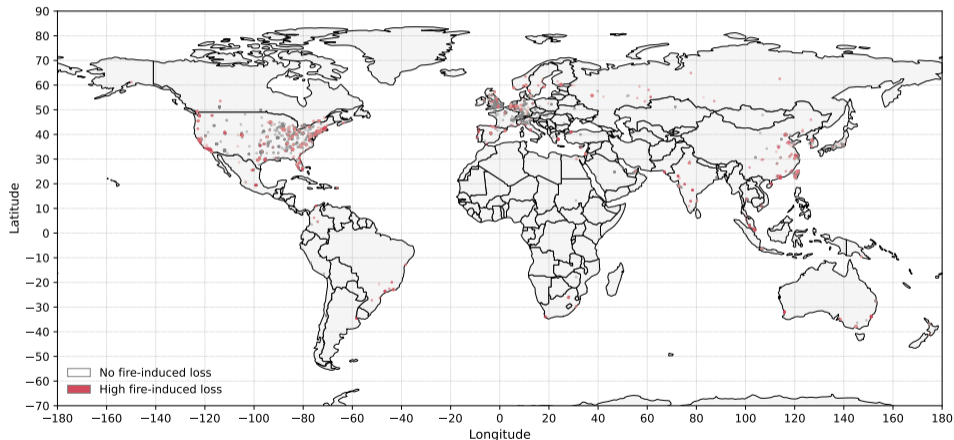
Measures for firm-level forest loss

- **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 km²)** within 10km around a firm
 - (3) Classify two types of loss: (a) **forest loss from fires**; (b) **forest loss from human activities**
- **Robustness:** subsamples of (1) Orbis single HQ with zero branches, (2) small firms (bottom decile of total assets) → HQ more aligned with main operation

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>
Total	100%		<i>Annual gross forest loss</i>

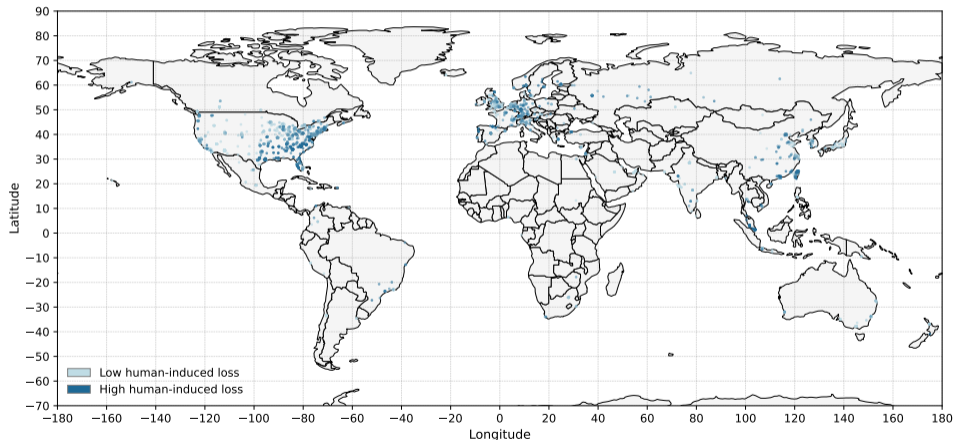
Source for percentages: Classifying drivers of global forest loss, Curtis et al. (2018 *Science*)

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):
 - $Dependency \times (1 + \underbrace{\text{normalized country-level forest loss}}_{= 1 \text{ for highest-deforestation country; } = 0 \text{ lowest}})$

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):

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

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

Baseline results

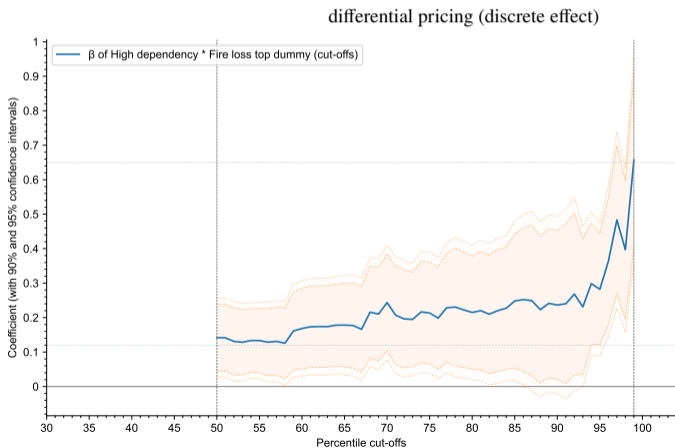
- At *Dependency* mean (0.91): 1 km² fire loss → 15 bps higher yield spread

<i>Dependent variable: Yield spread</i>						
<i>Dependency measures</i>	<i>Dependency</i>				<i>Weighted dependency</i>	
	(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)
<i>Dependency measure × Fire loss</i>	0.425** (0.176)		0.424** (0.183)	0.415** (0.177)	0.527** (0.230)	0.586** (0.261)
<i>Dependency measure × 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 × 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: Fire 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):

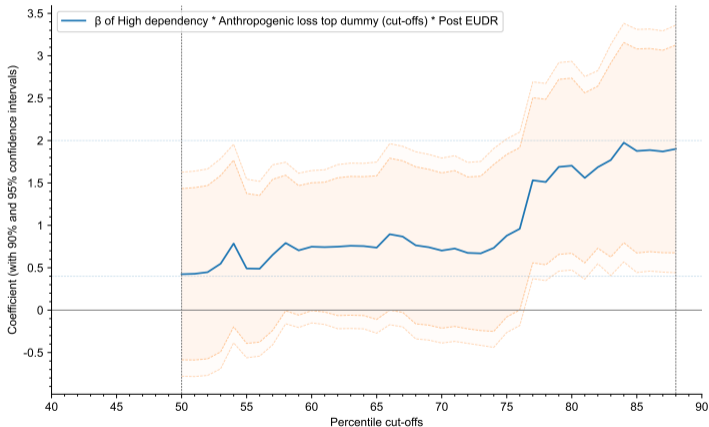
$$\text{Yield spread}_{b,f,t} \sim \beta_7 \underbrace{(\text{Dependency}_i \times \text{Loss}_{f,t-1})}_{\text{differential pricing (fitted curve)}} \times \underbrace{\mathbb{1}[\text{Period} > \text{July 2019}]}_{\text{post-EUDR effect}}$$

- 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 km² 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

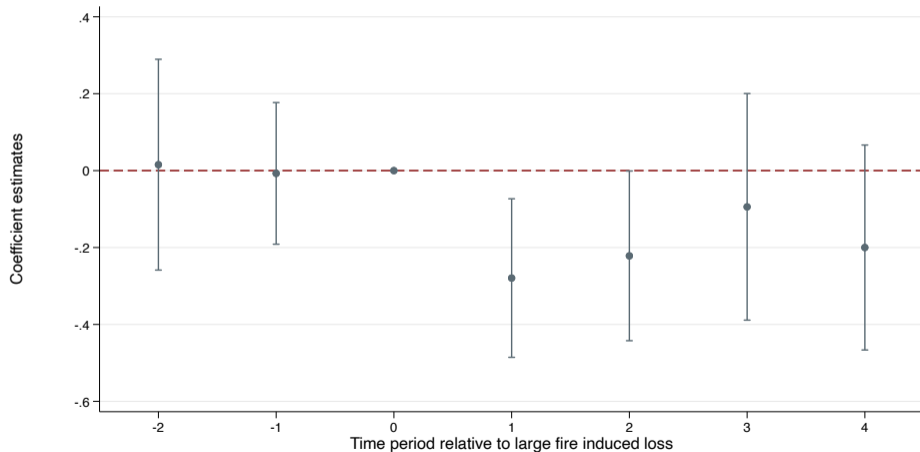
Borrower side: Does firm commitment mitigate pricing?

- **Hypothesis:** Firms that disclose deforestation issues may be seen as more risk-aware and committed to mitigation
- **Design:** Compare four groups: committed vs. non-committed firms, before vs. after EUDR, and re-estimate $Dependency \times Anthropogenic\ loss$
- **Findings:** [▶ view table](#)
 - **Post-EUDR**, only non-committed forest-dependent firms face **25.2 bps higher spreads** following human-induced forest loss
 - No differential pricing pattern for committed firms
 - Results are consistent when using **E-score** as an alternative commitment proxy

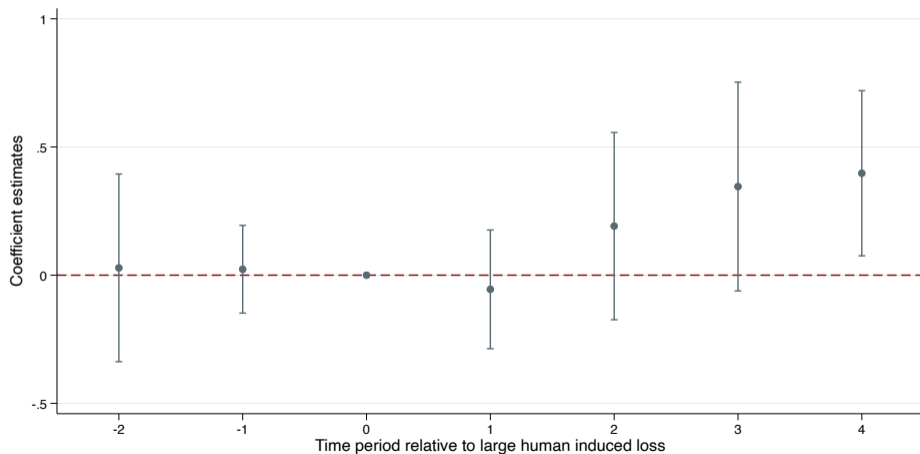
Mechanism: Forest loss and firm operation

- **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

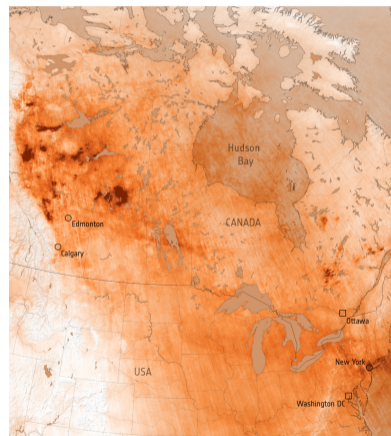
- Forest-dependent firms face higher loan spreads following fire-induced forest loss
- Human-induced deforestation only leads to higher spreads after the EU deforestation regulation framework is proposed
- Loan recipients with high transition risks respond by:
 - Reducing reliance on forest-based inputs 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

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Carbon monoxide concentration
(Average, 01 May - 13 June)

lower higher

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 [▶ Back to summary](#)

Policy shock: The introduction of the EUDR

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

<i>Dependent variable: Yield spread</i>				
<i>Loss measure</i>	<i>Fire loss</i>		<i>Anthropogenic loss</i>	
	(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 × <i>Post EUDR</i>	-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

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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

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

Note 3: Other two-way interactions are not presented

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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

<i>Dependent variable: Yield spread</i>				
<i>Bank-Firm pair</i>	EU pair	Non-EU pair	OECD pair	Non-OECD pair
	(1)	(2)	(3)	(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)
<i>Dependency × Anthropogenic loss × Post EUDR (phase 1)</i>	<i>2.260*** (0.642)</i>	<i>0.288 (0.195)</i>	<i>4.201*** (1.205)</i>	<i>0.407 (0.255)</i>
<i>Dependency × Anthropogenic loss × Post EUDR (phase 2)</i>	<i>4.608*** (1.608)</i>	<i>0.186 (0.113)</i>	<i>8.662** (3.112)</i>	<i>0.333 (0.251)</i>
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>				
<i>Bank subsample</i>	Committed	Committed	Non-committed	Non-committed
<i>Subsample period</i>	Pre-EUDR	Post-EUDR	Pre-EUDR	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	-0.037 (0.100)	0.196*** (0.073)	-0.061 (0.062)	0.214 (0.188)
<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

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Borrower engagement: Firm commitment on deforestation

- *Committed firms*: firms that mention “deforestation” in prior-year disclosures
- Robustness: Use E-score to measure firms’ green engagement → similar results

<i>Dependent variable: Yield spread</i>				
<i>Firm subsample</i>	Committed firms		Non-committed firms	
	Pre-EUDR	Post-EUDR	Pre-EUDR	Post-EUDR
<i>Subsample period</i>	(1)	(2)	(3)	(4)
Dependency	-0.197 (0.185)	0.0686 (0.149)	0.0268 (0.0845)	0.163 (0.106)
Anthropogenic loss	-0.333 (0.445)	0.00833 (0.815)	0.165 (0.121)	-0.374* (0.195)
Dependency × Anthropogenic loss	0.931 (0.811)	0.0956 (0.875)	-0.0322 (0.0697)	0.252*** (0.0940)
<i>Chi-square test</i>	(1)=(2) 0.151		(3)=(4) 6.445**	
<i>P-value</i>	0.698		0.011	
Observations	270	291	9,450	5,026
Adjusted R-squared	0.700	0.562	0.294	0.413

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

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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)

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Ex-post outcome: Production (continued)

<i>Dependent variable</i>	<i>Supply dependency</i>		<i>Country-adj supply</i>	
	<i>+3 years</i>	<i>+4 years</i>	<i>+3 years</i>	<i>+4 years</i>
<i>Outcome window (forward)</i>	(1)	(2)	(3)	(4)
If get loan (t or t+1)	0.0593** (0.0273)	0.0634** (0.0295)	0.111** (0.0417)	0.115** (0.0440)
<i>Post large anthropogenic loss</i>	0.0423* (0.0235)	0.0396 (0.0243)	0.0613 (0.0387)	0.0577 (0.0402)
<i>If get loan × Post large anthropogenic loss</i>	-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>	1.174*** (0.334)	1.215*** (0.359)	1.200*** (0.359)	1.126*** (0.359)
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)
If get loan × <i>Post large anthropogenic loss</i>	1.555** (0.593)	1.575** (0.620)	1.595** (0.632)	1.525** (0.646)
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

<i>Dependent variable: Divestiture</i>						
<i>Type of divested plants</i>	Nonzero forest dependency			High forest dependency		
	<i>Outcome window (forward)</i>	+2 yrs	+3 yrs	+4 yrs	+2 yrs	+3 yrs
	(1)	(2)	(3)	(4)	(5)	(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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