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US banks' exposures to climate transition risks[1]

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[1] This contribution was prepared for the workshop. The views expressed are those of the authors and do not necessarily reflect the views of the Central Bank of the Republic of Türkiye, the BIS, the IFC or the other central banks and institutions represented at the event.

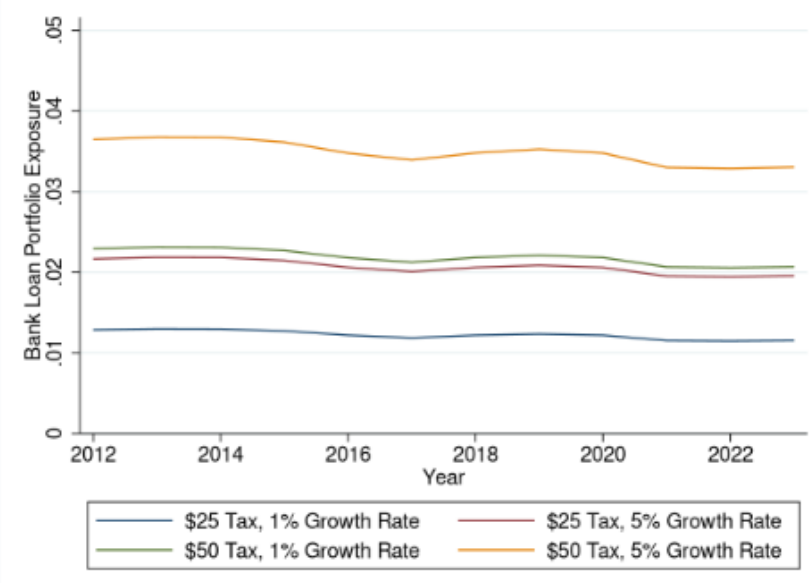
U.S. Banks' Exposures to Climate Transition Risks

Policymakers have grown increasingly concerned with understanding financial institutions' exposures to climate transition risks. However, while climate risk is a problem with forward-looking ramifications, most approaches to measure transition risk use backward-looking data, such as carbon emissions. In our paper "U.S. Banks' Exposures to Climate Transition Risks", we introduce a forward-looking approach to measure banks' exposures to specific climate transition policies using general equilibrium model estimates.

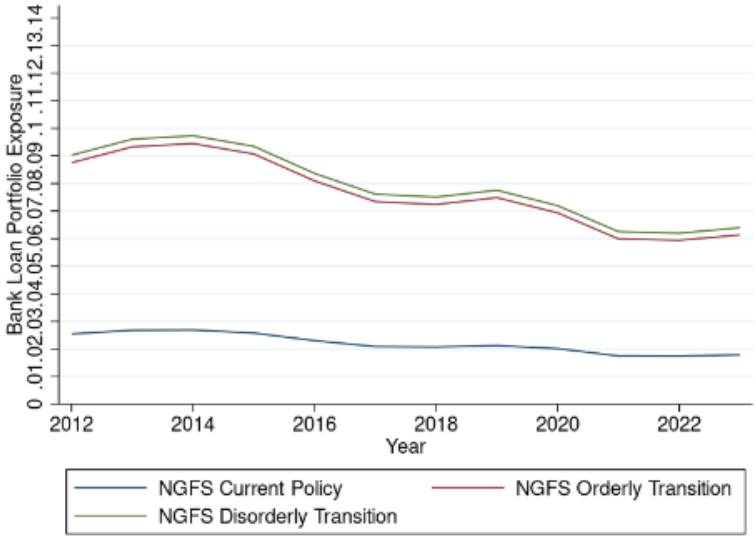
In our paper, we use estimates from three general equilibrium models, two of which we present here. Our first approach builds on the Jorgenson, Goettle, Ho and Wilcoxen (2018) model, which provides estimates of expected decreases in industry output due to carbon taxes. The authors consider four scenarios, with the least stringent being a $25 initial carbon tax and a 1 percent tax growth rate, and the strictest being a $50 initial carbon tax and a 5 percent tax growth rate. We also use the G-Cubed model estimates of expected changes in industry output for the Network for Greening for the Financial System (NGFS) scenarios, or NGFS (2022). The G-Cubed explores three different policy scenarios: (1) an orderly transition, where a carbon tax is immediately enacted to reduce carbon emissions to net zero by 2050, (2) a disorderly transition, where in 2030 a carbon tax sufficient to reduce end-of-century temperature rise to 2 degrees Celsius is passed, and (3) a status quo scenario where current climate policy is maintained.

For both of these approaches, banks' exposures are calculated as the decrease in the value of their loan portfolios. When calculating the measure, we assume that bank loan portfolio values drop proportionally to the change in output. However, the paper also includes alternative versions of the analysis, which account for loan probabilities of default, as well as assuming that loans to industries most adversely affected by transition risks lose their entire value.

The estimates of the bank loan portfolios from the Jorgenson et al (2018) model are shown below. In the most extreme case, where a $50 per ton carbon tax growing at 5% per year is enacted, the bank's loan portfolio exposure is no more than about 3.5%. In the least stringent scenario, where a $25 per ton carbon tax growing at 1% per year is enacted, the exposure is closer to 1%. In either case, the exposure of banks is relatively small. Similarly, when we produce alternative estimates accounting for loan probabilities of default, and potentially larger losses for industries more sensitive to climate transition risks. In fact, even when making the strong assumption that loans in industries with the top-two deciles of exposures lose their entire value, bank loan portfolios decrease by no more than 14% of their values as of 2023.



The conclusions are broadly similar when examining the estimates from the G-Cubed model, which are shown below. The estimates from the status quo scenario are relatively low, at about 2%. When examining the estimates of bank loan portfolio exposures under the disorderly and orderly transition scenarios, those are about 6% as of 2023.



To conclude, the analysis in this paper uses general equilibrium model estimates to provide a forward-looking approach to estimates banks' exposures to climate transition risks. The results show that at most, banks climate transition risk exposures are no more than about 14%. The measure introduced in this paper will be a useful tool for policy makers to examine how specific climate policies affect banks.

U.S. Banks' Exposures to Climate Transition Risks

Addressing Climate Change Data Needs: The Global Debate and Central Banks' Contribution

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Effects of Climate Transition Risk on Banks

- How does climate transition risk affect banks?
  - *Transition risk* arises from changes in policies as economies transition to less carbon-intensive environments.

- How much are banks exposed to a specific climate transition policy (e.g. \$50 carbon tax growing 5% annually)?

  $\Rightarrow$ We develop a measure to assess banks' credit portfolio exposure to a specific set of climate transition policies.

Empirical Challenges

1. Existing approaches typically rely on backward-looking data (e.g. carbon emissions).
   - We propose a **forward-looking** measure that quantifies the effect of a specific set of climate transition policies on banks.
2. Reduced form approaches typically do not capture the general equilibrium effects.
   - We build on estimates from **general equilibrium** climate models.
3. Publicly available credit data may not accurately represent current exposure if the bank sells the loan after origination.
   - We employ a granular dataset (**Y-14**) that provides current loan-level credit exposure information for major U.S. banks.

Our Approach in Brief

General Equilibrium Climate Model Estimates

E.g., How much does each industry's output fall if a carbon tax gets introduced?

Industry	Change in Output
Coal	-30%
Renewable	+20%

Y-14 Data

E.g., Bank's credit portfolio:

Industry	Share of Lending
Coal	50%
Renewable	50%

Study bank exposure to transition risk
- across time
- across banks
- across policies

Investigate how banks manage transition risk

Key Findings

1. Banks' exposures to transition risk is generally manageable.
   - The average bank's credit exposure (as of 2023) does not exceed 14% under even the most severe scenario
2. Across policies, banks' transition risk exposure is larger under stricter policies.
   - Relative to a $25 carbon tax, a $50 carbon tax increases banks' exposures by 1%.
3. Carbon emissions explain at most 60% of variation in our measure.
4. Banks that signed the Net-Zero Banking Alliance appear to have reduced their exposures compared to non-signatories.

Climate Models: Overview

1. **Jorgenson et al. (2018)**
   - Estimates changes in industry-level output from 2015 to 2050, if a range of carbon tax policies are put in place in 2020.
   - e.g. Initial carbon tax rate of \$50 and annual tax growth rate of 5%.

2. **NGFS G-Cubed Model (2022)**
   - Estimate changes in industry-level output from 2020 to 2050.
   - Considers NGFS scenarios (current, orderly, and disorderly transitions).

Climate Model (1)

Jorgenson et al. (2018)

- Estimates industry-level decreases in output for 36 industries conditional on a specific carbon policy.
- Assumes a carbon tax is put in place in 2020, and grows from 2020 until 2050.
  - Provides estimates of change in industry-level output from 2015 until 2050.
  - Model estimates produced for several initial tax rates ($25 or $50) and tax growth rates (1% or 5%).
- Also models the redistribution of the tax proceeds.
  - Model outputs produced for redistribution as a lump sum dividend, a capital tax cut, or a labor tax cut.

Example of Estimates from Jorgenson et al. (2018)

IGEM Industry	$25 tax, 1% growth rate	$25 tax, 5% growth rate	$50 tax, 1% growth rate	$50 tax, 5% growth rate
Agriculture	0.009	0.016	0.017	0.028
Oil mining	0.026	0.045	0.049	0.079
Gas mining	0.059	0.097	0.103	0.157
Coal mining	0.163	0.237	0.252	0.338
Nonenergy mining	0.016	0.028	0.028	0.046
Electric utilities	0.047	0.077	0.082	0.124
Gas utilities	0.049	0.087	0.092	0.154
Water and wastewater	0.016	0.026	0.028	0.046
...				
Health care and social assistance	0.003	0.006	0.006	0.010
Accommodation and other services	0.007	0.011	0.012	0.020
Other government	0.001	0.001	0.001	0.002

Climate Model (2)

NGFS G-Cubed Model (2022)

- Estimates industry-level decreases in output for 12 industries from 2020 until 2050.
- Unlike the other models, the policy scenarios set a certain carbon tax conditional on achieving a desired policy outcome.
  - Current Policy
  - Orderly Transition – sufficient policies to achieve net-zero emissions by 2050 is immediately adopted
  - Disorderly Transition – policy to limit end-of-century temperature rise to under 2 degrees adopted in 2031

Exposure Measure

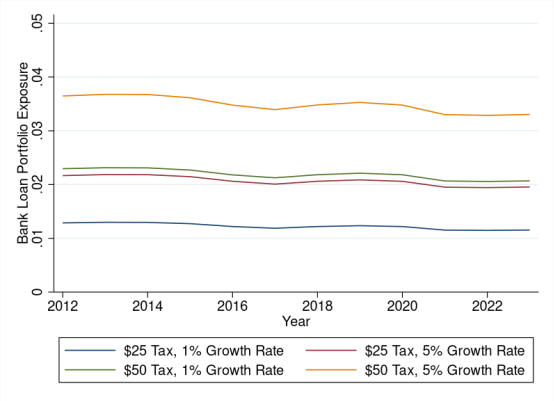
What proportion of bank b's loan portfolio value would be lost if policy P gets implemented?

$$Exposure_{b,t}^{P} = \sum_{j \in J} w_{b,j,t} \; Markdown_{j}^{P},$$

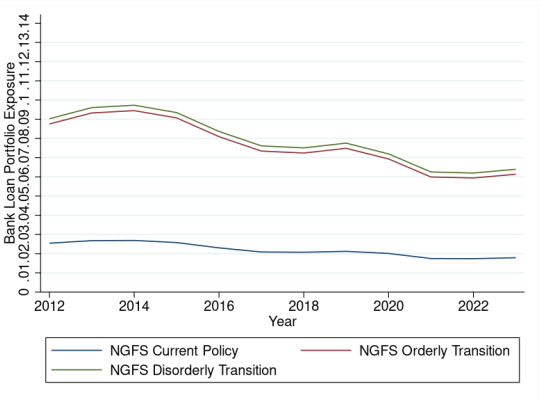
- $w_{b,j,t}$ is proportion of bank b's loan made to industry j at time t.
- $Markdown_{j}^{P}$ is the drop in the output or profits of industry j under policy P.

- **Key Assumptions:**
  1. Banks lose the value of loans proportionally to the drop in the output or profit of the borrower's industry.
  2. Bank b maintains their allocation of loans across industries as of time t.

Average Exposure over Time



(a) Jorgenson et al.



(b) NGFS

- The maximum average exposure is less than 4% based on Jorgenson et al., while it is 9.5% based on NGFS.

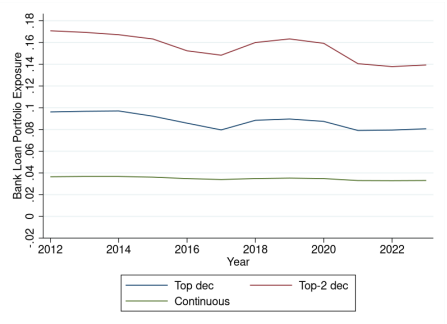
Exposure Measure under Stress

Considering potential non-linear effects: what if banks are *more severely affected* by the riskiest industries?

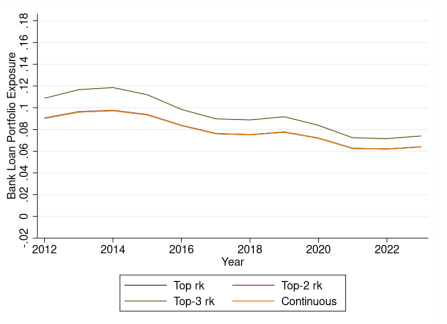
$$ExposureUnderStress^{P}_{b,t} = \sum_{j \in J} w_{b,j,t}\ \mathbb{1}(Markdown^{P}_{j} > x) + \sum_{j \in J} w_{b,j,t} \mathbb{1}\left(Markdown^{P}_{j} \leq x\right) \cdot Markdown^{P}_{j}$$

- w_{bjt} is proportion of bank b's loan made to industry j at time t.
- $Markdown^{P}_{j}$ is the drop in the output of industry j under policy P.
- x is a cutoff where if the drop in industry output is above x, we assume the industry goes "bankrupt".
- Pick x so we focus on either the top-decile or top-two-decile exposed industries.

Average Exposure Under Stress over Time



(a) Jorgenson et al.: \$50 initial tax, 5% annual tax growth rate



(b) NGFS: Disorderly transition

- Based on Jorgenson et al., the average *exposure under stress* is 11% higher than the average exposure.
- Based on the NGFS model, the average *exposure under stress* remains similar as the NGFS scenarios are already severe.

Exposure Adjusted for Expected Loan Losses

1. Compute loan losses for each loan:

$$Loss_{l,t} = Loss\ Given\ Default_{l,t} \times Probability\ of\ Default_{l,t}$$

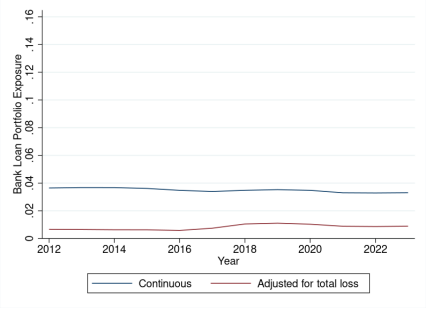
2. For each industry, exploit loan-level empirical relationship between loan losses and sales to obtain expected loss:

$$Loss_{l,t} = \alpha_j + \beta_j \log(Sales_{l,t}) + \varepsilon_{l,t}$$

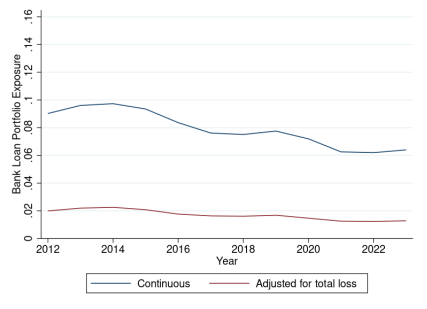
3. Compute adjusted exposure:

$$\begin{aligned} AdjExposure^P_{b,t} = &\sum_{j \in J} w_{b,j,t}\ \mathbb{1}(Markdown^P_j > x)(\hat{\alpha}_j + \hat{\beta}_j Markdown^P_j) \\ &+ \sum_{j \in J} w_{b,j,t} \mathbb{1}\left(Markdown^P_j \leq x\right)(\hat{\alpha}_j + \hat{\beta}_j Markdown^P_j) Markdown^P_j \end{aligned}$$

Average Exposure Adjusted for Expected Loan Losses over Time



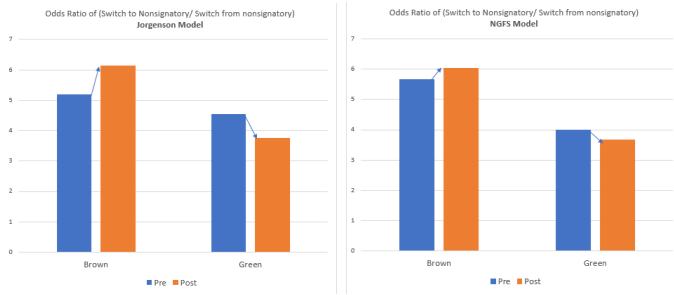
(a) Jorgenson et al (2018) $50 initial tax, 5% annual tax growth rate



(b) NGFS disorderly transition

- Adjusting for the loss given default (LGD) and probability of default (PD) reduces exposures.

Brown Borrowers are Switching to non-Signatories



(a) Jorgenson et al. (b) NGFS

- Examine whether brown borrowers switched lenders after the announcement of the Net-Zero Banking Alliance in April 2021
- Brown borrowers became more likely to switch to non-signatories and green borrowers were more likely to switch to signatories

How Much of Exposure is Explained by Carbon Emissions?

Model Scenario	I	II	III	IV
	Panel A: Jorgenson et al (2018) Tax and Growth Rate Scenarios			
	\$25 Tax, 1% Growth Rate	\$25 Tax, 5% Growth Rate	\$50 Tax, 1% Growth Rate	\$50 Tax, 5% Growth Rate
Emissions R2	0.572	0.577	0.582	0.588
	Panel B: Jorgenson et al (2018) Redistribution Scenarios			
	Lump Sum Redistribution	Capital Tax Cut	Labor Tax Cut	
Emissions R2	0.577	0.595	0.577	
	Panel C: Goulder and Hafstead (2018) Redistribution Scenarios			
	Lump Sum Redistribution	Corporate Tax Cut	Payroll Tax Cut	Individual Income Tax Cut
Emissions R2	0.257	0.257	0.257	0.258
	Panel D: NGFS Scenarios			
	Current Policy	Disorderly Transition	Orderly Transition	
Emissions R2	0.496	0.411	0.416	

- Much of the variation in exposures is *not* driven by emissions.
- Based on the industry-level emissions data, R^2 is even smaller.

Conclusion

- We develop a novel measure of US banks' exposure to transition risk building upon general equilibrium model estimates.
- We find that the estimated exposures are generally modest, and are no higher than 14% relative to current loan balances even in the most severe scenario.
- Banks' exposures to the riskiest industries appear to be mildly decreasing over time.
- Banks decreased lending for highly exposed industries in recent years.