Climate Risk in the American Financial System

Ari Singer-Freeman
(Under the supervision of Dr. Yasser Boualam)

Roadmap


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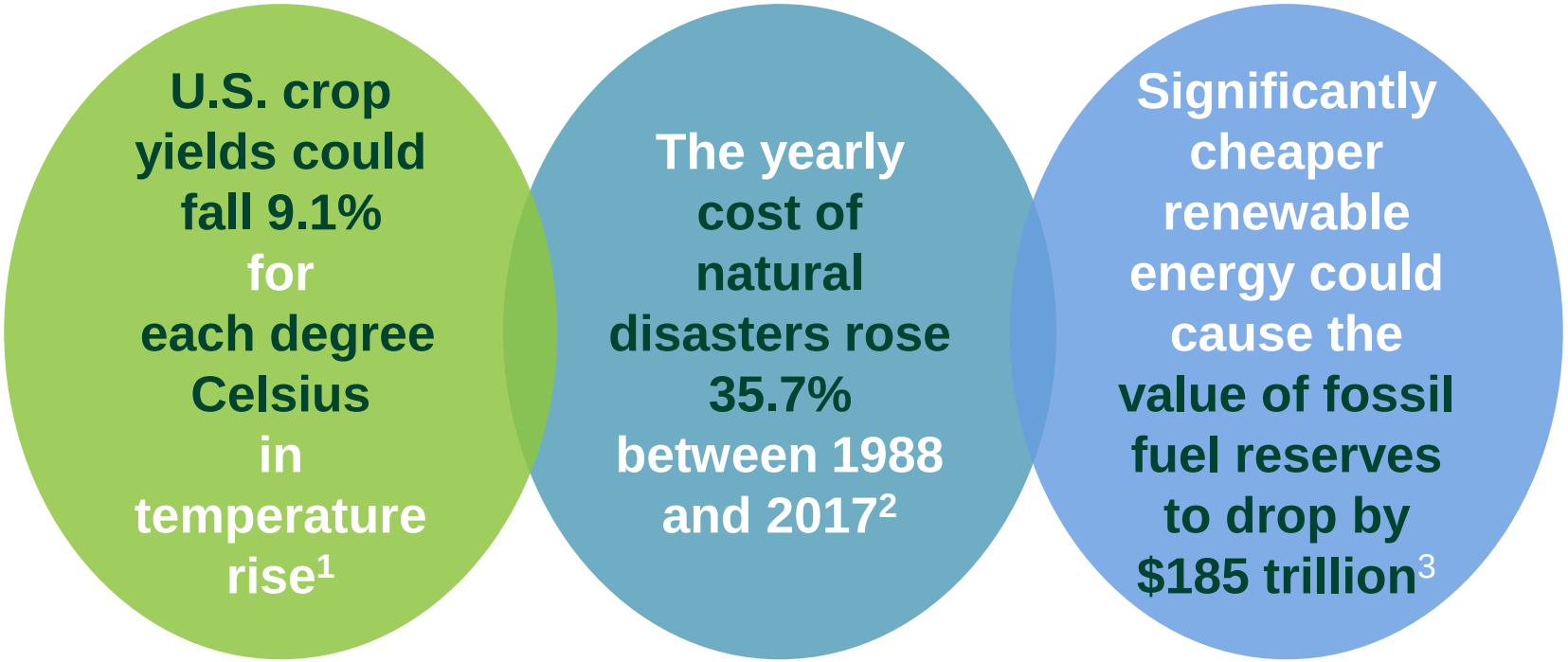
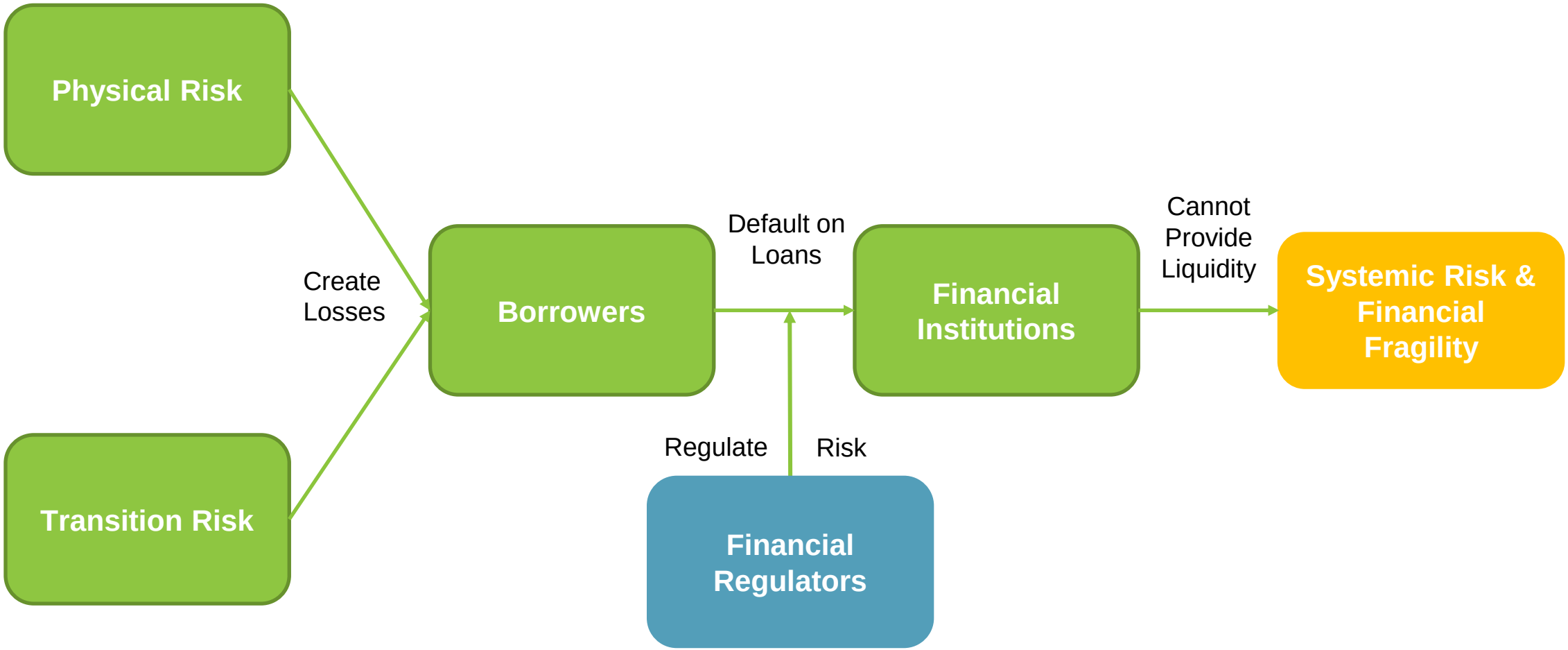
Introduction/Purpose

Climate change is already seriously harming the United States' economy, and costs will rise in the future



1. Hsiang et al., 2017
2. Munich Re, 2019
3 Linquiti and Cogswell, 2016

Climate change will put companies at risk of defaulting on their debt, potentially creating financial fragility



Financial fragility is when financial markets fail, and can cause widespread damage

THE WALL STREET JOURNAL.

WEDNESDAY, SEPTEMBER 17, 2008 - VOL. CCLII NO. 66

DJIA 11099.02 ▲141.51 1.3% NASDAQ 2207.90 ▲1.1% NIKKEI 11609.72 ▼5.0% DJ STOXX 50 2658.77 ▼1.1% 10-YR TREAS ▼1/32, yield 3.493% OIL $91.15 ▼$4.56 GOLD $776.50 ▼$6.60 EURO $1.4143 YEN 105.92

U.S. to Take Over AIG in $85 Billion Bailout; Central Banks Inject Cash as Credit Dries Up

Emergency Loan Effectively Gives Government Control of Insurer; Historic Move Would Cap 10 Days That Reshaped U.S. Finance

By Matthew Karnitschnig, Deborah Solomon And Liam Pleven

The U.S. government seized control of American International Group Inc.—one of the world's biggest insurers—in an $85 billion deal that signaled the intensity of its concerns about the danger a collapse could pose to the financial system.

The step marks a dramatic turnabout for the federal government, which had been strongly resisting overtures from AIG for an emergency loan or some intervention that would prevent the insurer from falling into bankruptcy. Just last weekend, the government essentially pulled the plug on Lehman Brothers Holdings Inc., allowing the big investment bank to go under instead of giving it financial support. This time, the government decided

surance businesses, giving the Fed some protection even if markets continue to sink. And if AIG rebounds, taxpayers could reap a big profit through the government's equity stake.

"This loan will facilitate a process under which AIG will sell certain of its businesses in an orderly manner, with the least possible disruption to the overall economy," the Fed said in a statement.

It puts the government in control of a private insurer—a historic development, particularly considering that AIG isn't directly regulated by the federal government. The Fed took the highly unusual step using legal authority granted in the Federal Reserve Act, which allows it to lend to nonbanks under "unusual and exigent" circumstances, something it invoked when Bear Stearns Cos. was rescued in March.

As part of the deal, Treasury

ance industries, while Wall Street has watched two of its last four big independent brokerage firms exit the scene.

The U.S. on Sept. 6 took over mortgage-lending giants Fannie Mae and Freddie Mac as they teetered near collapse. This Sunday, the U.S. refused to bail out Wall Street pillar Lehman Brothers, which filed for bankruptcy-court protection and is now being sold off in pieces. That same day, another struggling Wall Street titan, Merrill Lynch & Co., agreed to sell itself to Bank of America Corp.

The AIG deal followed a day of high drama in Washington. The Treasury's Mr. Paulson and Federal Reserve Chairman Ben Bernanke convened in the early evening an unexpected meeting of top congressional leaders. Late in the trading day Tuesday, anticipation that the government might assist the insurer

Urgent Mission

Plunging shares, soaring credit costs push the government to step in.

DJIA daily close

Overnight dollar Libor

Fed chief Ben Bernanke

Lending Among Banks Freezes

By Carrick Mollenkamp, Mark Whitehouse And Neil Shah

Banks abruptly stopped lending to each other or charged exorbitantly high rates Tuesday, threatening to spread the troubles of American International Group Inc. and Lehman Brothers Holdings Inc. to a broad range of financial institutions and the global economy.

The breakdown came despite efforts by central bankers to keep money flowing. Central banks in the U.S., Europe and

WSJ, Sept. 17, 2008

- Financial institutions serve as market makers for capital and financial assets
- Companies need capital to grow, operate, and innovate
- Uncertainty can also cause abnormal financial asset prices
- According to the IMF, $4 trillion in bank losses during the financial crisis destroyed $50 trillion in global wealth[1]

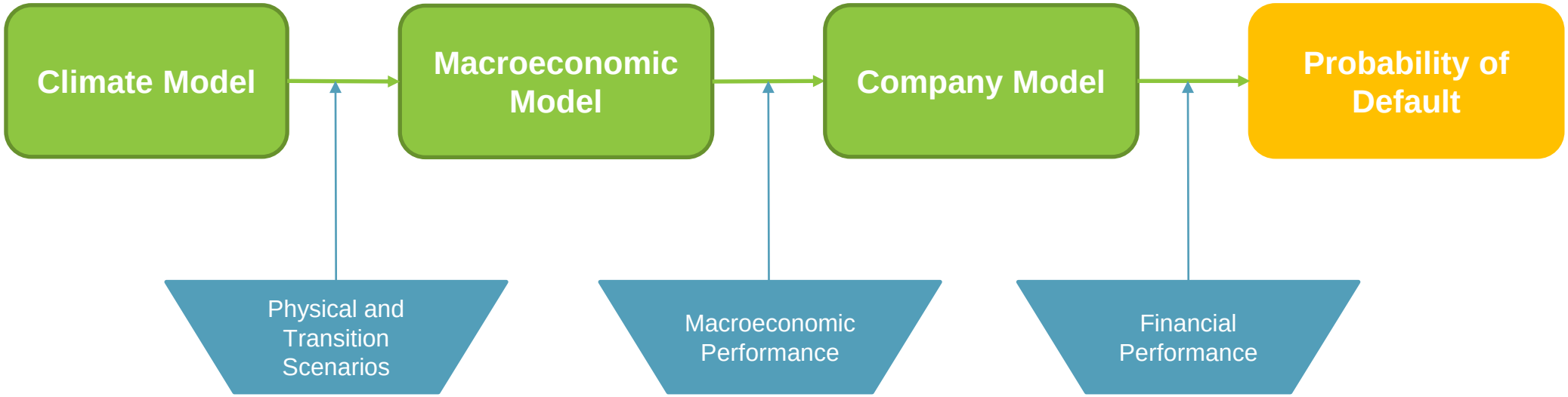
1. https://www.imf.org/external/pubs/ft/wp/2010/wp1047.pdf

Research Question:

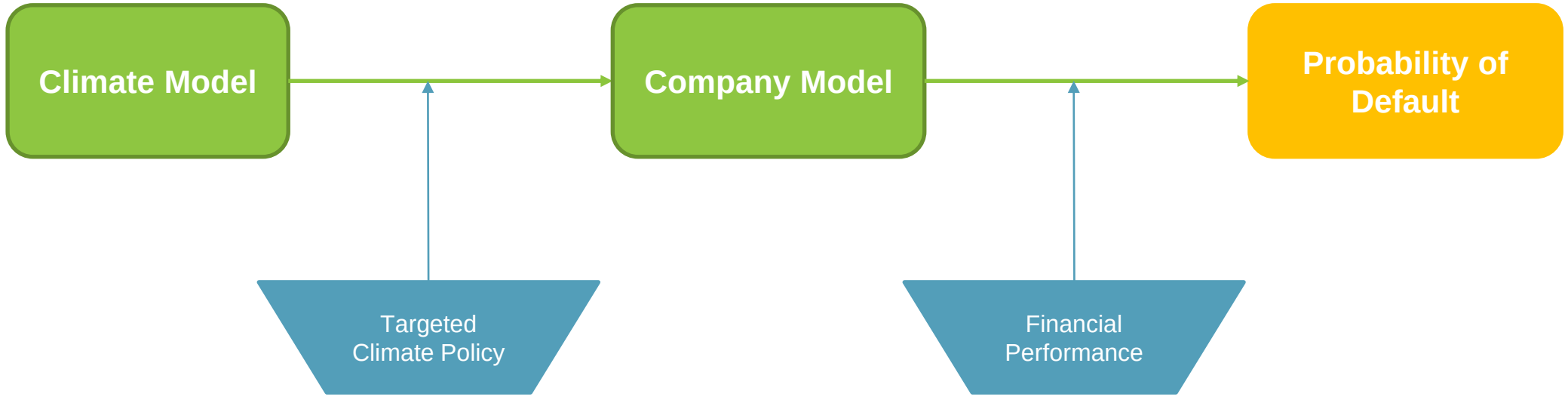
Will climate risk in the form of a carbon tax create systematic financial risk in the United States?

Review of Literature

The top-down approach to measuring financial institutions' climate risk considers macroeconomic risk



Bottom-up approaches make fewer assumptions and are better suited for modeling the impacts of targeted climate policy

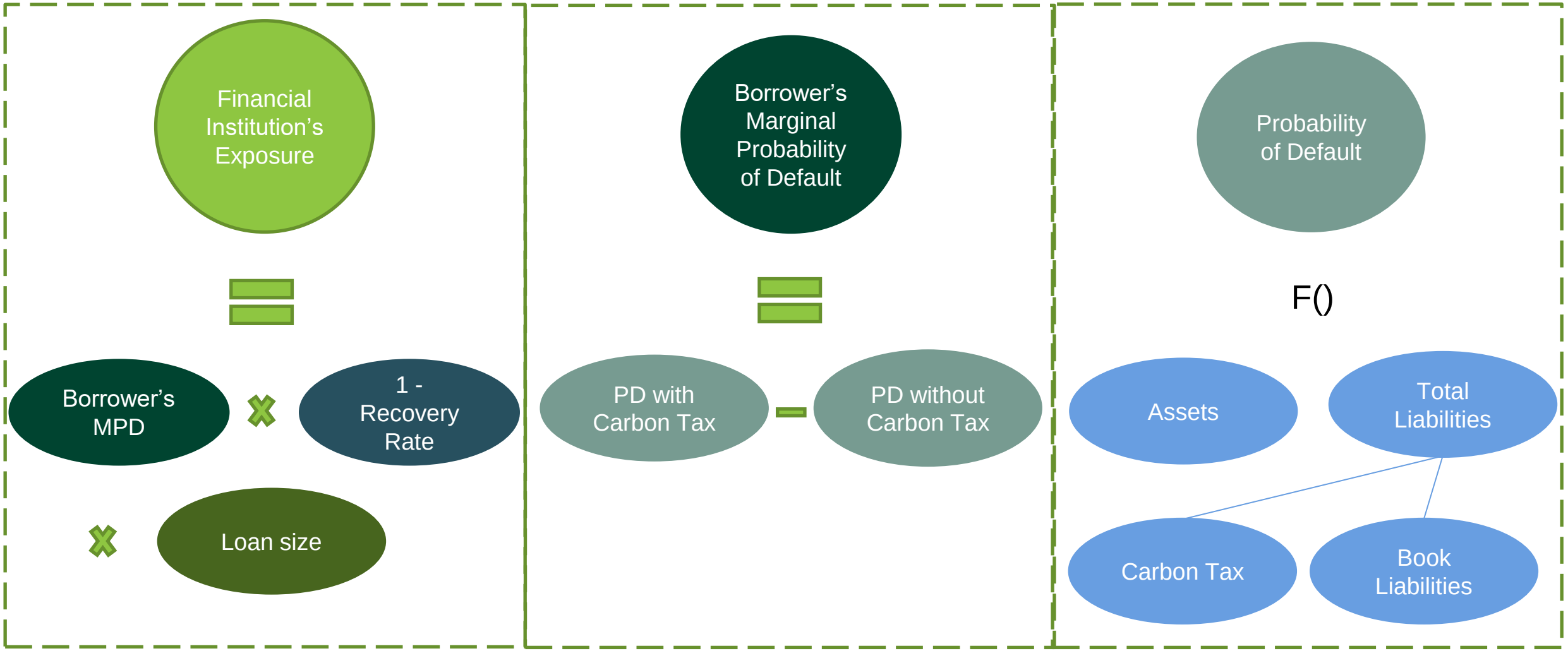


Research indicates that climate risks are material, but are unlikely to cause systemic risk

- **Top-Down Approach**: Allen et al. (2020) found that that probabilities of default could increase by over 400% by 2040 in some French industries, and by 1.6% in others
  - Certain companies within industries will also face outsized exposure due to climate change
- **Top-Down Approach**: Vermeulen et al. (2018) found that regulatory ratios could fall by 16% in the Netherlands
  - Losses will be material, but not threaten financial stability
- **Bottom-Up Approach**: Reinders et al. (2020) found that a £100 carbon tax would decrease regulatory assets by 3.8% to 29.9%

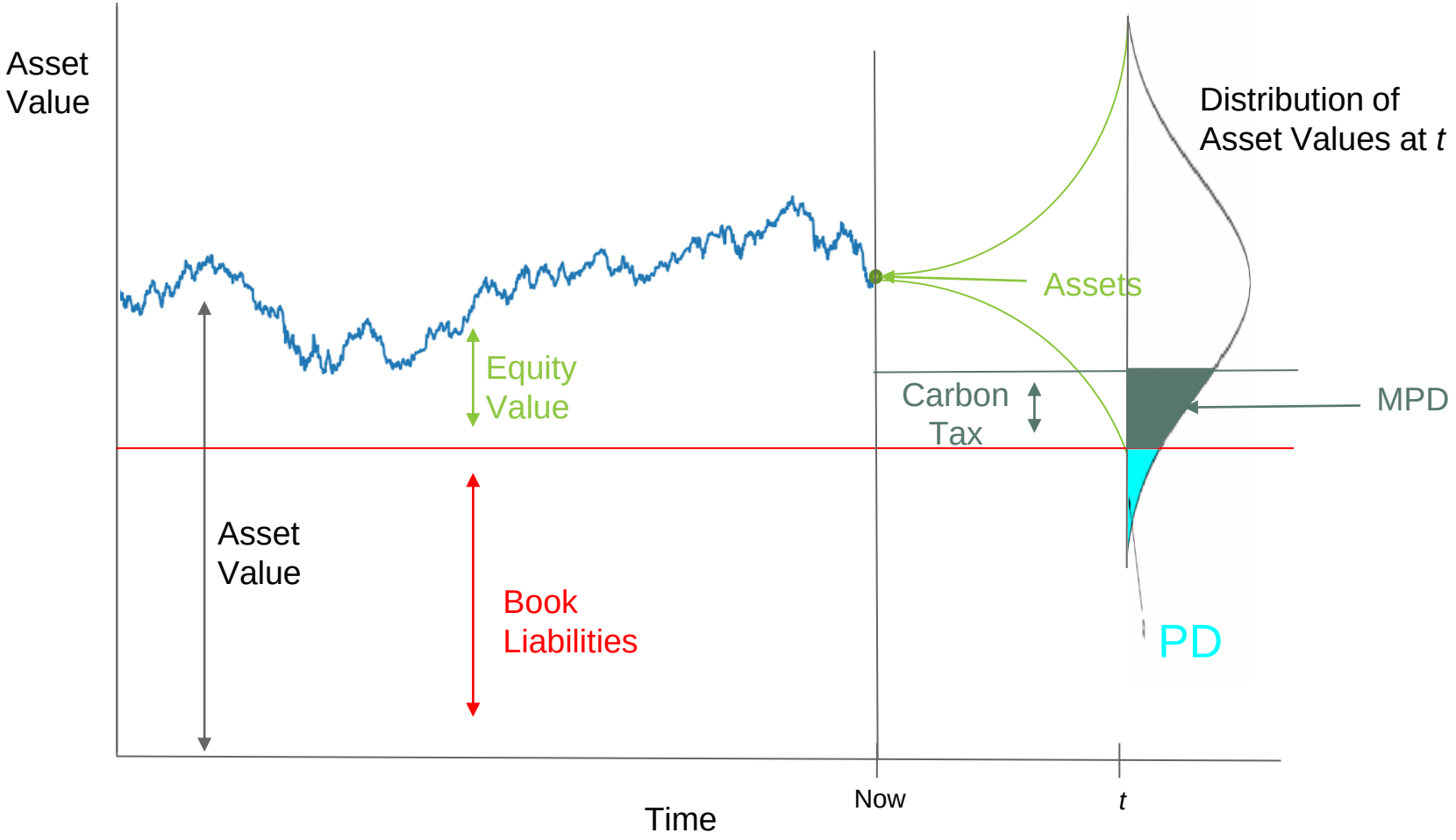
Methodology

I calculated institutions' losses based on the marginal percentage of borrowers that enter default due to a carbon tax



I used Merton's Model of Default to calculate borrowers' probabilities of default and marginal probabilities of default

Graphical Representation



Calculation

- $d1 = \ln\left(\frac{A}{L}\right) + \frac{r + \frac{\sigma_A{}^2}{2} * t}{\sigma_A * \sqrt{t}}$
- $d2 = d1 - \sigma_A * \sqrt{t}$
- $Equity\ Value = A * N(d1) - \mathrm{L} * e^{-r*t} * N(d2)$

I calculated yearly carbon taxes by multiplying Scope I emissions by a tax rate, and aggregated carbon taxes over time

- If a company is in a CDP report, I averaged its emissions from 2015-2018
- Otherwise, I imputed its emissions based on average emissions per dollar of revenue for other companies in its industry
- I treated the carbon tax as debt, meaning that taxes for years two through five were discounted with long term debt

I examined how default rates would change under various scenarios that previous research has found to be reasonable

- **Time-frame**: 0 to 5 years
  - Time for a firm to begin to change its operations

- **Carbon Tax**: $0 to $150
  - Based on
    - Social Cost of Carbon
    - Cost of Carbon necessary to reach Paris Agreement goals
    - Biden Administration's guidance for cost of carbon

- **Recovery Rate:** 0% and 69%
  - Based on
    - Average secured recovery rate
    - Devaluation of assets

I drew my data from three different sources, each with different limitations

Emissions Data — Carbon Disclosure Project

- Voluntary yearly survey of sustainability goals and performance
- Limitations include that data is self reported and sparse

Lending Data — DealScan

- Contains upwards of 90% of syndicated loan data in the United States
- Limitations include lack of coverage of bilateral agreements and lack of corporate financial data

Corporate Data — CapitalIQ

- Aggregates data from regulatory filings
- Limitations include misrepresented data and poor crossover with DealScan

Results

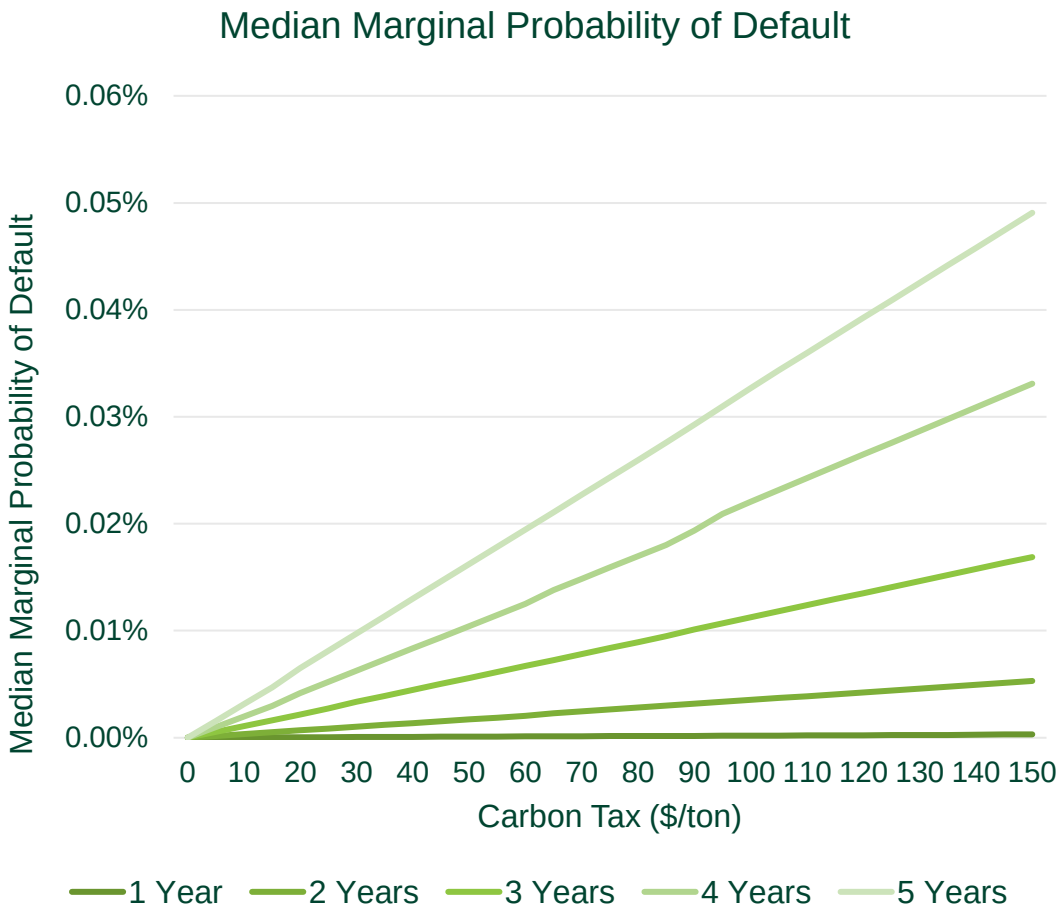
$30.3 Billion

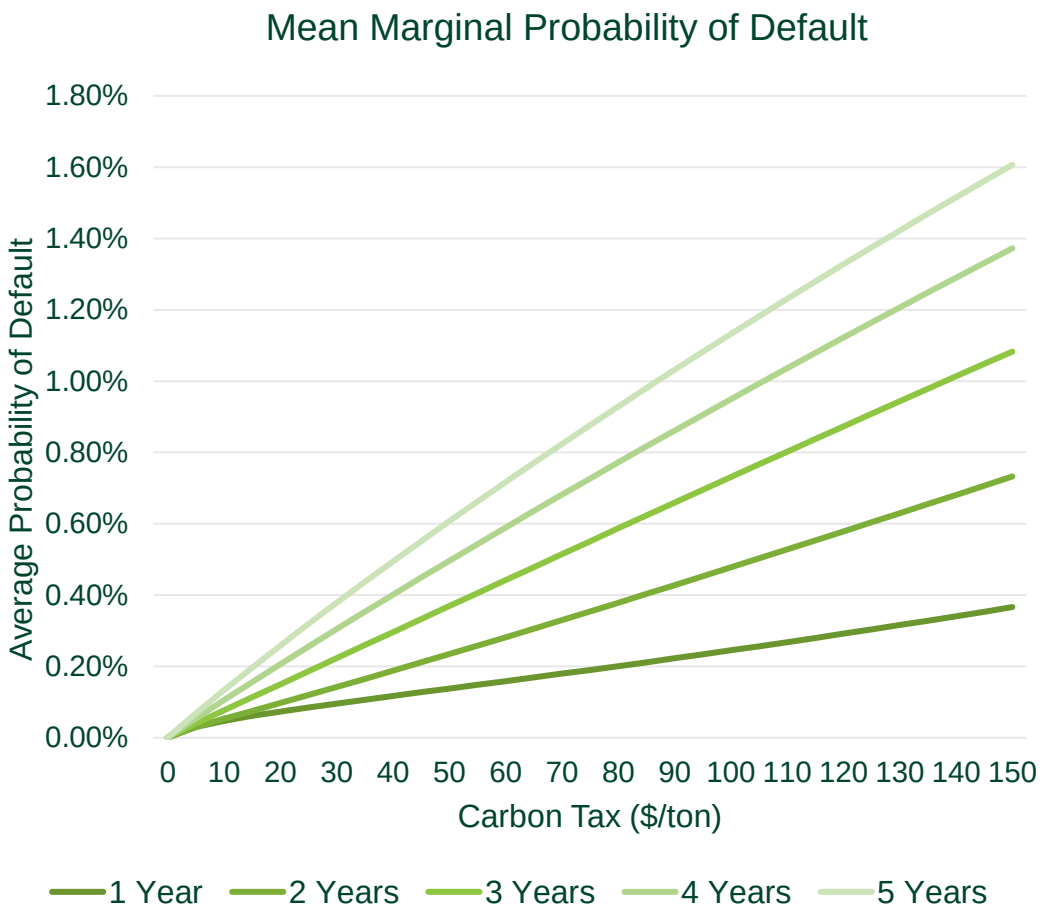
in scaled losses industry-wide

0.61%

increase in probability of default

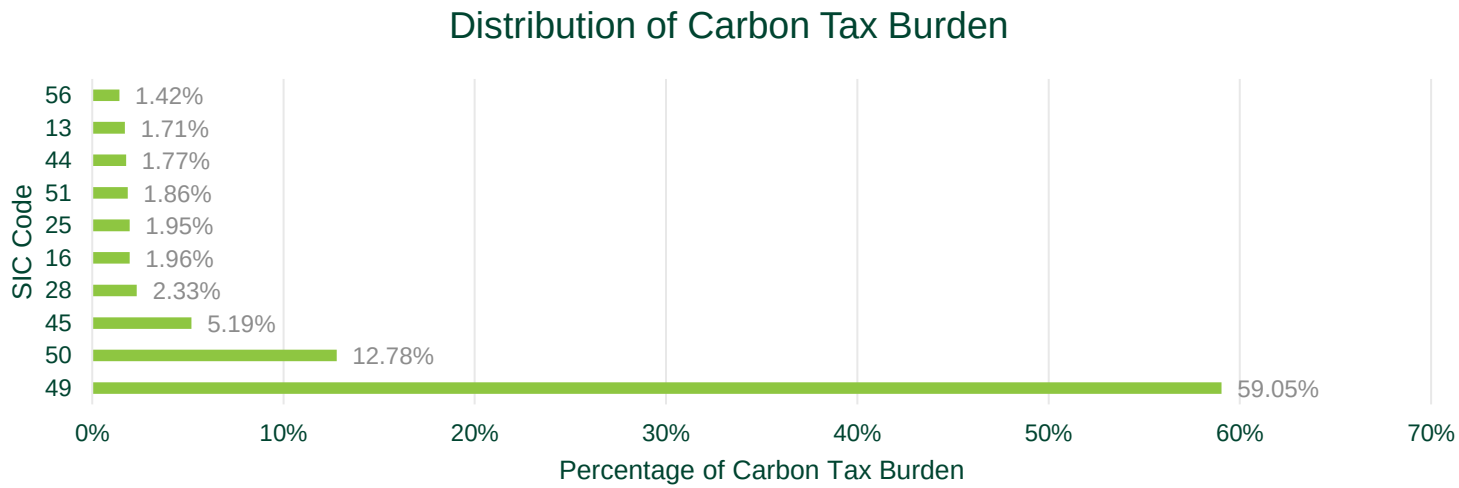
Certain companies account for most of the climate risk facing financial institutions

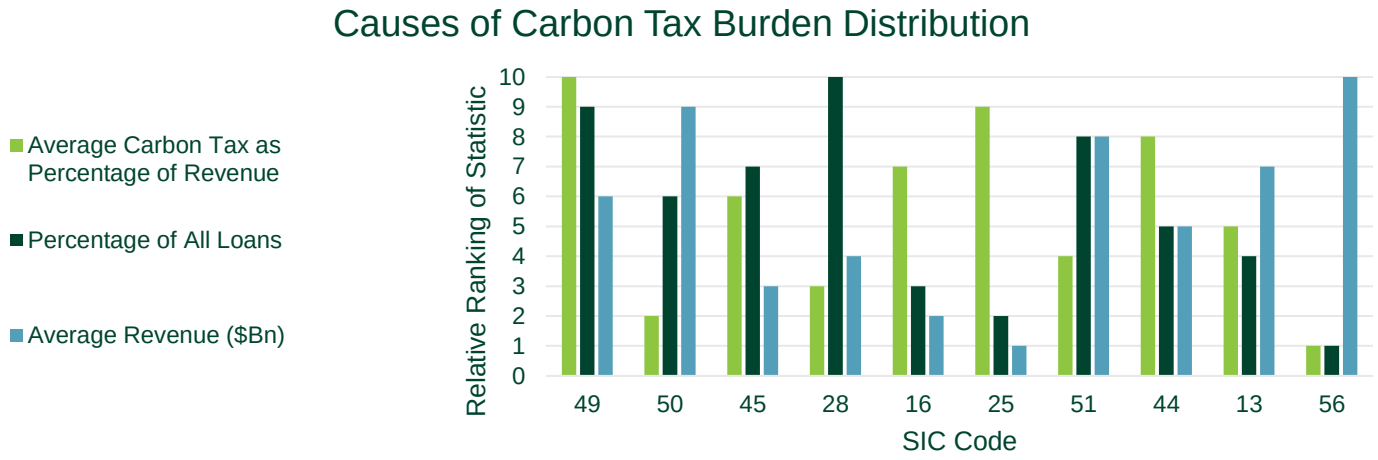




Carbon tax burden is concentrated in a small number of important industries

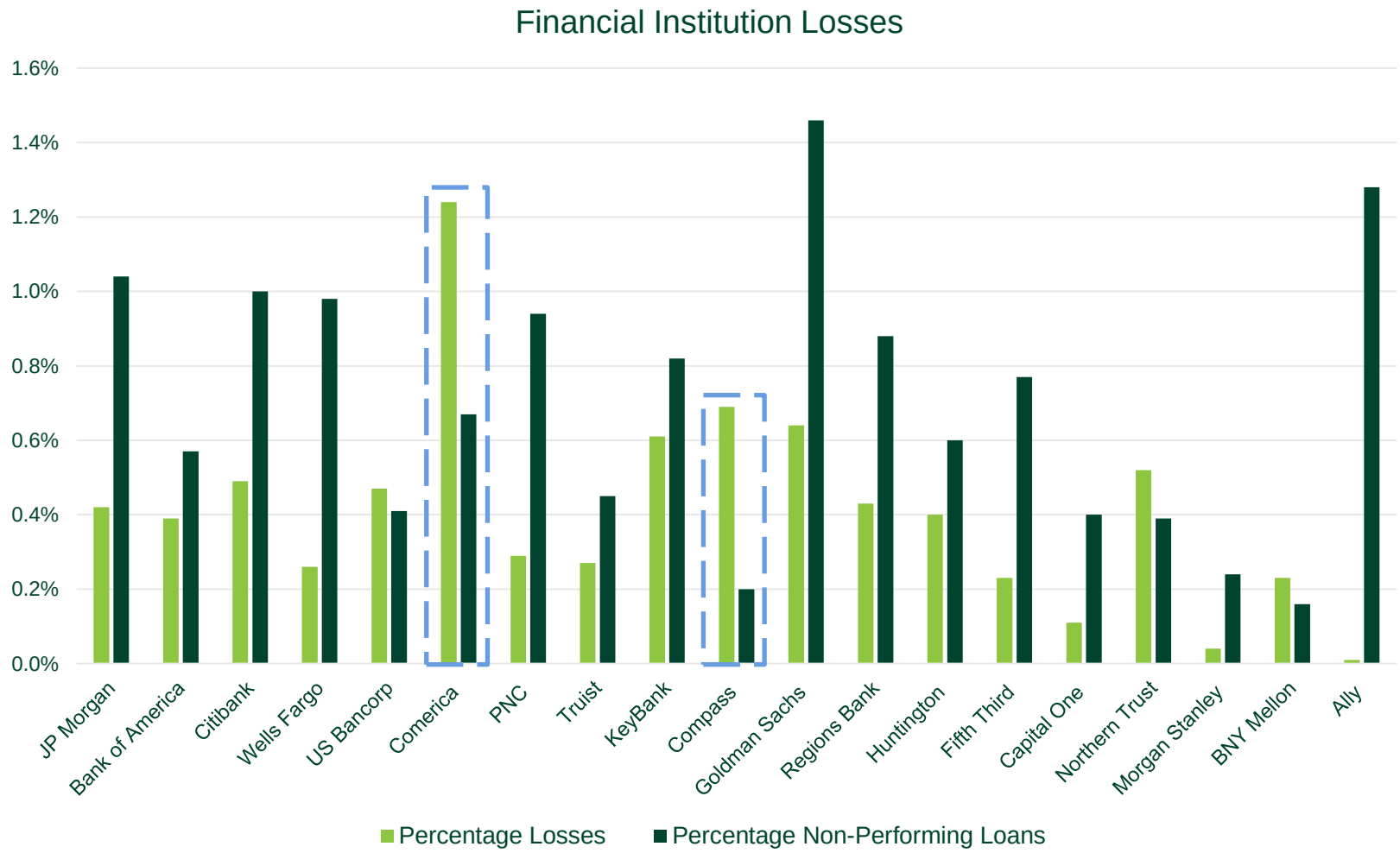
SIC Code	Industry Description
49	Electric, Gas, and Sanitary Services
50	Wholesale Trade – Durable Goods
45	Air Transportation
28	Chemicals and Allied Products
16	Heavy Construction
25	Furniture and Fixtures
51	Wholesale Trade – Nondurable Goods
44	Water Transportation
13	Oil and Gas Extraction
56	Apparel and Accessory Stores





Certain financial institutions bear outsized exposure to climate risk

Financial Institution	Adjusted Losses ($MM)
JP Morgan	$2,058.46
Bank of America	$1,729.86
Citibank	$918.75
Wells Fargo	$896.30
US Bancorp	$613.20
Comerica Bank	$546.91
PNC Bank	$482.92
Truist	$464.03
KeyBank	$428.99
Compass Bank	$276.06
Goldman Sachs	$252.36
Regions Bank	$228.16
Huntington Bank	$164.80
Fifth Third Bank	$144.79
Capital One Bank	$81.85
Northern Trust	$56.24
Morgan Stanley	$28.18
BNY Mellon	$27.31
Ally	$1.33

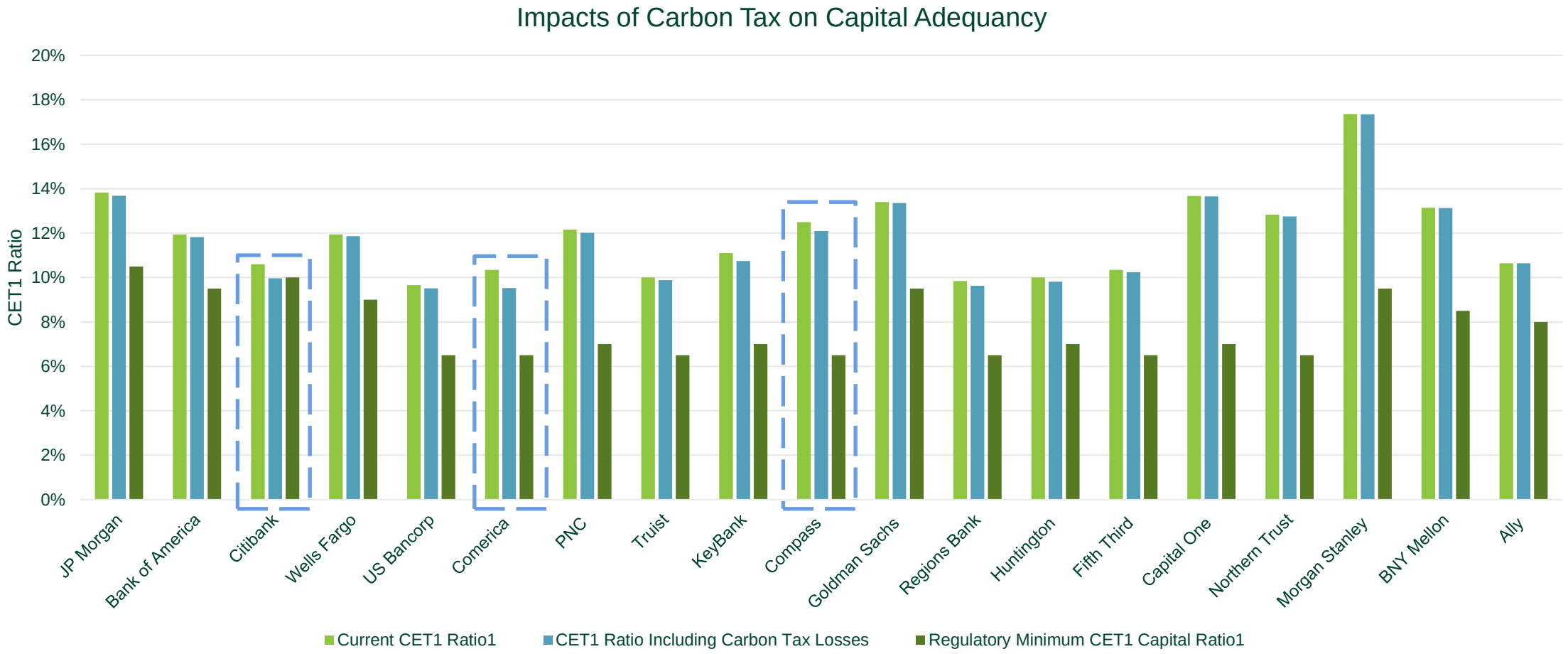


Discussion

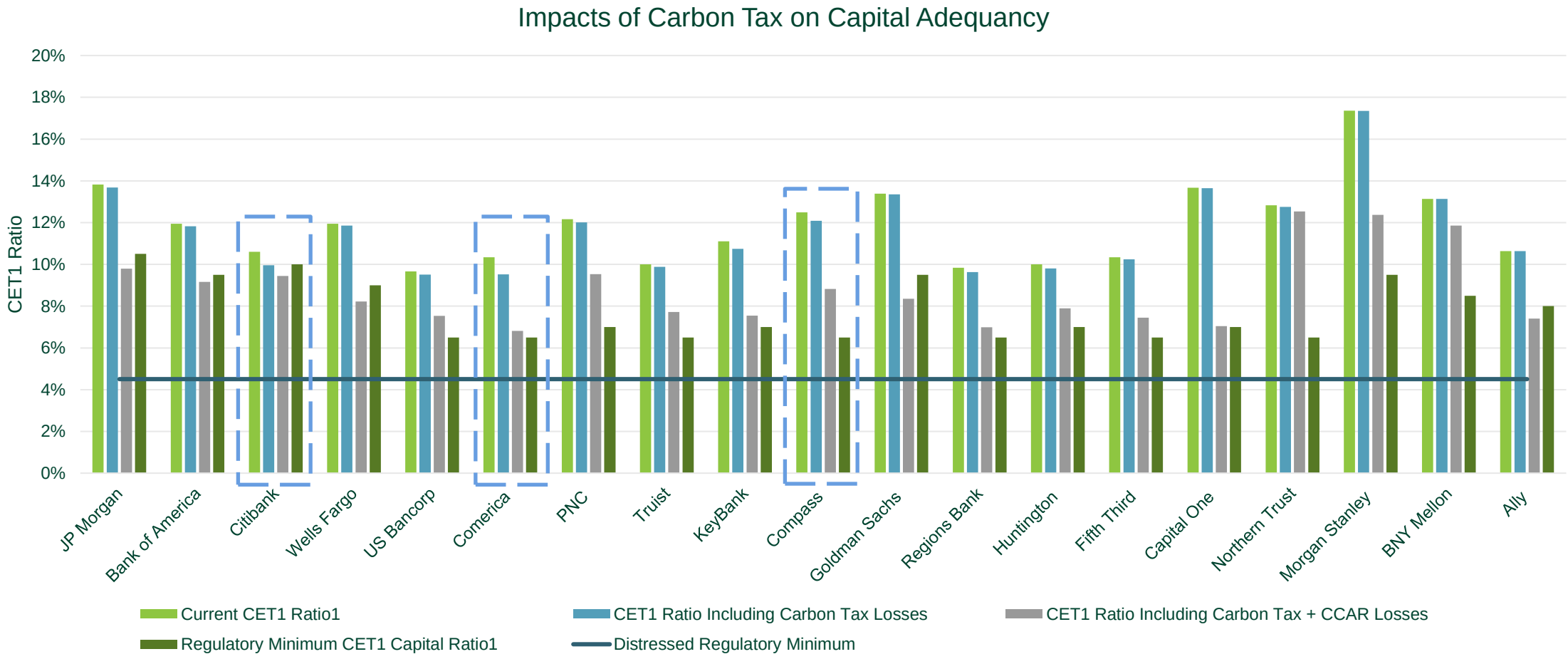
The rest of my analysis is based on the base case described on this slide

- $50 carbon tax
  - Biden Administration base case: $51
  - Average peer reviewed value: $54.71
  - Range to reach Paris goal: $34-$64 by 2025
- 5-year time-horizon
  - Time for company to begin to respond to carbon tax and decrease emissions
- 0% recovery rate
  - Value of assets that secure loans will be impaired by a carbon tax

Citibank’s losses push it under its capital reserve requirements

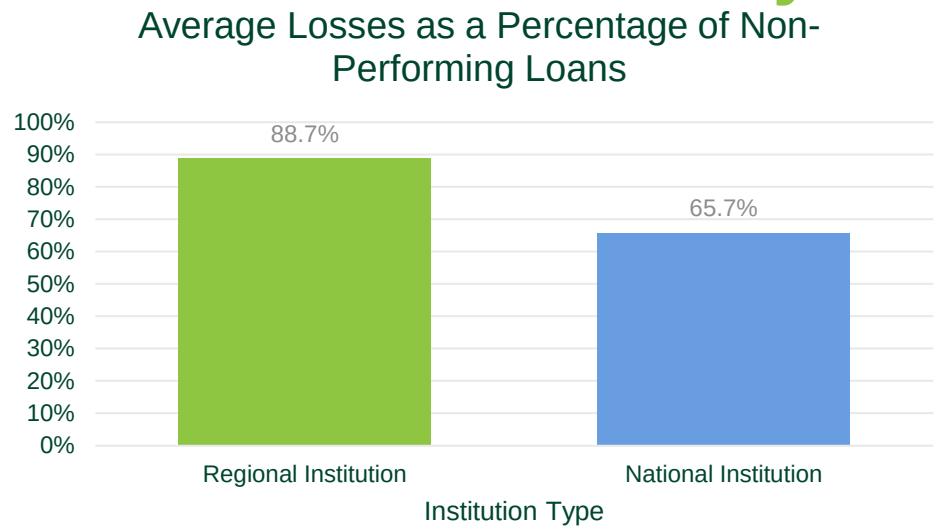


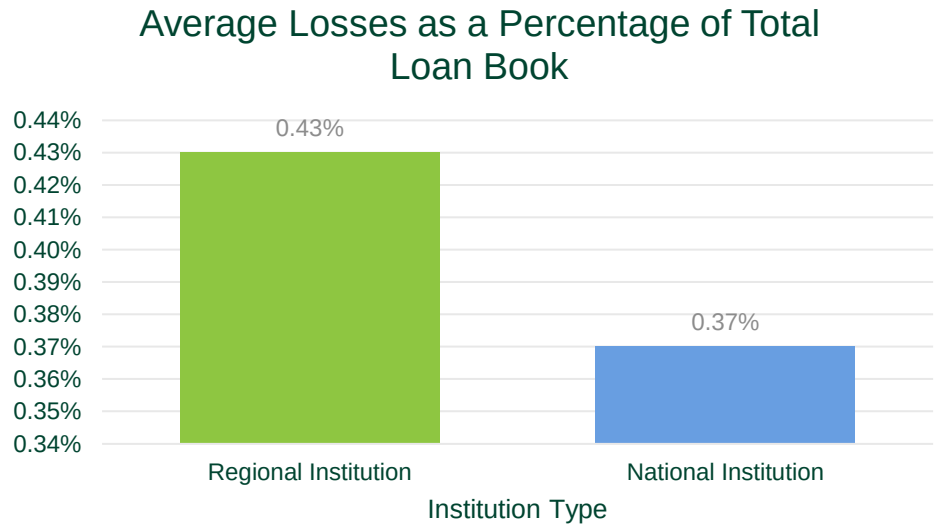
Financial institutions in my sample fair well under the CCAR severely adverse scenario



Regional banks potentially pose threats to financial stability

- In aggregate, unlikely climate risk will lead to financial instability
- Select banks bear high levels of climate risk
- Regional banks bear higher levels of climate risk
- Individual failures can spread
  - Causing sub-systemic risk, or risk in certain industries or regions





Regulators should consider expanding oversight and mandatory disclosure

- Regulators should consider including regional banks in annual CCAR exercises
- Given the potential severity of climate risk, regulators should consider mandating better emissions disclosures

Going forward, more precise emissions calculations and a wider scope could build on my research

- Including Scope II and III emissions may yield a better approximation for the impact of transition risk on financial stability
- Including physical risks in measurement would likely flip the relationship between a carbon tax and financial instability away from being positive
- With more time, I could make fewer simplifications
  - Companies' response to carbon tax
  - Merton's Model
  - Equity exposure

Conclusion

- The risks of climate change are primarily borne by a few companies, industries, and financial institutions
- Although it is not clear whether climate change will cause systemic financial instability, the possibility certainly exists
- Regulators should consider expanding their oversight to include regional banks

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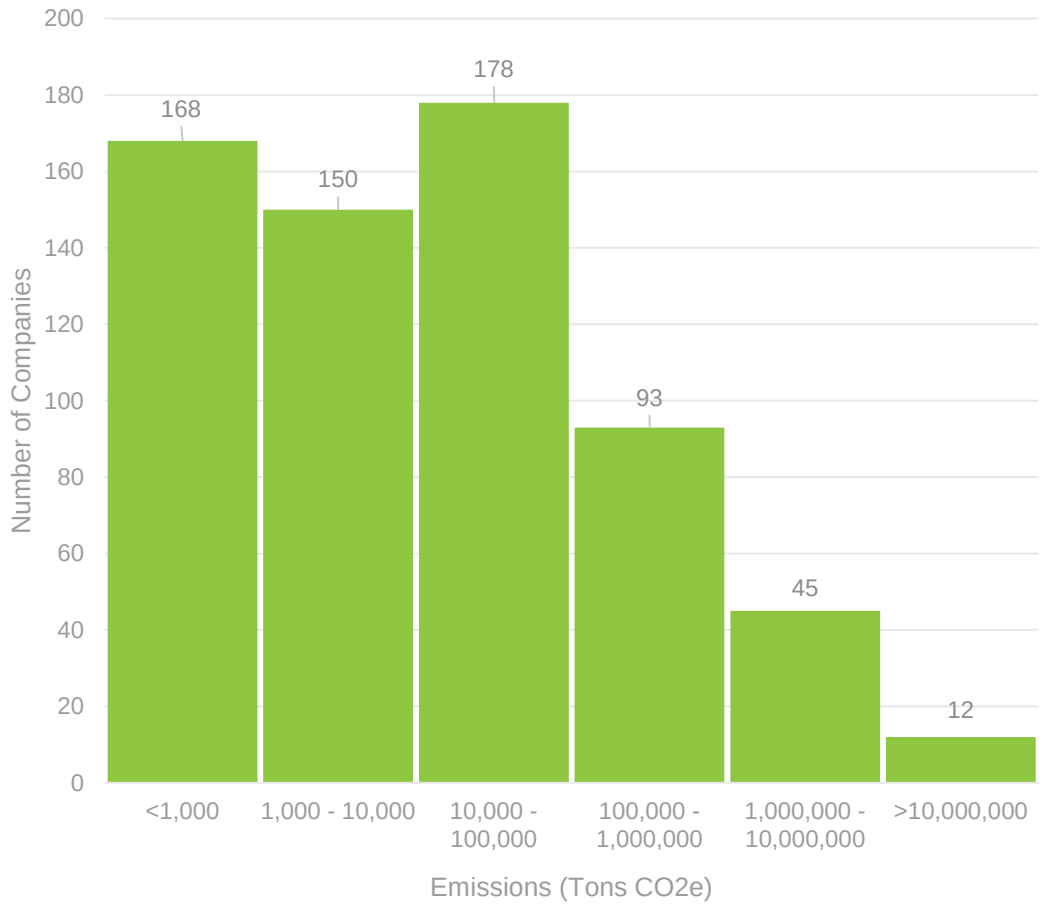
Questions

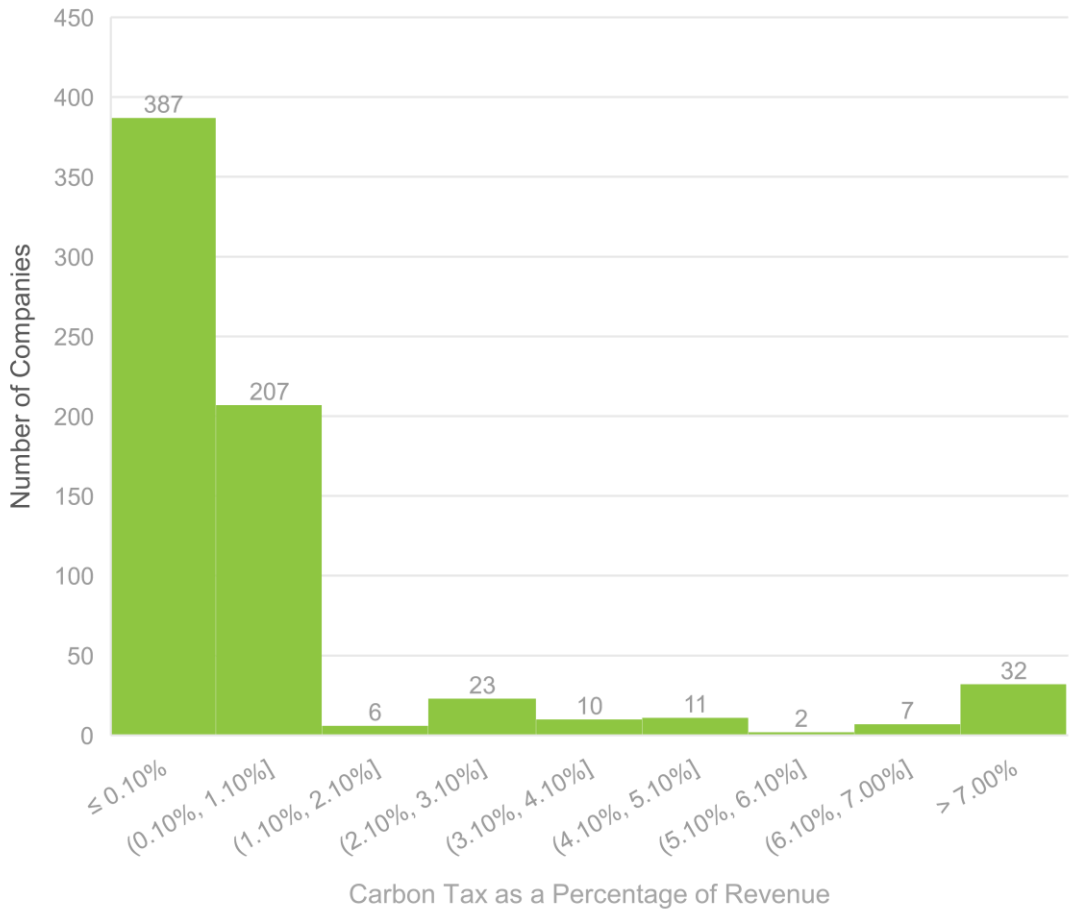
Appendix

The following terms will be important throughout my presentation

- **Default:** When a company's liabilities exceed its assets, and it cannot repay its loans
- **Marginal Probability of Default:** Increase in a company's probability of defaulting on its debt due to climate change
- **Scope I Emissions:** Emissions that come from properties that a company owns or operates
- **Transition risk:** Risk associated with the transition to a low-emission economy
- **Physical risk:** Risk associated with the first order impacts of climate change
- **Systemic financial fragility:** Vulnerability of a financial system to a financial crisis
- **Sub-systemic financial fragility:** Financial instability in certain regions, industries, or financial institutions
- **CET1 Capital**: least risky assets that a bank holds. Balance sheet items include cash, common stock, etc.

Company emissions are skewed heavily to the right and cannot be accounted for by company size





Carbon tax burden is concentrated in a small number of important industries

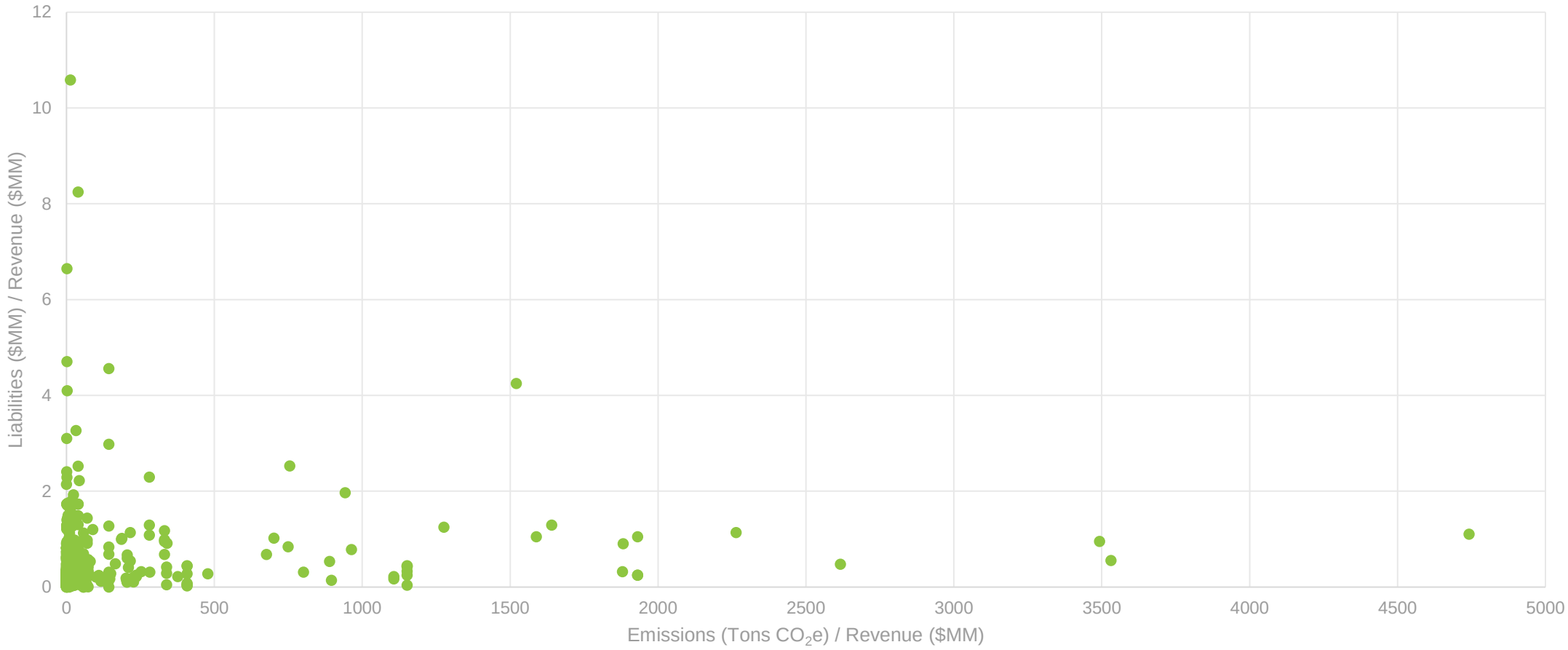
SIC Code	Industry Description	Percentage of Carbon Tax Burden	Average Carbon Tax as Percentage of Revenue	Percentage of All Loans	Average Revenue ($Bn)
49	Electric, Gas, and Sanitary Services	59.05%	12.14%	5.37%	6.89
50	Wholesale Trade – Durable Goods	12.78%	0.05%	2.13%	454.27
45	Air Transportation	5.19%	5.54%	2.34%	4.26
28	Chemicals and Allied Products	2.33%	0.51%	8.25%	6.08
16	Heavy Construction	1.96%	5.63%	0.31%	3.49
25	Furniture and Fixtures	1.95%	11.14%	0.19%	3.06
51	Wholesale Trade – Nondurable Goods	1.86%	0.68%	2.80%	21.86
44	Water Transportation	1.77%	7.11%	1.03%	6.62
13	Oil and Gas Extraction	1.71%	1.48%	0.70%	8.77
56	Apparel and Accessory Stores	1.42%	0.01%	0.10%	879.43

Certain financial institutions bear outsized exposure to climate risk

Financial Institution	Adjusted Losses ($MM)	Percentage Losses	Percentage Non-Performing Loans	Percentage Losses - Rank	Percentage Non-Performing Loans - Rank	Percentage Losses / Percentage Non-Performing Loans
JP Morgan	$2,058.46	0.42%	1.04%	9	3	39.90%
Bank of America	$1,729.86	0.39%	0.57%	11	12	68.35%
Citibank	$918.75	0.49%	1.00%	6	4	48.54%
Wells Fargo & Co	$896.30	0.26%	0.98%	14	5	26.26%
US Bancorp	$613.20	0.47%	0.41%	7	14	113.55%
Comerica Bank	$546.91	1.24%	0.67%	1	10	184.93%
PNC Bank NA	$482.92	0.29%	0.94%	12	6	30.57%
Truist	$464.03	0.27%	0.45%	13	13	61.22%
KeyBank	$428.99	0.61%	0.82%	4	8	74.36%
Compass Bank	$276.06	0.69%	0.20%	2	18	343.62%
Goldman Sachs & Co	$252.36	0.64%	1.46%	3	1	43.77%
Regions Bank	$228.16	0.43%	0.88%	8	7	48.27%
Huntington Bank	$164.80	0.40%	0.60%	10	11	66.13%
Fifth Third Bank	$144.79	0.23%	0.77%	16	9	29.68%
Capital One Bank	$81.85	0.11%	0.40%	17	15	27.31%
Northern Trust	$56.24	0.52%	0.39%	5	16	132.07%
Morgan Stanley Bank NA	$28.18	0.04%	0.24%	18	17	15.82%
Bank of New York Mellon	$27.31	0.23%	0.16%	15	19	146.59%
Ally Commercial Finance LLC	$1.33	0.01%	1.28%	19	2	0.43%

Bank	Losses as Percentage of Loan Base	Losses as a Percentage of CET1 Capital	Losses as a Percentage of CCAR Scenarios[1]	Regulatory Minimum CET1 Capital Ratio[1]	Current CET1 Ratio[1]	CET1 Ratio Including Carbon Tax Losses	CET1 Ratio Including Carbon Tax + CCAR Losses
JP Morgan	0.42%	1.00%	8.72%	10.50%	13.82%	13.68%	9.79%
Bank of America	0.39%	0.98%	5.92%	9.50%	11.94%	11.82%	9.16%
Citibank	0.49%	5.95%	7.01%	10.00%	10.60%	9.96%	9.45%
Wells Fargo & Co	0.26%	0.65%	2.78%	9.00%	11.94%	11.86%	8.22%
US Bank NA	0.47%	1.61%	4.61%	6.50%	9.66%	9.51%	7.54%
Comerica Bank	1.24%	7.90%	N/A	6.50%	10.34%	9.52%	N/A
PNC Bank NA	0.29%	1.22%	4.20%	7.00%	12.16%	12.01%	9.53%
Truist	0.27%	1.23%	4.07%	6.50%	10.00%	9.88%	7.72%
KeyBank	0.61%	3.29%	10.72%	7.00%	11.10%	10.74%	7.55%
Compass Bank	0.69%	3.20%	N/A	6.50%	12.49%	12.09%	N/A
Goldman Sachs & Co	0.64%	0.31%	3.15%	9.50%	13.39%	13.35%	8.35%
Regions Bank	0.43%	2.17%	6.00%	6.50%	9.84%	9.63%	6.99%
Huntington Bank	0.40%	1.85%	5.32%	7.00%	10.00%	9.81%	7.90%
Fifth Third Bank	0.23%	0.99%	2.13%	6.50%	10.34%	10.24%	7.45%
Capital One Bank	0.11%	0.20%	1.20%	7.00%	13.67%	13.65%	7.04%
Northern Trust	0.52%	0.56%	8.03%	6.50%	12.83%	12.75%	12.54%
Morgan Stanley	0.04%	0.04%	0.81%	9.50%	17.36%	17.35%	12.37%
Bank of New York Mellon	0.23%	0.12%	5.46%	8.50%	13.14%	13.13%	11.86%
Ally Commercial Finance	0.01%	0.01%	0.05%	8.00%	10.64%	10.64%	7.40%

There is a positive relationship between emissions and leverage (excluding the most highly levered companies)



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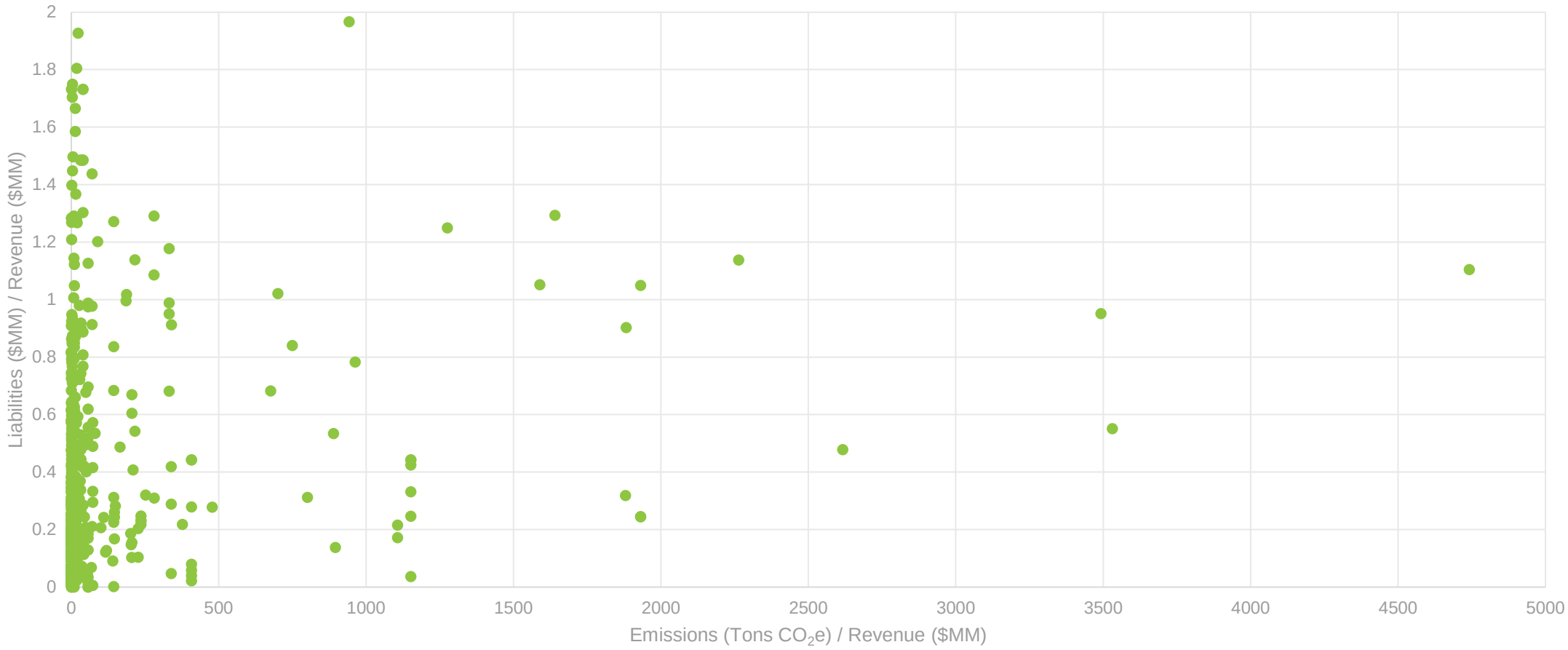

Financial instability is when financial markets fail, and can cause widespread damage

Bank	SIC Code 1	Industry 1	Percentage of Liabilities 1	SIC Code 2	Industry 2	Percentage of Liabilities 2	SIC Code 3	Industry 3	Percentage of Liabilities 3
JP Morgan	45	Air Transportation	39.46%	49	Electric, Gas, and Sanitary	21.03%	25	Furniture Manufacturing	5.82%
Bank of America	45	Air Transportation	31.06%	49	Electric, Gas, and Sanitary	16.34%	36	Electronics Manufacturing	8.09%
Citibank	49	Electric, Gas, and Sanitary	43.80%	45	Air Transportation	32.91%	51	Wholesale Trade - Non-Durable	3.63%
Wells Fargo & Co	49	Electric, Gas, and Sanitary	24.67%	45	Air Transportation	16.80%	25	Furniture Manufacturing	14.65%
US Bancorp	45	Air Transportation	41.70%	49	Electric, Gas, and Sanitary	23.91%	51	Wholesale Trade - Non-Durable	7.44%
Comerica Bank	45	Air Transportation	33.50%	49	Electric, Gas, and Sanitary	31.80%	51	Wholesale Trade - Non-Durable	15.82%
PNC Bank NA	49	Electric, Gas, and Sanitary	43.56%	51	Wholesale Trade - Non-Durable	10.49%	12	Coal Mining	8.25%
Truist	51	Wholesale Trade - Non-Durable	23.64%	25	Furniture Manufacturing	17.89%	16	Heavy Construction	12.88%
KeyBank	49	Electric, Gas, and Sanitary	73.09%	16	Heavy Construction	11.99%	73	Business Services	7.91%
Compass Bank	36	Electronics Manufacturing	88.81%	49	Electric, Gas, and Sanitary	7.27%	70	Hotels	1.98%
Goldman Sachs & Co	49	Electric, Gas, and Sanitary	50.63%	45	Air Transportation	33.74%	16	Heavy Construction	2.41%
Regions Bank	49	Electric, Gas, and Sanitary	43.54%	16	Heavy Construction	18.24%	12	Coal Mining	10.80%
Huntington Bank	12	Coal Mining	38.82%	49	Electric, Gas, and Sanitary	25.47%	32	Stone, Clay, Glass, and Concrete Manufacturing	20.59%
Fifth Third Bank	25	Furniture Manufacturing	33.60%	51	Wholesale Trade - Non-Durable	16.02%	26	Paper and Allied Products	12.06%
Capital One Bank	16	Heavy Construction	52.33%	73	Business Services	13.89%	13	Oil and Gas Extraction	5.10%
Northern Trust	25	Furniture Manufacturing	54.16%	28	Chemicals and Allied Products	20.59%	26	Paper and Allied Products	11.87%
Morgan Stanley Bank NA	46	Fossil Fuel Pipelines	31.97%	79	Amusement and Recreation Services	29.43%	48	Communications	22.04%
Bank of New York Mellon	49	Electric, Gas, and Sanitary	65.27%	26	Paper and Allied Products	32.39%	73	Business Services	0.82%
Ally Commercial Finance LLC	37	Transportation Equipment	98.13%	32	Stone, Clay, Glass, and Concrete Manufacturing	1.06%	59	Miscellaneous Retail	0.81%

Data Selection Methodology