Ceres

THE CERES ACCELERATOR FOR
SUSTAINABLE CAPITAL MARKETS

FINANCING A NET-ZERO ECONOMY

Measuring and Addressing Climate Risk for Banks

OCTOBER 2020

About Ceres

Ceres is a sustainability nonprofit organization working with the most influential investors and companies to build leadership and drive solutions throughout the economy. Through powerful networks and advocacy, Ceres tackles the world's biggest sustainability challenges, including climate change, water scarcity and pollution, and inequitable workplaces.

About the Ceres Accelerator for Sustainable Capital Markets

The Ceres Accelerator for Sustainable Capital Markets (the "Ceres Accelerator") aims to transform the practices and policies that govern capital markets in order to accelerate action on reducing the worst financial impacts of the global climate crisis and other sustainability threats. The Ceres Accelerator will spur capital market influencers to act on these systemic financial risks and drive the large-scale behavior and systems change needed to achieve a net-zero carbon economy and a just and sustainable future. For more information visit: ceres.org/accelerator.

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FINANCING A NET-ZERO ECONOMY
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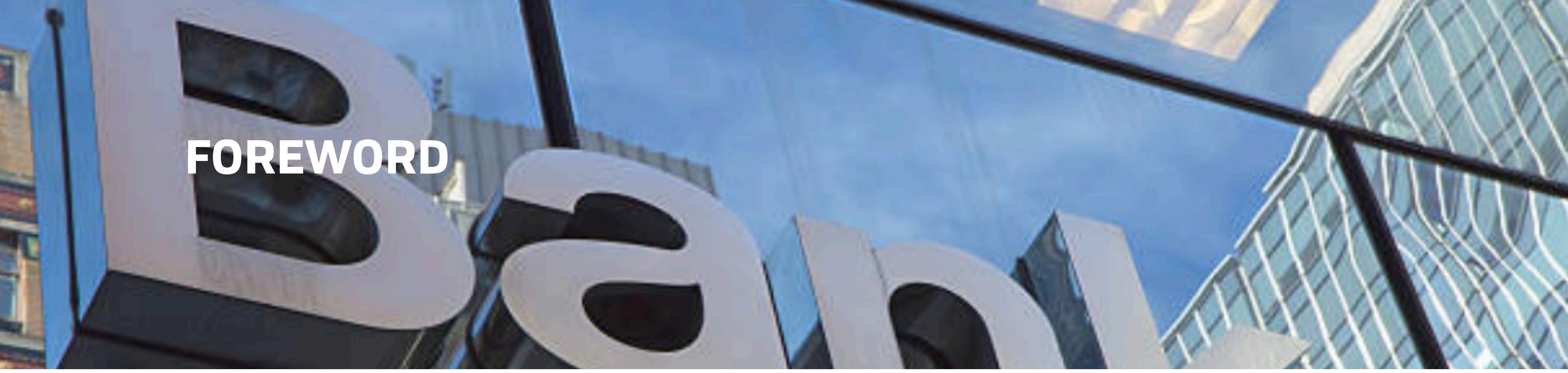
FOREWORD



In September 2020, as this report is being prepared, the backdrop onto which it will be released is unsettling. The U.S. economy is struggling under the stress of the COVID-19 pandemic, and the toll of centuries under discriminatory systems is manifesting itself in the inequitable distribution of lost lives and livelihoods along racial lines. As if living at a distance while reckoning with systemic racism was not enough, 2020 has delivered Americans an onslaught of climate-related disasters. My home state of California has been sending the most devastating snapshots of the future. Wildfires in the West have engulfed as much acreage as the state of Connecticut, causing tens of thousands to flee their homes and millions to suffer unhealthy air and orange skies.

Against this backdrop, Ceres' new report **Financing a Net Zero Economy: Measuring and Addressing Climate Risk for Banks** investigates the impacts of climate change on the syndicated loan portfolios of U.S. banks. The report finds much greater exposure to risks associated with the transition to a low-carbon economy than has been disclosed. Neglecting to address these risks carries with it the potential to seriously damage financial institutions and the broader economy as a whole.

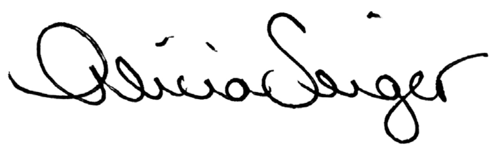
Accordingly, banks should follow Ceres' recommendations to urgently and more comprehensively assess, disclose and mitigate climate risk and to align their financing with the goals of the Paris Agreement. But voluntary action will not be enough. As Ceres' June 2020 report **Addressing Climate as a Systemic Risk** also found, this companion analysis concludes it is time for central banks and financial regulators to recognize climate risk as part of their mandate.

Ceres focused on syndicated loans because they represent a significant portion of bank activity and data is publicly available. Using this data, the report identifies the potential risks associated with loans not just to the fossil fuel industry, but also to the industries that rely heavily on fossil fuel, such as heavy manufacturing, agriculture, construction and transportation.

The report focuses on risks stemming from the transition to a low-carbon economy. It is important to keep in mind that transition risk is but one flavor of climate risk banks must manage. Physical risk (driven by extreme heat, drought, floods, wildfires, etc.) will affect the value of bank and customer assets, real estate loans and other lines of business. And as more communities, municipalities and states confront economic hardship resulting from climate impacts, banks and their customers must assess the risk of litigation for damages.

The modeling in this report is intentionally illustrative and offers directional insights from sectoral-level analysis. In its focus on a subset of transition risks and dynamics, it does not profess to address the multiple modeling challenges previous studies have identified. To understand the full picture, we need the banks to move forward with voluntary actions outlined in this report. We also need federal and state financial regulators to act. In fact, if done well, voluntary private sector action and regulatory oversight will be mutually reinforcing, with the former reducing the burden of the latter, and greater oversight providing more certainty and guidance to the banks' efforts.

As bankers there is immediate action that you can take to reduce your institutions' risk exposure and to provide the capital needed to catalyze the low-carbon transition. As investors and customers your active questions and engagement are more critical than ever. As regulators and legislators, your voices and your actions are needed to set clear guardrails for the financial stability and sound management of our economy. As today's climate challenges highlight, we do not have any time to waste.



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EXECUTIVE SUMMARY

As the lynchpin of the global economy, banks have an essential role to play in minimizing the worst impacts of climate change. How banks respond to the climate risk that they individually and collectively face depends heavily on how they measure and analyze their exposure to it.

The climate risk banks face stems from the failure of their clients to adequately prepare for a lower-carbon future. This risk has the potential to significantly damage financial institutions and the broader economy—and impede society's ability to tackle climate change at the speed and scale required to avoid its worst impacts. This is doubly true because the understanding of tail risks—risks once thought too extreme to consider—has dramatically changed, first with the 2008 financial crisis and now with the COVID-19 pandemic.

Many banks have begun to act. Some lending policies are being adjusted for risky fossil fuel companies. Some banks have called on policymakers to address systemic climate risk. Global players including Barclays, [1] JPMorgan Chase [2] and Morgan Stanley [3] have even made climate commitments that cover their financing activities.

But for most banks, the current view of climate risk is incomplete—it focuses narrowly on fossil fuel sectors or broadly on the need for policy action. It is what lies in the middle—the massive amount of financing banks provide to sectors, including agriculture, manufacturing, construction and transportation, that rely heavily on oil, gas and coal—that could threaten climate and financial stability if unaddressed.

This report investigates the syndicated loan portfolios of the largest U.S. banks and their exposure to climate transition risk, which arises from the policy, regulatory, consumer preference and reputational impacts of the transition to a lower-carbon economy. It complements other leading-edge approaches and highlights the imperative for banks to use their proprietary data to fully test its findings.

Key Finding #1

Over half the syndicated lending of major U.S. banks is exposed to climate transition risk because many bank clients in a wide range of sectors have inadequately prepared for emissions reductions in line with the Paris Climate Agreement.

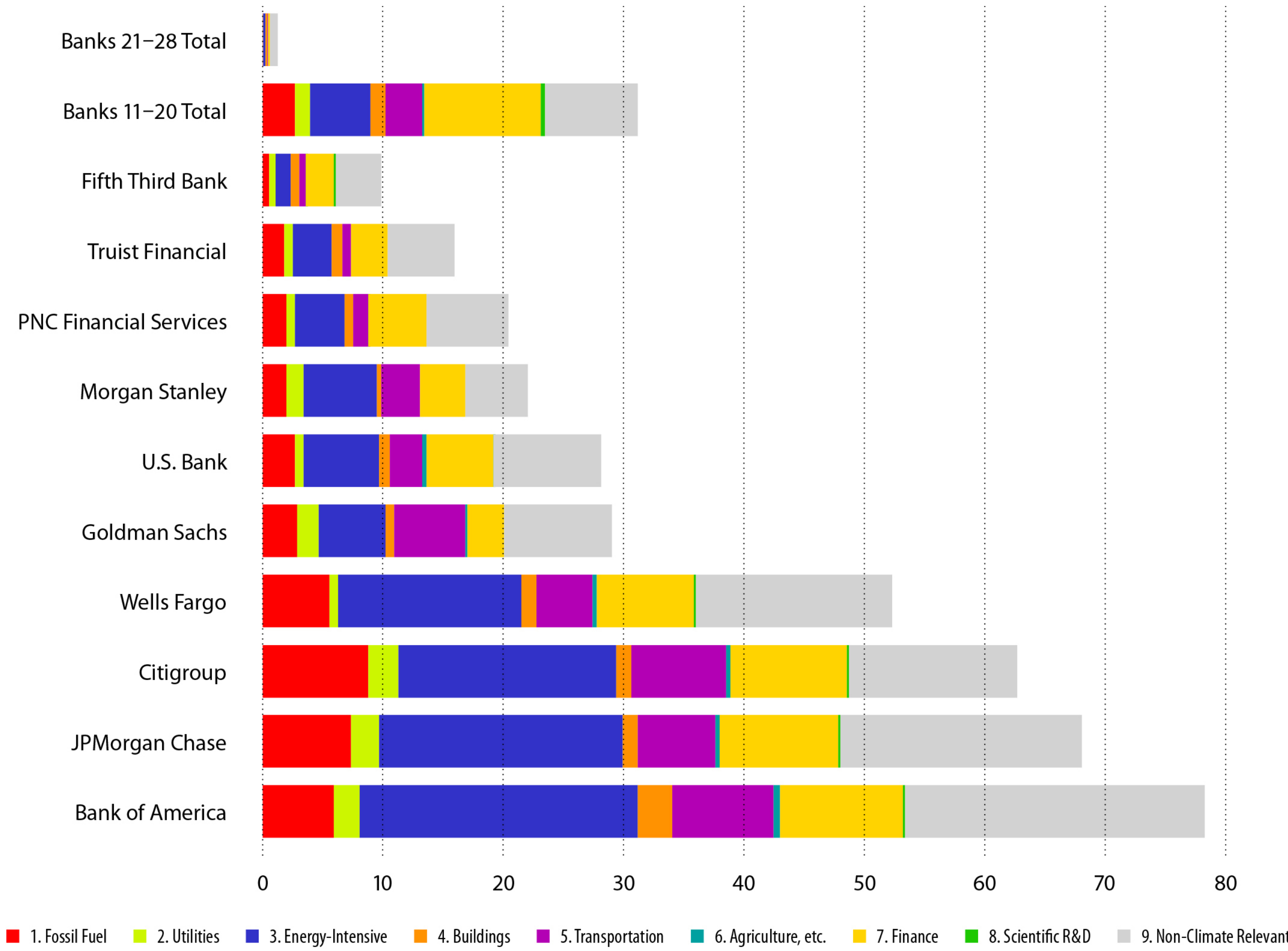

Figure 1: Climate-relevant sectors in U.S. syndicated loan portfolios ($ billions).

Given this potential exposure, every bank should assess its resilience against disorderly climate transition scenarios (brought on, for instance, by a sudden shift in investor and public sentiment around climate risks following a policy change). The limited publicly available data show that in a worst-case scenario, banks could sustain heavy losses on their syndicated loan book and, by extension, other areas of their business, as the market shares and profitability of unprepared clients decline.

Key Finding #2

Banks may face substantial losses from direct exposure in the months following a major sentiment shift.

- The "Core-Impact" view of banks' exposure to the fossil fuel and electricity sectors produces modest loss estimates—up to 3% for the syndicated loan portfolio of an average bank.
- But the "Wide-Impact" view, which accounts for all non-financial, climate-relevant sectors (including energy-intensive manufacturing, buildings, transportation and agriculture) produces much higher average loss estimates—up to 18% on these loans.

- The six largest banks in the U.S. all face above-average risk in the wide-impact results.

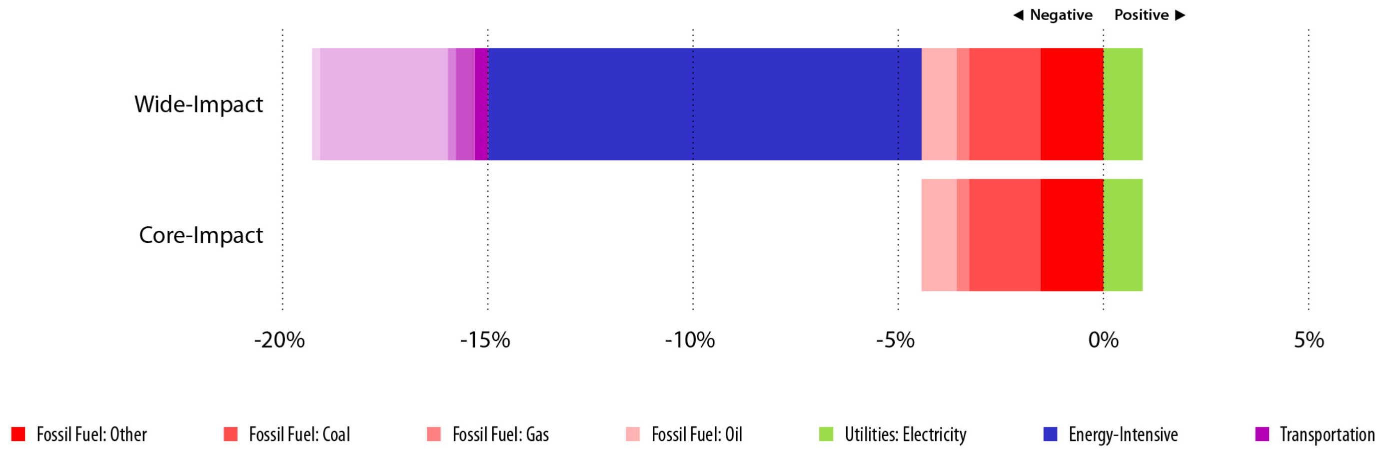

Figure 2: Percentage losses on the syndicated loan portfolios of major U.S. banks (by sector) in the months following a shock.

These losses reflect a worst-case scenario, but only for a portion of each bank's business and a single type of risk. Banks face other risks, including from physical risk (extreme weather, fires, droughts or sea level rise). They also face potential legal liability and risks from other elements of their business lines. Together, these could combine to ratchet up total exposure even more. Just as critical but perhaps less obvious is that banks also face indirect transition risk from interbank lending and other exposures within the financial system itself. This key driver of the 2008 financial crisis has not been factored into publicly disclosed climate risk analysis to date.

Key Finding #3

Banks' level of leverage and connectivity within the financial system could lead to substantial **incremental climate risk**.

- The extent to which banks finance each other leads to **indirect transition risk** from exposure to other firms' own direct risk.
- Additionally, banks could face **balance-sheet contagion (or "fire sales,")** where assets are rapidly devalued and banks are forced to sell them to stay in compliance with regulatory capital requirements.

These results are not the final word. **Individual banks have the power to substantially change this narrative and differentiate themselves from peers.** Methodologies for stress testing and scenario analysis are robust enough to be widely used and provide a starting point for the urgent work of conducting more granular risk assessment at the client level. By improving client selection and engagement, banks will not just lower their risk and create new upside, they will help propel the transition to a zero-carbon economy. That will, in turn, minimize risks to financial stability and the entire banking sector and help catalyze more momentum to curb the most severe impacts of climate change by meeting the objectives of the Paris Agreement.

Further dialogue and analysis around these complex issues is required, which is why Ceres views this report as the next step in a deeper collaboration with the sector on how to act on the report's recommendations, which fall into three broad categories:

Assess and Disclose Risk (Recommendations 1-5)

Most firms in climate-relevant sectors today are exposed to climate risk, but there are a growing number that would greatly benefit from a low-carbon transition scenario. Quantifying the upside (and downside) at both the firm and portfolio levels will improve banks' client selection and identify a larger number of investable opportunities that could offset potential losses.

Improve Tools and Methods (Recommendations 6-9)

Existing analysis can be strengthened by developing science-based, transparent valuation approaches that can be used to meaningfully engage clients on their own climate strategies. Key improvements needed as part of this include:

- Requiring that clients provide more data in key climate-related areas, such as energy technology and emissions profiles
- Aggregating those data using methods such as carbon accounting
- Further developing risk management techniques, including stress testing and scenario analysis
- Building climate risk into day-to-day decision-making tools, such as client earnings models

Act to Mitigate Climate Risk and Ultimate Impact (Recommendations 10-13)

Good analysis allows banks to decarbonize their portfolios through **client engagement**, which is critical for achieving real economy emissions reductions. Engagement only reduces risk if it leads to target setting and emissions reductions by clients, so banks need accountability mechanisms to ensure this occurs.

That is why Ceres is calling on every bank to set a **Paris-aligned emissions target** before the next major UN climate conference in November 2021. This should include detailed interim targets and specific timelines for sectoral portfolios to reach net-zero emissions—some sectors as soon as 2030, others by 2040 or 2050.

This will ensure that client engagement is focused on results and also serve as an external signal about the bank's own risk. Banks that set such targets will send an unambiguous message that they are serious about reducing their own climate risk and about building a just and sustainable global economy.

Ceres' Recommendations for Banks

1. While this report focuses on transition risk, banks should assess all elements of climate risk and opportunity that may affect their business (including transition risk, physical risk and litigation risk), and disclose an overall assessment to investors and other external stakeholders.
2. Banks should assess their entire balance sheet to identify which assets may be exposed to climate transition risk (including indirect risk from elsewhere in the financial system).
3. Banks should disclose a portfolio risk assessment that identifies the sectors that the bank considers to be climate relevant and the percentage of assets in these sectors that the bank considers to be at risk.
4. Risk assessment should include stress testing based on both backward-looking data (such as past emissions) and forward-looking data (such as planned expenditures). The findings of these analyses should be disclosed at a high level.
5. U.S. banks should align their policy positions and lobbying with the regulatory recommendations outlined in Ceres' June 2020 report **Addressing Climate as a Systemic Risk**.
6. Banks should use, improve and develop internal valuation tools that translate climate-relevant information into securities prices, earnings forecasts and value-at-risk estimates.
7. Banks should seek industry agreement to use their market power and relationship leverage to incentivize clients to voluntarily disclose additional forward- and backward-looking climate data.
8. Banks should internally prioritize and reward their employees for integrating climate considerations into day-to-day decision-making.
9. Banks should recognize the risk mitigation potential of constructing a more fundamentally sound, equitable and sustainable economic system.
10. Banks should publicly state that they will use engagement and leverage to accelerate client transition plans and wind down relationships that do not include such plans.
11. Banks should communicate to employees and investors any risk-mitigation value they ascribe to their sustainable finance programs.
12. Banks should set and disclose financing portfolio targets that are aligned with the goals of the Paris Climate Agreement and should include detailed interim targets and specific timelines for sectoral portfolios to reach net-zero emissions—some sectors as soon as 2030, others by 2040 or 2050.
13. Banks should publicly commit to and begin work on the 12 recommendations above within the next year.

Introduction and Context

Climate linked events have cost the U.S. nearly $1.8 trillion since 1980 [1], with direct economic losses surpassing $500 billion between 2015 and 2019 [2]. Steeper economic losses are projected in the years ahead if urgent, concerted actions are not taken by the private sector, policy makers and civil society to address the most severe impacts of climate change.

The landmark Stern Review, **The Economics of Climate Change**, [3] warns that unmitigated climate change could cost the world 5 - 20% of GDP per year. In a 2019 CDP survey [4], 215 of the world's largest public companies reported nearly $1 trillion at risk from climate impacts, much of it in the next five years. A London School of Economics study [5] projects that, unless addressed, climate change could reduce the value of global financial assets by as much as $24 trillion by 2100—permanent damage far worse than the 2008 financial crisis.

Against this backdrop, the Paris Agreement forged a political consensus around limiting the increase in global average temperature to well below 2°C, with the ultimate aim of limiting it to 1.5°C. Achieving this goal would require an unparalleled ramp up of all low-carbon technologies in all countries.

One way or another, whether through planned and deliberate actions like the Paris Agreement or in a disorderly manner because of lack of preparation, society and the global economy will have to make the transition to a low-carbon economy.

This report investigates banks' climate-related financial risks and their exposure to a disorderly transition. Based on the finding that a majority of bank lending is in climate-exposed sectors, the report also lays out a blueprint for bank action with key recommendations for how banks can discuss their climate risk exposure and the mitigation strategies they can use to address this risk exposure and broader climate-related societal impact.

Elements of Climate Risk

At the highest level, climate risk is divided into transition risk and physical risk. Transition risks are the economic and financial risks arising from the policy, regulatory, consumer preference and reputational impacts of a transition to a lower-carbon economy. They are the focus of this report. Physical risks are the risks to real assets due to climate-fueled natural occurrences, such as sea level rise, fires, droughts and other extreme weather events [6]. Physical risk remains critical for banks and likely adds substantially to total climate risk. It is not discussed here, as it is complex enough to warrant its own study. Additionally, this report does not cover litigation risk associated with climate-relevant sectors (e.g., PG&E's 2019 bankruptcy resulting from massive wildfire liabilities), as the analytical methods used would not apply. As a result, though this report investigates worst-case scenarios for transition risk, its findings are almost certainly an underestimate of the total risk exposure banks face.

RECOMMENDATION

Banks should assess all elements of climate risk and opportunity that may affect their business (including transition risk, physical risk and litigation risk), and disclose an overall assessment of risk.

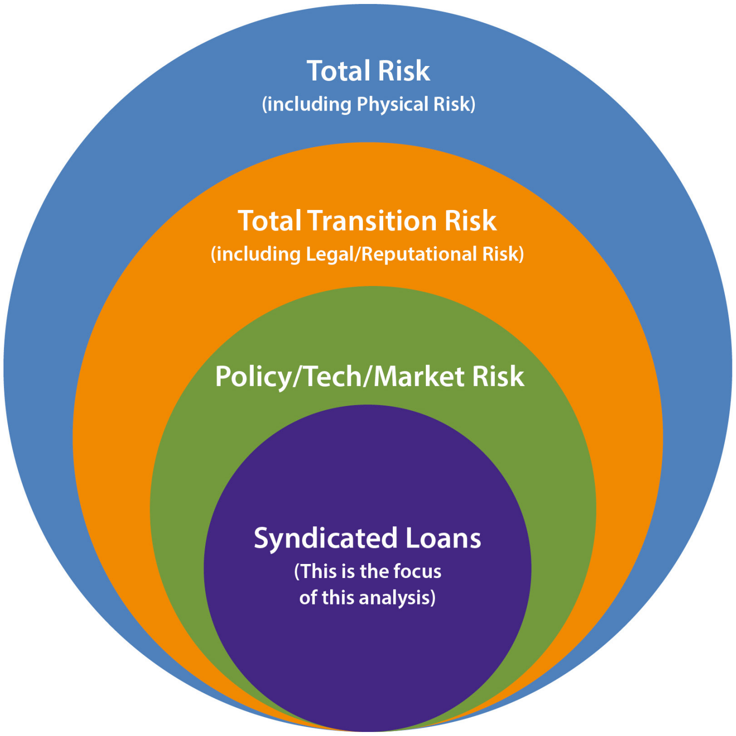

Figure 3: Elements of bank-sector climate risk and the scope of this report. Adapted from TCFD.

A Disorderly Transition Scenario

Based on the history of climate change politics in the U.S., this analysis assumes that the transition to a low-carbon economy will be unplanned and **disorderly**.

Many scenario analyses assume (often implicitly) that economies will go through a planned, **orderly** energy transition and that the market will be able to anticipate price changes (on average). Under this assumption, the transition risk for banks and the financial system more generally is limited.

In a disorderly transition scenario, companies should expect sudden economic shocks that rapidly change asset values, rather than gradual shifts. Recent market shocks related to COVID-19 show how unexpected price changes can have major impacts on high-carbon assets—Shell [7] and BP [8], among others, have taken multi-billion dollar write-downs in recent months.

This analysis considers three types of shocks that could materialize:

1. **Technological shocks** (for example, the rapid drop in renewable energy production costs and fast increase in their performance, or the change in minimum technology standards)
2. **Policy and regulatory shocks** (for example, the disordered introduction of a global carbon tax or a climate-related change in bank capital requirements) [9]
3. **Sudden changes in the climate sentiments** of financial actors [10], due to shifts in the expectations of market participants about the impact of climate risks (including items (1) and (2) and legal risk, reputational risk, etc.)

These three types of shock differ in the time scale in which they could materialize: 5-10 years for technological shocks, 3-5 years for policy shocks and one year or a matter of months for climate sentiments. The timeline for policy changes could be affected by the results of the U.S. elections in November and other key geopolitical events. The different types of shocks also differ in the ability of market players to anticipate their effect, with climate sentiments being the least predictable. Multiple kinds of shocks may also occur together or as a result of each other, making the situation even more uncertain.

Regulators and institutional investors increasingly understand that the potential impacts of climate change and the investments needed to address them are a **systemic risk** for the financial system—as well as a source of transformational opportunities.

Climate change has the potential to cause structural shocks to capital markets that could spread widely across financial and economic systems, impacting actors in a highly correlated and destructive manner [11]. As the Network for Greening the Financial System (NGFS), the group of more than 60 central banks and regulators created to focus on the potential financial threats of climate change, wrote in its first comprehensive report, **"there is a strong risk that climate-related financial risks are not fully reflected in asset valuation."** [12]

Transition risks are likely to affect the economy more broadly than other climate risks, impacting many companies' financial performance within the next few years [13]. Transition risks are expected to directly affect the value of fossil fuel-related assets. They are also expected to indirectly impact the value of assets in many other sectors. These impacts can be positive or negative, depending on whether firms anticipate the changes and adapt their business to thrive in a low-carbon economy [14].

A compelling case for bank action rests not only on the existence of mispricing but also on its **materiality**. Typically in financial risk assessment, materiality is measured by looking backward using historical data. Banks and investors are used to making decisions based on the benchmark in their respective markets [15]. Climate risks, in contrast, have to be assessed by looking forward at different climate scenarios. Historical information on economic and financial performance is much less relevant to assessing the materiality of climate risk because its characteristics and impacts on companies depend on the future evolution of the climate.

A **forward-looking** assessment of climate risks that considers different climate scenarios is needed. Multiple methodologies have been developed to do this—a recent report [16] from the Banque de France provides an overview of the current state of the art. All these approaches (including the one used in this report) can and should be further improved but this is not an excuse for banks to delay action. In fact, many European banks [17] [18] [19] and the world's largest investors [20] [21] are already employing these methods, indicating their robustness. Other banks must follow their lead and focus not on a single scenario but on how to make their portfolio resilient to all the possible scenarios that they could face.

This requires an assessment of all the channels through which financial institutions are exposed to climate risk via their investments in firms and assets, considering not only firms' emissions but also their location and their climate transition and adaptation strategies. This kind of assessment is critical for banks to undertake as they make decisions about lending, underwriting and asset management. Unfortunately, both banks and investors have been frustrated by low data availability or poor data quality or comparability—or all three.

This creates a situation of **gridlock** between the financial sector and its regulators, where regulatory action would help banks get the kind of data needed for risk assessment. But regulators are waiting for investors and banks to prove there is risk before mandating more disclosure.

Clarity from policymakers and regulators around climate risk is needed. Ceres' recent report **Addressing Climate as a Systemic Risk** [22] provides detailed analysis of the kinds of regulation and policy action that would give U.S. companies and investors that clarity and ensure climate risk is regulated like any other major financial risk. The report lays out detailed recommendations key U.S. financial regulators could adopt under their existing mandates. Implementing those recommendations would provide a strong basis for the financial services industry to deal with climate risk in a robust and concerted manner.

RECOMMENDATION

U.S. banks should align their policy positions and lobbying with the regulatory recommendations outlined in Ceres' report *Addressing Climate as a Systemic Risk*.

However, the urgency of climate change and the related risk to financial institutions means the industry cannot wait on regulators. The banking sector must move forward on voluntary disclosure, risk assessment and mitigation. Several banks [23] [24], including global players such as Barclays [25], JPMorgan Chase [26] and Morgan Stanley [27], are beginning to show the way, having committed to Paris alignment or net-zero emissions from their financing portfolios.

This report lays out illustrative examples of the risk assessment banks should undertake and how it can be done even when data are limited. It is based on publicly available information that covers only a portion of banks' businesses. Although it is indicative of the overall risk banks face, it is not intended as a benchmark or a definitive view of risk exposure. Rather, it is a **call to action** for banks to undertake and disclose more detailed analysis using internal data and then use that analysis to make better risk management decisions. It is also a guide for investors of the analysis they should expect from the banks in their portfolios.

Section	Analysis	Sectors	Data	Key Finding	Pg.#
1	Exposure to Climate Risk	All	Syndicated Loans	Over 2/3 of Loans Exposed Absolute Loan Exposure Relative Loan Exposure	20 21 22
3.1	Direct Losses - Core Impact	Fossil Fuel, Electricity	Syndicated Loans	Average Loss of ~3% in a Crisis	31
3.1	Direct Losses - Wide Impact	All Except Finance	Syndicated Loans	Average Loss of ~18% in a Crisis	31
3.2	Indirect Losses - Core Impact Losses Compared to Assets	Finance Finance	Syndicated Loans Syndicated Loans	Indirect Loss 160% of Direct Loss Direct and indirect losses are ~8% of bank assets on average	33 34
3.3	Case Study - Mexico	All	Banco de Mexico	Losses are Additive, including "fire sales"	56

Figure 4: Summary of technical analysis in this report.

Banks face three main challenges in analyzing climate financial risk:

1. **Assessment** of the exposure of economic activities to climate risk
2. **Identification** of the relevant sets of forward-looking climate scenarios
3. **Integration** of information about forward-looking climate scenarios into financial risk pricing and climate stress testing

This report discusses each of these items and the mitigation strategies banks can use once they understand their level of risk. Grounding bank responses to climate change in a solid, risk-based argument, in addition to the overwhelming moral case for action, should make it clear to every bank that measurement, target setting and disclosure are urgently needed to mitigate risk, improve competitive standing and ensure the goals of the Paris Climate Agreement are met.

SECTION ONE
Identifying Portfolio Climate Risk

Before climate risk can be fully measured and addressed, the parameters must be adequately defined. This may seem like an academic exercise, but it gets to the heart of the question of whether or not financing poses truly material climate risks. This section details why the first step in sufficiently understanding the scale of climate risk is ensuring that the scope of the analysis includes the full breadth of exposed sectors, rather than only the most carbon-intensive ones.

A comprehensive banking sector response to climate change must start with addressing the apparent disconnect between the impact bank activities have on the climate and the risks faced by individual banks. Banks are at the center of the global financial system, providing lending to firms in all sectors and facilitating issuances of debt and equity for those firms. It is all but impossible for any industrial activity to occur without the involvement of a bank. As a result, bank financing decisions have a significant impact on what kinds of industrial activity occur.

Almost every major bank has expressed concern about the impact of climate change on its business, customers and communities. Compared to many other climate-relevant sectors, banks have been outspoken about the need for policy to address climate change. For example, the CEOs of the largest U.S. banks worked with Ceres to make a public statement [1] of support in the lead up to the landmark Paris Agreement.

However, the ability and willingness to address climate change has not translated into sufficiently rapid action. Even as their policies have evolved, banks continue to allocate capital in a way that **exacerbates** climate change. Although the largest U.S. banks have made more than a trillion dollars in sustainable finance commitments [2] over the next ten years, impact assessments such as the Banking on Climate Change [3] report [4] and the World Resources Institute's Green Targets Tool [5] show that the overall impact of bank financing on climate change continues to be negative—in many cases, substantially so.

This disconnect will continue until climate risk is part of day-to-day capital allocation decisions—based on risk and return. Despite the growing consensus in the financial sector about the relevance of climate risks for economic performance and financial stability, research shows that financial actors are still not pricing climate-related risks (or opportunities) into the value of financial contracts or portfolios [6] [7] [8].

Without a solid argument for climate action by individual banks that is grounded in risk, there is a **collective action problem** that discourages banks from acting based on an impact argument alone: any reduction in fossil fuel financing by one bank is likely to be offset by other banks taking up that market share, resulting in a short-term disadvantage for the banks that move first—and a lack of reductions of greenhouse gas emissions in the real economy. Additionally, without the risk case, it is difficult for U.S. investors to develop a solid fiduciary argument to ask banks to take action, even if the broader risk to their portfolio is unacceptable to them.

Fortunately, the reason there is not a comprehensive risk case for bank climate action is not due to a fundamental disconnect between risk and impact. Rather, it is because of the specific characteristics of climate risk and the inadequacy of common risk management tools for identifying that risk. Ironically, the resulting underpricing of the risk actually creates more risk for individual banks and the overall financial system—the mispricing of large and correlated assets can lead to asset price volatility and systemic risk [9], as it did with mortgage-backed securities in 2008.

To date, most bank climate risk analysis has focused on a small number of sectors, largely treating them as independent from each other. Data availability has driven this, since stakeholder pressure has primarily focused on obtaining climate-relevant information from fossil fuel and electric power companies. Attempts to apply standard risk management measures (for example, impact times likelihood) suffer from information gaps and short-term time horizons, along with a number of characteristics that makes climate risk distinct from other risks.

Unique Elements of Climate Risk [10]

Deep uncertainty

Forecasts of climate change and its impact contain irreducible uncertainties because of the nature of the risks to the climate system, including tail events [11] and tipping points [12]. As the system gets closer to such tipping points, the possibility of irreversible environmental change increases, as does the possibility of triggering domino effects [13]. There is also uncertainty around the future productivity growth rate and the appropriate discount rate, both commonly used in cost-benefit analyses of climate change. Assumptions about these uncertainties are commonly made despite them being the object of fierce debate among economists [14, 15, 16] and still fundamentally uncertain.

Non-linearity

Recent analysis shows that effects from climate-related extreme weather events are highly non-linear [17]. Fourteen of the 15 hottest years on record have occurred since 2000, while 2015-2019 were the five hottest years on record [18].
If this trend continues, historical data could be a poor predictor of future events and their magnitude – the core of climate risk.

Forward-looking nature of risk

While the time horizon of financial markets is typically a few months, the impacts of climate change are rolling out over years and decades. This creates a tendency for firms to delay action and also means that short-term financial impacts are likely to come from shifts in policy, technology and market sentiment— potentially surprising firms that focus on only the long-term aspects of the problem.

Endogeneity

The perceptions that policymakers and market actors have of future climate risks today have an impact on how these climate risks will play out. If governments delay policy action and market actors do not decarbonize their portfolios, climate risks could affect countries' and investors' financial stability in the near future. This endogeneity leads to many different possible risk pathways that would each have large differences in the prevalence of certain climate policies and energy technologies [19] [20].

The unique characteristics of climate change underscore why **a new risk management approach is needed**. A backward-looking approach to financial risk assessment based on historical data is a poor proxy of the materiality of climate-related financial risks. A more forward-looking analysis of the characteristics of climate risks is crucial to informing effective climate-financial risk assessment. [21] While many banks are grappling with how to address this unique challenge, that work must move more quickly and should be discussed in relevant disclosures.

Climate Policy-Relevant Sectors in U.S. Bank Lending Portfolios

A forward-looking assessment of how different economic development pathways affect climate risk is extremely complex. This kind of analysis needs to take into account the outcome of global policy negotiations, the speed and direction of technological change and changes in consumer behavior. There is a lot of uncertainty around each of these variables and they all affect each other in multiple ways.

To deal with this uncertainty, a range of scenarios for future socio-economic pathways have been developed and quantified in the scientific community [22].These take into account projections of future energy trends, such as those developed by the International Energy Agency [23]. Climate policy scenarios focus on a given climate policy objective (for example, limiting global warming to 1.5°C) and make structural assumptions about global allocations of emission reductions and the pace of technological change. Such scenarios feed into integrated assessment models, [24] which show how different market sectors must change in order to meet climate policy objectives.

These sectoral economic impacts are at the root of transition risk. Any evaluation of transition risk has to translate sector-level impacts (based on the integrated assessment model) to the firm or asset level (where banks make financing decisions). Right now, many financial institutions select the most climate-relevant sectors to evaluate based on the expertise of their internal banking and sustainability teams. This often results in a focus on electric power and oil and gas. More systematic approaches, such as that used by Bank of America in its recent Task Force on Climate-related Financial Disclosures (TCFD) report [25], show a much broader range of sectors being affected.

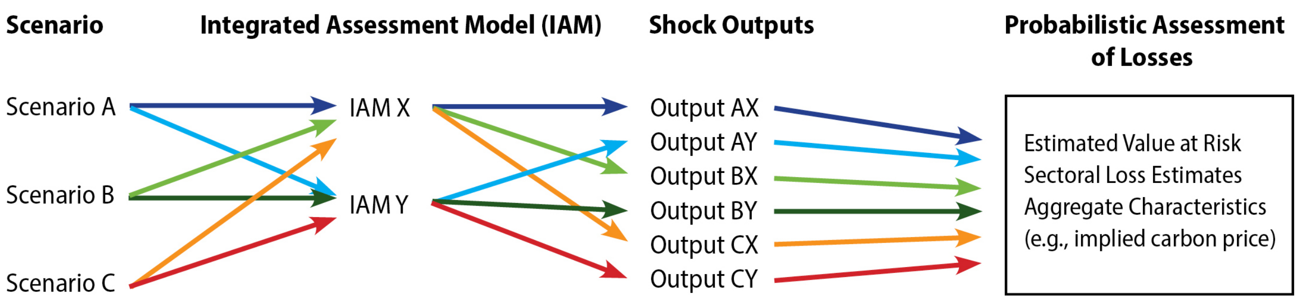

Figure 5: Constructing a probabilistic risk assessment from a set of scenarios and IAMs (illustrative).

Who is CLIMAFIN?

The technical analysis in this report was developed by CLIMAFIN, a consulting firm founded by three leading researchers, each with deep expertise in the relationship between banking and climate change:

Stefano Battiston SNF Professor of Banking, University of Zurich

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The CLIMAFIN methodology is the outcome of more than 10 years of scientific research and is notably being used by European regulators, such as the European Central Bank (ECB) [26] and the European Insurance and Occupational Pensions Authority (EIOPA) [27].

This report uses a systematic mapping exercise to identify sectors potentially exposed to transition risk—the notion of Climate-Policy Relevant Sectors (CPRS) [28]. The CPRS classification groups sectors of economic activity in categories that are relevant for the assessment of climate policy according to three main dimensions:

1. Contribution to greenhouse gas (GHG) emissions
2. Role in the energy value chain (for instance the mining and quarrying sector has low direct emissions but high indirect emissions in the value chain)
3. Sensitivity (for example, in terms of cost) to climate policy implementation [29]

At the broadest level, the CPRS classification aggregates economic activities into the following sectors:

- **Fossil fuel** Activities related to the exploration, exploitation, transformation or distribution of oil, coal or gas.
- **Energy-intensive** Activities related to the production of goods or raw materials using significant amounts of energy [29], e.g., the production of steel, cement, chemicals or non-ferrous metals.
- **Utilities** Activities related to construction and operation of power plants.
- **Transportation** Activities related to the transport of passenger and freight by air, rail, road and water.
- **Buildings** Activities related to construction and real-estate services.
- **Agriculture** Activities related to the cultivation of plants or animals, including forestry.
- **Finance** Activities related to financial intermediation.
- **Scientific R&D** Activities related to scientific research and development of new technology.
- **Other** All other activities i.e., those that are not directly climate-relevant. This includes in particular non-energy-intensive manufacturing, service activities (other than transport and finance), retail and wholesale trade (other than motor vehicles).

Each sector above (for example, Fossil fuel) is made up of several, more granular sub-sectors (such as Coal, Oil and Gas). These are referred to as CPRS2 sectors. The detailed classification scheme and full list of sectors can be found in Appendix C.

Data Details

It is important to note that any risk analysis using publicly available data can only provide a directional indication of exposure. This is because the only non-confidential credit data available for U.S. banks are on syndicated loans (sourced from the Refinitiv DealScan® dataset). Although syndicated loans make up a meaningful portion of banks' commercial loan portfolios (especially for the larger banks), DealScan shows exposure at a single point in time—the time of issue—which may differ from what is held on banks' balance sheets at any point thereafter. In a previous study, Carey and Hrycray (1999) [30] estimated that DealScan loans covered between half and three-quarters of the volume for outstanding commercial and industrial (C&I) loans in the U.S. This, in addition to high-level disclosures in financial filings, suggests that the data is relatively representative of C&I lending in terms of sectoral distribution. But this is not the full picture—loans account for about 50% of U.S. bank holdings on average, [31] of which C&I makes up only about 30%. [32] **This is why it is so critical for banks to conduct and disclose their own analysis using complete data.**

Applying the CPRS system to U.S. banking portfolios can be done by using a detailed analysis of their portfolio of syndicated loans. This shows that, at the aggregate level, the direct exposure of U.S. banks to the fossil fuel sector is 9.78%, in line with data presented in their existing climate disclosures. However, the relative exposure to all non-financial climate-policy-relevant sectors is large (more than half - 53.45%), mostly due to the financing activity conducted by the banks in the energy-intensive sector. Moreover, since banks are exposed to the financial sector itself, they bear additional indirect exposures to climate-policy-relevant sectors (another 16.16%).

In total, over **two-thirds** (69.61%) of the average syndicated loan portfolio is exposed to climate risk. Figure 6 shows the aggregate amount of outstanding syndicated loans held by U.S. banks broken out by CPRS2 sectors.

This finding is a major driver of the potential losses banks could face. The energy-intensive manufacturing sector is the largest exposure category, and it is rarely mentioned in banks' climate disclosures. It is also not covered in the Environmental & Social Risk Management (ESRM) policies of any major U.S. bank, except in very general terms. The same is true of banks' exposure to other financial sector firms. Agriculture, transportation and buildings are also mentioned infrequently and, although they make up a smaller portion of the syndicated loan book, they are nonetheless

Amount	CPRS2 Sector
2.32%	Fossil Fuel: Coal
1.20%	Fossil Fuel: Gas
2.38%	Fossil Fuel: Oil
3.88%	Fossil Fuel: Other
9.78%	**Fossil Fuel: Subtotal**
3.82%	Utilities: Electricity
0.07%	Utilities: Waste
3.89%	**Utilities: Subtotal**
25.73%	Energy-Intensive
3.09%	Buildings
1.04%	Transportation: Air
0.52%	Transportation: Railways
7.25%	Transportation: Roads & Vehicles
0.69%	Transportation: Water
0.72%	Transportation: Other
10.22%	**Transportation: Subtotal**
0.51%	Agriculture, etc.
0.23%	Scientific R&D
53.45%	**Non-Financial CPRS Subtotal**
16.16%	Finance
69.61%	**All CPRS Total**
30.39%	Other: Non-Climate Relevant

Figure 6: Percent of syndicated loans outstanding (for all U.S. banks in 2019) in each CPRS2 sector. Total exposure: $553 billion.

important. They could very well represent a larger portion of non-public lending done by banks, particularly as it extends into the retail banking sector through auto loans and mortgages. This analysis makes clear that, although emissions from fossil fuel do drive the majority of GHG emissions in the economy, the risks from those emissions are not limited to the fossil fuel and electricity sectors. They diffuse throughout the value chain and affect large parts of bank loan portfolios. However, not every firm or asset class in these sectors is exposed equally to climate risk. An auto loan to a consumer presents substantially lower climate risk to the bank than a syndicated loan to an auto company, and whether that auto company is Tesla or GM also matters a great deal. This heterogeneity means that further, more detailed analysis is required. Given that two-thirds (69.61%) of bank portfolios are potentially exposed (see Figure 6), this is an analysis that every bank should conduct immediately.

RECOMMENDATION

Banks should assess their entire balance sheet to identify which assets may be exposed to climate risk, including indirect risk from elsewhere in the financial system.

There is also heterogeneity in the sectoral exposure of individual banks. Figures 7 and 8 provide a sectoral breakdown for the largest U.S. banks. Their holdings are shown in absolute value (Figure 7) and in relative terms (Figure 8), again using the CPRS system.

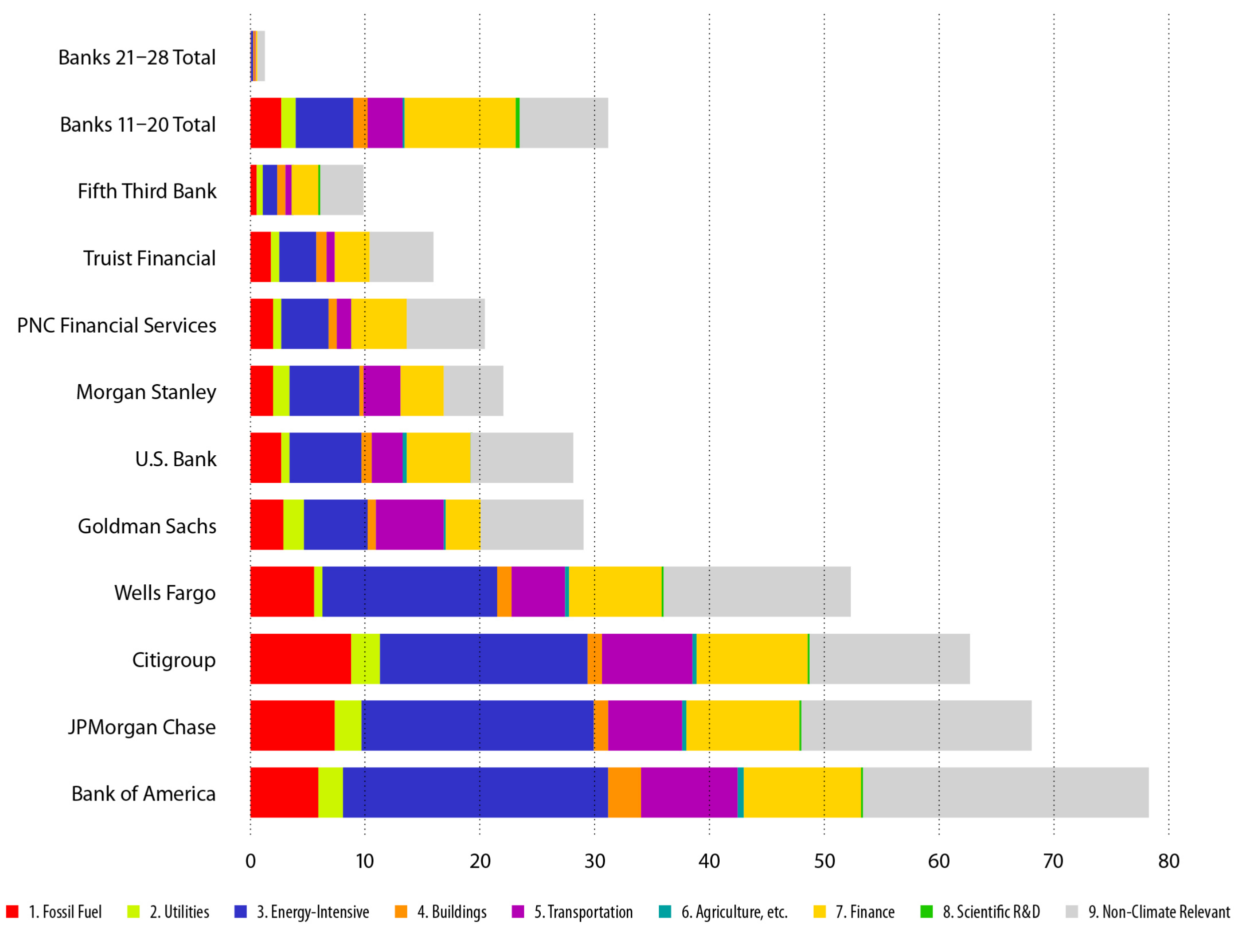

Figure 7: Climate-Relevant Sectors in U.S. Syndicated Loan Portfolios ($ billions).

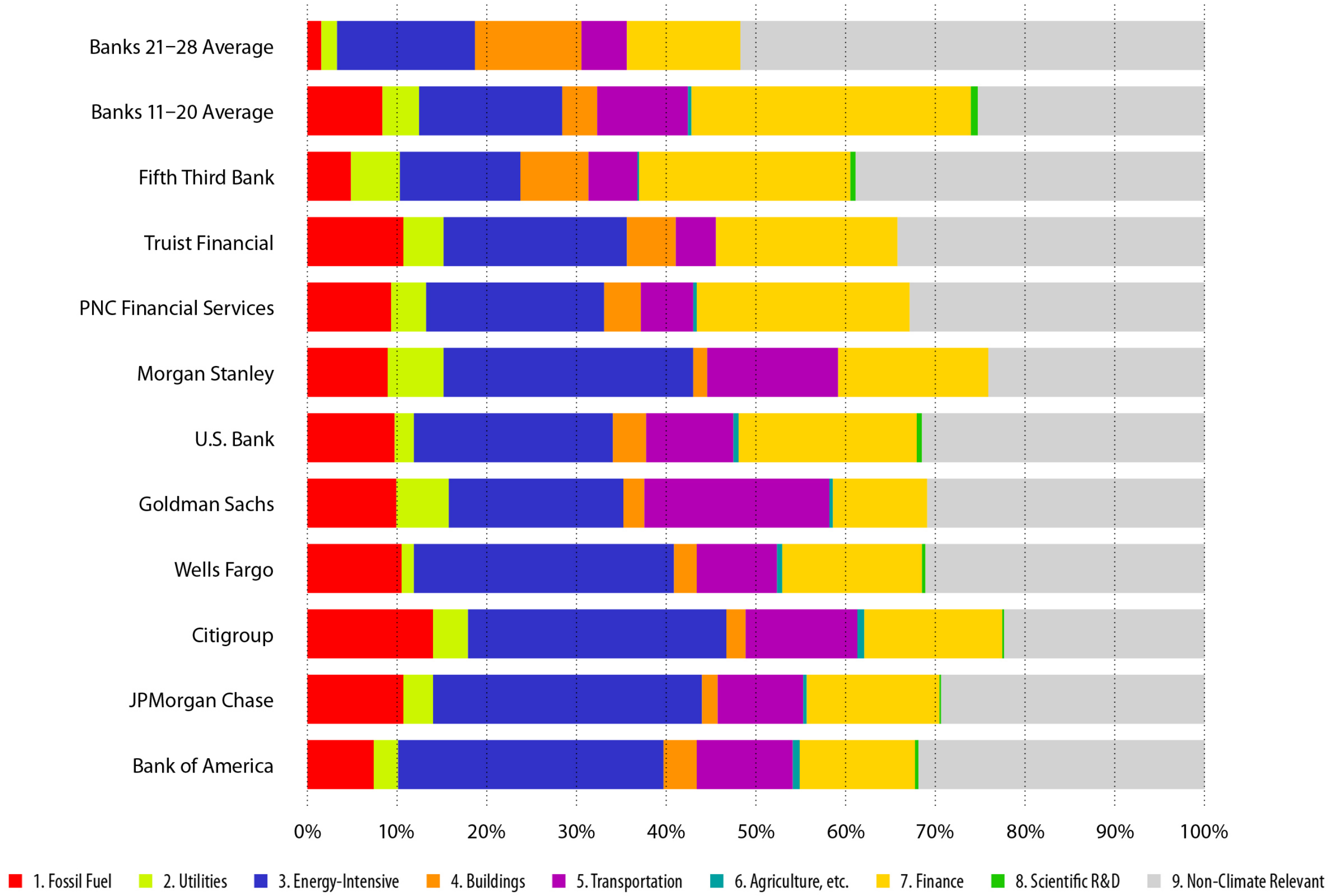

Figure 8: Percentage composition of portfolio of syndicated loans of major U.S. banks by climate-policy-relevant sector.

The analysis also shows that there are large differences at the individual level for each bank in terms of volume and sectoral distribution of exposures. The three largest syndicated loan books (Bank of America, JPMorgan Chase and Citigroup) account for 45% of banks' exposure, while the ten largest account for 85%. Based on high-level disclosures in financial statements, the syndicated loan data used may also be more representative of the overall loan portfolio for these large banks than it is for smaller banks—hence the focus on the largest institutions.

Although there are differences between the largest banks in terms of sectoral exposure, the information needed to assess and manage climate risk will be more granular than what is shown here. Even large banks that look similar from a sectoral perspective may not face the same level of risk. The biggest differences in risk may show up at the asset level for banks that are fully diversified. Additionally, given the concentration of market share within the largest banks, systemic risk considerations also become more important.

Smaller banks (shown in aggregate above) display wide variation in sectoral distribution. This likely reflects their ability to focus on particular market segments and business lines (and differing levels of focus on syndicated lending). For them, understanding their market position as it relates to climate risk, and conveying this information to their investors, is critical. Given resource constraints and lower levels of expertise, starting at a broad, sectoral level is appropriate.

RECOMMENDATION

Banks should disclose a portfolio risk assessment that identifies the sectors that the bank considers to be climate-relevant and the percentage of assets in these sectors that the bank considers to be at risk.

Investors looking to distinguish banks from each other on climate risk have often considered the quality of disclosure as an indication of good risk management. [33, 34] Only a handful of banks have published any kind of portfolio assessment and, among U.S. banks, only Bank of America has published a sectoral assessment of risk. Some banks have used Moody's Environmental Heat Map [35], which may provide a useful starting point until proprietary analysis can be conducted, particularly for smaller banks. However, as with credit ratings, there is significant advantage to be gained for banks to do their own more granular assessments. This report, as well as Moody's work, is best used as an illustration and a starting point.

SECTION TWO
Identifying Relevant Climate Scenarios

Conducting the analysis necessary to integrate climate risk into financial decision making is very complex and has yet to be fully done—or at least publicly disclosed—by any U.S. bank. This section identifies the current state-of-the-art in this important work and how to develop this further to get to the level of sophistication needed to make fully informed decisions.

Central banks, financial regulators, investors and individual financial institutions that have developed forward-looking climate scenario analysis have typically considered three to four different scenarios, often including:

1. A scenario where **transition risks** predominate (as different sources of energy change in value), such as a 1.5°C or well-below 2°C scenario
2. A scenario where **physical risks** predominate (based on increasingly frequent severe weather and climate patterns), such as a 4°C scenario
3. A “**too late, too sudden**” intervention where both physical risk and transition risk are important, as is the disorderly nature of the transition

This type of scenario analysis is valuable and aligns with the TCFD recommendations. But banks have struggled with how to integrate climate scenario analysis into risk management, given the long timescales involved and the difficulty in translating broad scenarios into specific financial risk metrics. The root of this difficulty is that scenario analysis, as a tool, is not designed for this purpose.

Scenario analysis helps decision makers conceptualize a full range of possible outcomes given a certain situation and assess the resiliency of their business, typically at the executive level. It cannot be used for what might be called “decision modeling under uncertainty,” which encompasses many common banking tools, including stress testing, Value-at Risk (VaR) analysis, earnings projections and securities pricing.

Existing research, including the Green Swan report [1] from the Banque de France and the United Nations Environment Programme Finance Initiative (UNEP FI) TCFD banking pilot [2], has identified several pathways that link climate scenario analysis and stress testing. The steps needed include a probabilistic assessment of outcomes and variables, a formal mathematical model and risk tolerance thresholds for decision-making. The model used in this analysis is one of several that adopt a stress testing framework for this kind of approach, allowing scenarios to be translated into quantitative measures of risk. It is designed to supplement, not replace, a higher-level scenario analysis. The two should work in concert to provide decision makers with a full picture of climate risk and opportunity over different timescales and different kinds of planning and decision-making horizons.

There are a number of factors to consider when moving from scenario analysis to climate stress testing. Some are considered in existing approaches (like UNEP FI's) but more work remains for banks to do. The unique characteristics of climate risk (deep uncertainty, non-linearity and endogeneity) mean banks need to consider multiple scenarios with unknown probabilities. Additionally, considering several scenarios (of different shock size and relative probability) is fundamental to computing the standard financial risk metrics used by investors, such as the Value at Risk (VaR) [3]. Good risk assessment departs from the idea of "most likely/feasible scenario" and considers instead several scenarios, ranging from feasible to extreme, to assess how the climate-related VaR on a particular portfolio might evolve.

RECOMMENDATION

Risk assessment should include stress testing based on both backward-looking data (such as past emissions) and forward-looking data (such as planned expenditures). The findings of these analyses should be disclosed at a high level.

Climate economics research has provided a diverse set of scenario models that meet the target of the Paris Agreement. Among these, the most often used, including by the Intergovernmental Panel on Climate Change (IPCC), are Integrated Assessment Models of Climate Change (IAMs) [4]. IAMs are equilibrium models of the economy that consider the economic impact of GHG emission targets and (to some extent) physical damages from climate change.

This analysis uses the results of a series of recent policy evaluation projects (named LIMITS [5], CD-LINKS [6] and GREEN-WIN [7]) to create a consolidated assessment based on 13 different 2° climate policy scenarios (see Appendix E) and eight different IAMs developed by leading academic institutions. This produces a **probabilistic** assessment of the future output of different sectors of the real economy. Rather than test the impact of one specific scenario against a baseline scenario, this analysis measures the impact of one risk (transition risk) which may materialize in various scenarios. It is therefore non-specific as to exactly when a shock occurs and its main features—each scenario makes its own assumptions and they must be considered in aggregate.

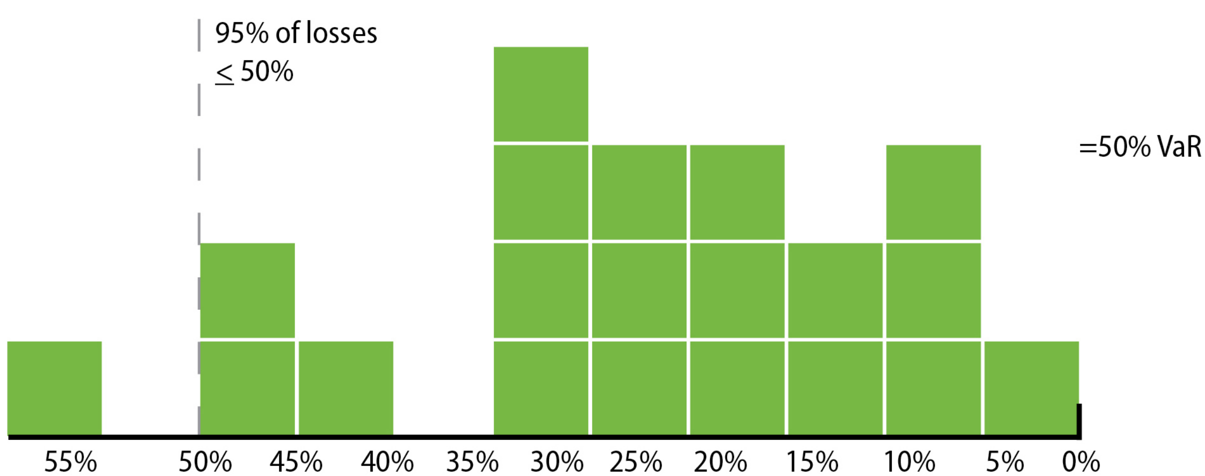

Figure 9: How climate VaR is calculated (illustrative). Each box represents one scenario/IAM combination.

IAMs are already being used by U.S. and global banks for scenario analysis (for example, the UNEP FI TCFD Pilot Project [8] uses the REMIND model), but generally only a single IAM has been used rather than a larger set. In bank analyses to date, as well as in stress testing approaches used by central banks and financial regulators, the macroeconomic model chosen (and its assumptions) plays a main role in channeling the impact of the climate shock into the economy. Using multiple IAMs reduces the sensitivity to any particular assumption.

IAMs alone are not sufficient to conduct a financial stress test because they typically assume that the financial sector functions flawlessly and that climate-aligned investments are available without frictions or endogenous decision-making. Indirect impacts from financial sector interdependencies and the potential for the financial sector itself to be the source of a shock (e.g., from a rapid change in investor sentiment) are layered on top of the IAM output in this report.
This is done using financial network analyses developed after the last financial crisis, which highlights:

- The relevance of firms' leverage and position in the financial network, and of network structure
- The role of network structure in amplifying shocks to the financial sector [9]
- The conditions where shocks can drive systemic financial risk [10]

The illustrations below provide a visual representation of the difference between a scenario where financial actors are independent (i.e., using IAMs alone) and one where they are networked together (i.e., these real-world considerations are integrated into the IAM analysis, as this study does). The wide extent of interbank lending in the U.S. financial system makes the networked model more appropriate for risk analysis.

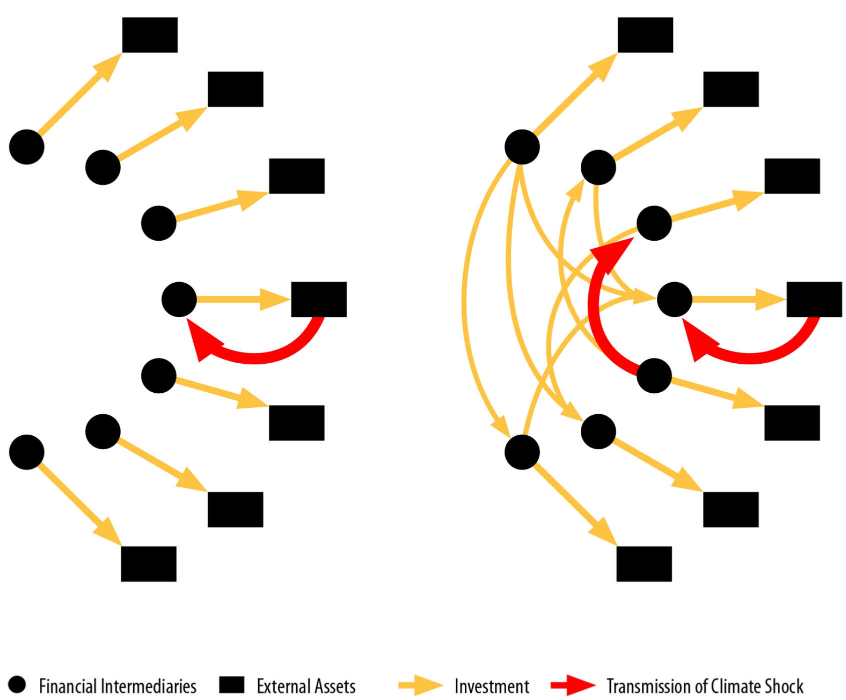

Figure 10: Illustrative comparison of networked (right) and non-networked (left) models of climate risk.

The final question is which climate policy scenarios should be used as an input to the IAMs. The IPCC Special Report on Global Warming of 1.5°C [11] illustrated the severe consequences of not achieving the Paris Agreement's most ambitious aspiration, and 1.5°C alignment has since become the benchmark for climate leadership. However, most current climate modelling still uses less ambitious scenarios. As a result, this analysis is based on the disorderly transition of the economy from a business-as-usual (BAU) trajectory to a trajectory compatible with various 2°C policy scenarios (such as the scenario referred in the LIMITS database [12] as StrPol450ppm). Those trajectories are shown in Figure 11. It is worth noting that though this analysis incorporates some worst-case-scenario parameters, a 2°C outcome is not one of them. A disorderly transition to a scenario corresponding to 1.5°C of warming would require a steeper reduction of GHG emissions and thus a larger shock on the economic sectors involved.

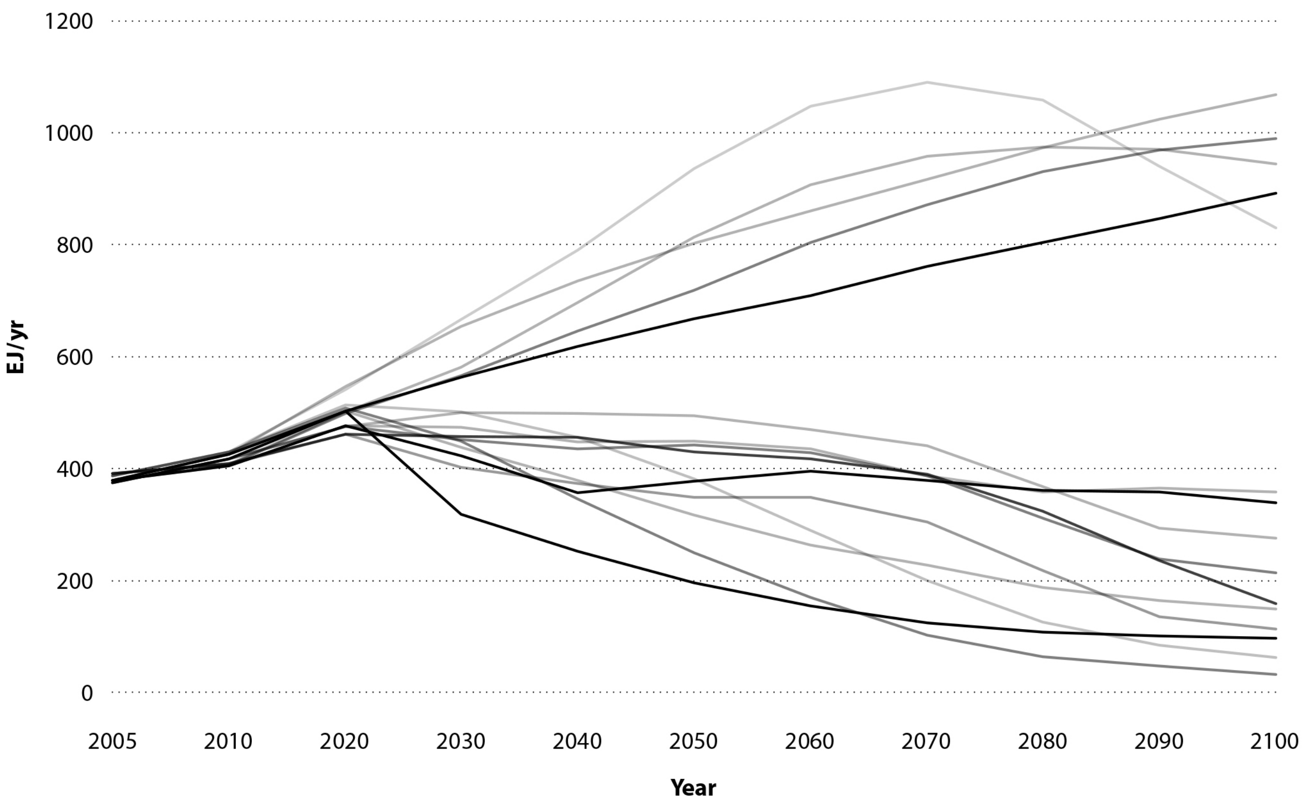

Figure 11: Fossil fuel based primary energy production for a selection of baseline and 2°C scenarios, in exajoules/year. (Kriegler et al 2013)

Scenario Assumptions: The Specifics

This study uses 13 climate policy scenarios where atmospheric GHG concentrations in 2100 are 450-500 parts per million of CO2 equivalent. According to the IPCC [13], this would keep the temperature change to less than 2°C relative to pre-industrial levels.

In this analysis, the market initially expects a business-as-usual economic and emissions trajectory up to 2050 and then, in the relatively near term, suddenly shifts to expecting a 2°C scenario in response to a policy shock. The policy shock is likely to be small but the resulting sentiment shock can be large and can amplify the policy effect. This sentiment shift takes place within the next five years. This corresponds with the scenario considered by the Principles for Responsible Investment [14], which forecasts "*a response by 2025 that will be forceful, abrupt, and disorderly because of the delay.*" It is also consistent with the scenarios used by the Network for Greening the Financial System—in fact, those scenarios are partially based on CLIMAFIN work. [15]

Two main policy instruments are used to achieve the target: carbon pricing and quantity constraints on emissions. The eight integrated assessment models (IAMs) used take as a given the climate policy objective and calculate least-cost economic pathways consistent with the policy outcome. Achieving a 2°C target requires a rapid shift away from fossil fuels and massive investments in renewable energy sources and the energy infrastructure. However it is not the case that the revenues of affected firms will instantaneously drop to levels consistent with a 2°C economy—only that investors suddenly expect that they will (in the longer term). Key developments that characterize the 2°C scenarios used include:

1. Full decarbonization of the **electricity supply** with massive expansion of low-carbon technologies, including wind, solar, biomass, CCS and nuclear
2. **Electrification** of energy use in homes, businesses and services, as well as transportation
3. Large-scale penetration of advanced **biofuels** in transport modes that cannot be electrified
4. Massive improvement in the **energy efficiency** of buildings

A commonly used indicator of the stringency of a climate policy scenario is the implied carbon price. Across the set of scenarios considered in the analysis, the average carbon price is ~$16/ton in 2020 and ~$95/ton in 2030, reflecting the increasing stringency of climate policy in that period. Note that this does not represent Ceres' or CLIMAFIN's view of the ideal carbon price; it is merely an output of the IAMs and scenarios used. A more aggressive set of scenarios would produce a higher carbon price as a function of the larger distance from business-as-usual.

It is also important to note that the results of the stress testing exercise in the next section are not driven by the carbon price alone (in contrast to most similar analyses). Instead, shocks to the value of assets in the portfolio mainly come from changes in market share and revenues of sectors and firms caused by the structural economic impacts of the climate policy scenario.

SECTION THREE
Integrating Scenarios into Pricing and Stress Tests for U.S. Banks

The analysis of exposure to climate-relevant sectors and the selection of a relevant set of scenarios are critical first steps to fully informed decision-making. Next, this analysis and scenario selection must be incorporated into the stress testing of banks' loan portfolios with respect to transition risk.

In this report, this financial impact assessment is based on the climate stress test [1] included in the CLIMAFIN methodology [2]. It builds on the economic pathways determined by IAMs to estimate changes in value added (by sector) caused by the shift from business-as-usual to Paris Agreement-aligned scenarios. An estimate of the shock is obtained from the differences in output across sectors between the two trajectories (business-as-usual and Paris-aligned) for the same IAM. Using multiple scenarios and multiple IAMs produces a range of possible outcomes, a weighted average of which is ultimately used to generate a consolidated outcome for each sector (see Figure 12) that does not depend on the assumptions of any single model.

These sectoral shifts are used to proxy the shock to the value of each firm's assets in case of a disorderly transition. A credit risk model is then used to convert the impact of the shock into a probability of default by the bank's client and on the value of that firm's liabilities. The results of the stress test are presented in three stages:

1. **Stage 1** An estimate of the **direct** (first-round) losses that banks may face through holdings in non-financial CPRS sectors
2. **Stage 2** An estimate of the **indirect** (second-round) losses from the exposure to other financial firms' direct losses
3. **Stage 3** Further deepening of the indirect impact on banks' balance sheets, through "**fire sales**" of distressed assets or, more technically, "balance sheet contagion"

Note that these three pathways are not independent—in many scenarios they reinforce each other. For example, "fire sales" are a third-round effect that is likely to compound with the second-round effect associated with interbank lending. Although the three pathways are presented sequentially for clarity, readers should consider the Banco de Mexico example in Appendix D to understand how the stages build on each other. Again, recall that it is not the transition per se that is the source of risk, but the failure to prepare for its possibility. A more detailed description of the methodology can be found in Appendix A.

Stage 1
Banks Face Direct Losses Due to Transition Risk

To date, banks' assessment of climate risk has generally focused on the fossil fuel and electricity sectors. While this is partially due to data availability, there is logic in putting these two sectors at the center of a conversation about transition risk. Because their products do generate the vast majority of GHG emissions in the economy, any sudden shock resulting from climate policy would have a severe impact on many companies in these sectors. Applying this report's methodology to these sectors demonstrates this, as the negative impacts on the market share and asset values related to coal, oil and gas, shown below make clear (see Appendix A for a detailed description of the models used to generate these numbers).

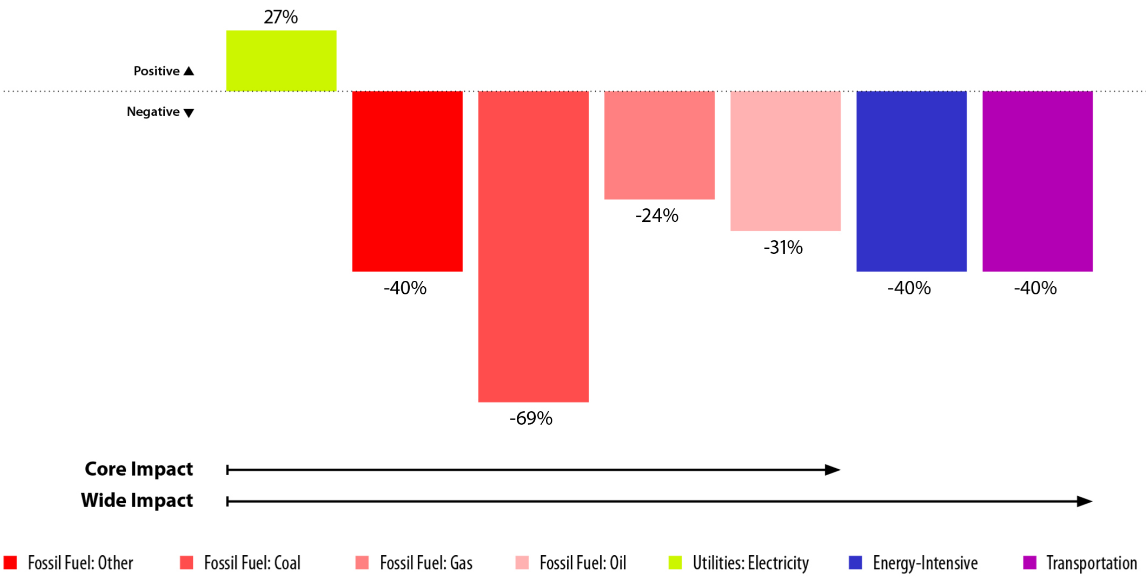

Figure 12: Estimated effect of a transition-related shock on climate policy-relevant sectors.

The fossil fuel and electricity sectors are designated as "**core-impact**" sectors, given how central they are to the problem and how much existing bank risk analysis focuses on these sectors. Banks generally acknowledge that these sectors face climate risk, and have taken some steps to evaluate and control this risk through Environmental and Social Risk Management policies that require additional due diligence and, in some cases, place financing restrictions.

However, as described in Section 1, transition risk exposure is not limited to core-impact sectors. In fact, exposure to these sectors for most banks represents less than 10% of their total lending. The biggest exposure to climate-relevant sectors for banks is in the sectors that use fossil fuels and electricity as key inputs, particularly energy-intensive manufacturing and transportation. Climate shocks flow through to these sectors based on the effect that curtailing fossil fuel supply (and/or raising its price) would have on their products and services. In a crisis scenario, the value of fossil fuel-based assets in these sectors would face a **40%** loss of value, on average.

The impact of a climate shock on these sectors has generally not yet been accounted for in banks' publicly available climate risk assessments, though these sectors make up close to 50% of syndicated loan portfolios in many cases (see Figure 8). These sectors are designated as "**wide-impact**" in the analysis below.

An estimate of portfolio-wide losses is generated by looking at changes in the probability of companies defaulting on their loans, based on the specific climate shock and the economic effects it would have on each sector. As loans are valued according to the expected payment they will yield, an increased default probability lowers the value of the loan because it increases the likelihood that the loan will not be repaid in full.

Loss-Given-Default

The loss of value on the loan, if the risk materializes, is measured by the loss-given-default (LGD). This analysis assumes a 100% LGD in the short run, a commonly made assumption in academic analyses of this kind.[3] [4] In reality, LGD follows a bimodal distribution [5] where losses on a particular loan are mostly near 100%, or under 10%. Over shorter time periods and in more severe crises, a greater proportion of loans fall into the former category. For example, in the 2008 financial crisis, the overall LGD for commercial and industrial loans was ~50%, but for loans that defaulted before 2009 (immediately following the shock) the LGD was about 80%. [6] Moreover, around 60% of defaulting loans had a workout period longer than six months, meaning that any recovery was uncertain during the depths of the crisis. So, although 100% LGD represents an upper bound on the losses banks could face in a worst-case scenario, in the absence of firm-level LGD projections (which banks should use in their own analysis), there is no obvious alternative assumption. This further highlights the illustrative nature of this report and the need for banks to conduct and disclose their own analysis. In the CLIMAFIN model, losses vary linearly with LGD, so alternative assumptions readers may wish to make are easily applied.

Aggregating potential losses up to the portfolio level results in an assessment of the potential percentage loss on the entire syndicated loan portfolio of a given bank (See Appendix A for mathematical details). Figure 13 reports estimates of the relative losses for the largest U.S. banks in a crisis situation. Overall, the loss on the average syndicated loan portfolio amounts to **~3%** in the core-impact scenario and **~18%** in the wide-impact scenario.

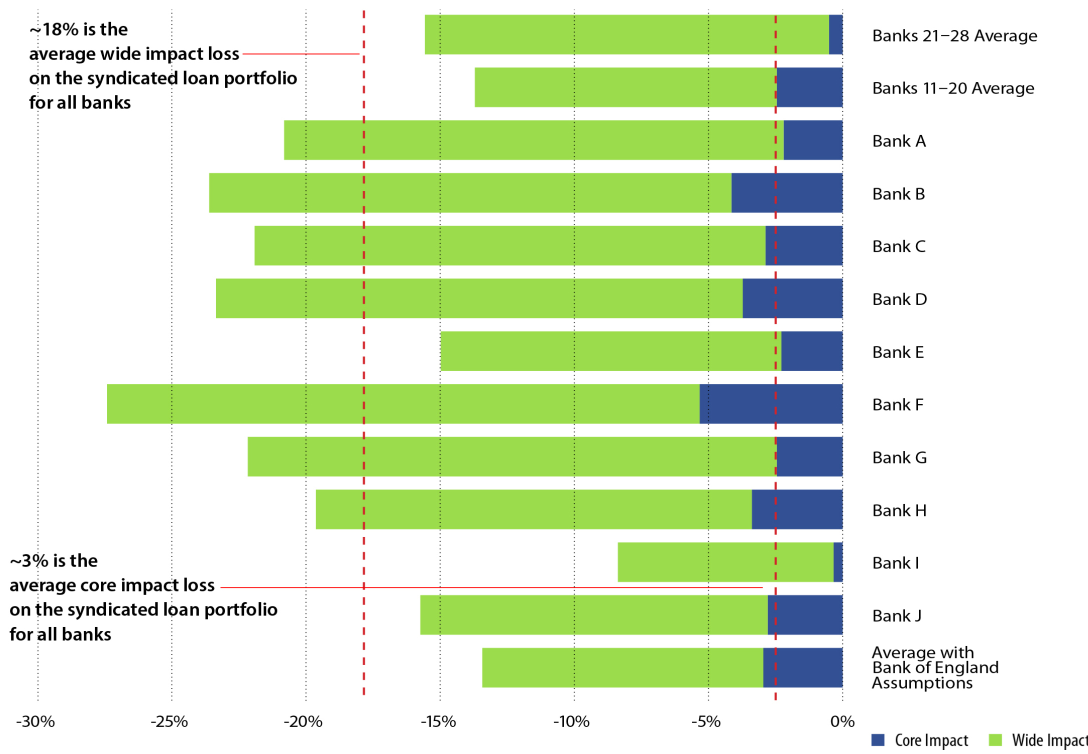

Figure 13: Percentage losses on the syndicated loan portfolio of major U.S. banks in a worst-case scenario.

The above chart is anonymized in order to highlight its illustrative nature. Rather than comparing themselves to peers, banks should focus on the broader picture, which shows substantial risk for all banks and highlights the need for further analysis by each of them. In the core-impact sectors, relative losses are similar among banks and mostly concentrated around the mean ~3% loss. Impacts are more varied in the wide-impact scenario, but **many banks face very substantial losses**. The six largest U.S. banks (Bank of America, Citigroup, Goldman Sachs, JPMorgan Chase, Morgan Stanley and Wells Fargo) are in this most vulnerable group.

Note that the wide-impact scenario assumes that the shock on fossil fuel sectors is fully transmitted to the wide-impact sectors. This is an extremely adverse assumption. In particular, it assumes that banks do not monitor climate risk in their lending decisions. Since banks do monitor climate risk, these findings should be interpreted as indicative and as an **upper bound** on direct, transition-related losses for the scenarios used. Recall, however, that the analysis excludes physical climate risk and litigation risk as well as the indirect losses discussed in subsequent sections, and is based on 2°C rather than 1.5°C scenarios, so it should not be considered a worst-case scenario overall.

In order to test the robustness of the findings to different shock assumptions, the average bank was also stress tested ("Average with Bank of England Assumptions") using the Bank of England's stress testing assumptions [7]. The results are in line with the wide-impact scenario though less severe.

This analysis **does not account for firm-level differences** in exposure; it assumes all banks hold the same average-risk loan portfolio in each sector. It also assumes that loans originated by one bank remain on that bank's balance sheet, since information about loan securitization is not publicly available, though in reality, syndicated loans are closer to a "flow" rather than a "stock". This means that further work is required by banks to determine with greater accuracy the risk that they individually face.

Given the substantial losses most banks incur in this analysis, climate transition risk should be considered as a **potential material risk** by banks, and treated as such in financial filings and communications with investors. Further analysis may show that risk mitigation efforts by banks have reduced the exposure, but claims to that effect should be supported by robust data and disclosure. Banks should not assume that they are protected because they fare better in this analysis than their peers. Some banks are already doing significant work to reduce their climate risk and more will follow their example as the extent of the risk becomes clear. Banks that do not act will be left behind as the market transforms.

Stage 2
Banks Face Indirect Losses Due to Financial Network Exposure

The preceding section showed how all banks are exposed to climate risk, with some more exposed than others. Widespread exposure is a characteristic feature of all past systemic banking crises in the U.S. [8] Another common trait these crises share is a massive amplification of losses through financial networks. For instance, while the 2008 subprime mortgage crisis racked up an estimated $500 billion in direct losses [9], the crisis eventually triggered indirect losses within the financial system that were 10 times greater and losses for the global economy almost 100 times greater [10] [11]. The Federal Reserve emphasizes the same dynamic in its policy on systemic risk, saying that "**interdependencies can also present an important source or transmission channel of systemic risk.**" [12]

The reason that indirect exposures have not typically been incorporated into climate risk management may be because of two commonly made assumptions that are well suited to certain types of risk analysis [13], but inadequate in cases where financial contagion is a concern (as it is with climate risk) [14]:

1. Banks' assets can be liquidated at any time with no loss, i.e., the recovery rate on external assets of banks is 100%
2. The value of a bank obligation (prior to maturity) is unaffected by losses on its equity unless the bank defaults

When assessing climate risk, banks should avoid making these assumptions, and instead should incorporate indirect risk into their analysis. This report does that by characterizing risk in terms of first and second-round losses. First-round losses are the direct losses from a shock, such as those discussed in the previous section. Second-round losses are the indirect losses in banks' equity due to the devaluation of the assets they hold in other financial institutions that have been hit by the same shock. The magnitude of second-round effects can vary significantly. Traditional methods [15], yielding small second-round effects, are appropriate only under specific market conditions [16]. More recent research shows that second-round effects can be comparable to or greater than the first-round effects (See Appendix B for mathematical details).

The second-round effects of a transition shock on syndicated loans are more substantial. On average, they represent 160% of first-round losses (i.e., ~5% vs. ~3%)

In fact, the second-round effects of a transition shock on syndicated loans are more substantial. On average, they represent **160%** of first-round losses (i.e., ~5% vs. ~3%), although the largest banks are somewhat less affected. Figure 14 estimates second-round losses for banks following a climate shock. First-round losses shown are the same as those in the core-impact scenario in Figure 13 above (and a ~3% loss for the average bank). Using the wide-impact scenario from the previous section would result in far greater second-round effects, as would the use of a 1.5°C climate scenario.

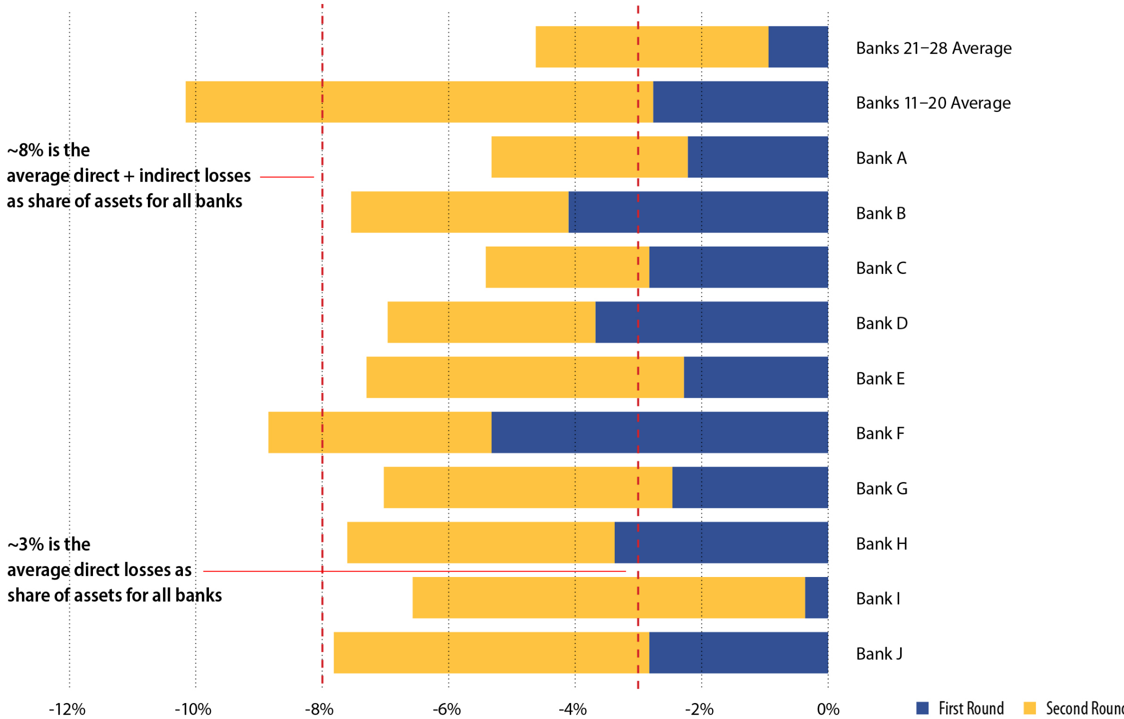

Figure 14: First and second round losses as share of assets (total syndicated loan assets on the balance sheet) in the core-impact scenario.

Combined first- and second-round losses (the losses from direct exposure to a shock and indirect exposure to other financial institutions hit by the same shock) represent a substantial share of assets for most banks **~8% on average**. While this loss might seem manageable, it is complicated by the fact that banks are highly leveraged (the average leverage ratio for U.S. banks is close to 10) [17]. This means that the losses could be much higher as a share of a bank's capital stock, creating a risk of default. While available data is not sufficient to fully test this assumption, the risk is high enough that the industry must turn its full analytical power toward validating (or invalidating) these conclusions.

RECOMMENDATION

Banks should use, improve and develop internal valuation tools that translate climate-relevant information into securities prices, earnings forecasts and estimates of value at risk.

As above, the analysis does not account for firm-level differences. Climate risk data needs to be understood at a granular level within every bank, and the loan book needs to be put in the broader context of each bank's business. Loans are often not just a business in themselves but a qualifier for other work, such as **investment banking** services. The potential impact on those services should be considered as well. Integrated relationships with clients flow into and out of the earnings models used to forecast client performance. Therefore, incorporating climate into earnings models is critical. This is discussed in more detail in Section 4.

The extent to which loans are actually exposed is critical as well. Some may be securitized or otherwise sold, and many large banks have extensive derivatives businesses that may include instruments that hedge or amplify climate risk. **Derivatives** strategies could materially affect a bank's potential losses, positively or negatively, but investors have no visibility into how they might do so. That's why it is imperative that banks conduct stress testing analysis themselves, and disclose the results to investors, regulators and the public.

Case Study: Bank X

To crystallize how the loan portfolio analysis in Section 1 flows through the climate shock analysis in Section 3, it is useful to walk through an example. Consider Bank X, a real bank that that has percentage exposures to the core-impact sectors as follows:

CPRS2 sector	Fossil fuel: Other	Coal	Gas	Oil	Electricity
Percentage of loan portfolio (A)	3.4%	1.8%	1.2%	2.9%	2.7%

The average losses for these sectors (and the bank), based on the disorderly transition to a Paris-aligned world, calculates as:

CPRS2 sector	Fossil fuel: Other	Coal	Gas	Oil	Electricity
Sector loss from shock (B)	-40%	-69%	-23%	-31%	27% Gain [18]
X's Loss 3.1% =Sum(A*B)	1.4%	1.2%	0.3%	0.9%	0.7% Gain

This results in a direct loss to Bank X of 3.1% of the value of its syndicated loan portfolio. Bank X has a leverage ratio (assets/equity) of 8.4 [19], so under the assumption that the syndicated loan portfolio is representative of the complete portfolio of the bank in terms of sectoral exposure, this would amount to first-round losses corresponding to 26% of total capital.

Facing the same shock as Bank X, the mean U.S. bank faces a first-round loss as well: 2.7% of its syndicated loan assets. The mean leverage ratio among U.S. banks is 9.5 [20]. Thus, first-round losses are 26% of capital, on average. Using a linear approximation, this implies a 26% decrease in the value of the interbank liability of the average bank. Given that Bank X has an interbank leverage ratio (estimated interbank assets/capital) of 1.5, this results in second-round losses for Bank X amounting to an additional 38.5 % of capital (mean bank's first round loss of 2.7% x 9.5 mean bank leverage ratio x 1.5 interbank leverage ratio).

Stage 3
Fire Sales of Distressed Assets Exacerbate Systemic Risks

"Fire sales" of tradable assets (such as asset-backed securities) played a key role in the 2008 financial crisis and have been extensively studied in the years since. Recent research has suggested fire sales could play a role in the context of a disorderly climate transition [21].

If lenders and investors experience a sudden and unexpected shock, they risk triggering what former Bank of England Governor Mark Carney calls "a climate Minsky Moment." [22] Named after an economist whose model was widely deployed to understand the events behind the 2007-2009 financial crisis, a "Minsky Moment" would be, in this case, a snowballing scenario where a sudden drop in assets triggered by a bursting "carbon-price bubble" precipitates broader financial and economic instability.

In "fire-sales" or, more technically, "balance-sheet contagion," financial institutions enter into a cycle of asset sales and deleveraging (reducing the share of debt to total assets, a ratio that increases as asset values decline). The chain of events plays out as follows [23]:

1. A first negative shock on an asset class (such as mortgage-backed securities) causes an increase in the financial leverage (or debt) of the banks exposed to that asset class
2. In an attempt to deleverage, i.e., to decrease the value of leverage back to its initial value or to a target value, several banks sell part of the same asset
3. If the sale volume is large enough, it creates downward pressure on the price of the very same asset, causing a further shock and a further sale reaction

These dynamics are an important dimension of systemic risk monitoring among financial supervisors [24]. The idea that fire sales could play a role in a disorderly climate transition is relatively new, but is supported by recent research [25].

The previous sections discussed both first-round shocks (direct exposure to climate-relevant firms) and second-round shocks (indirect exposure through financial networks). Fire sales can be thought of as "**third-round**" shocks, following initial losses from the first and second rounds.

A simple and common assumption is that, during a fire sale, the new price decreases exponentially with the amount sold, depending on its liquidity. The higher the market liquidity, the smaller the change in price. For example, in a scenario of moderate liquidity, a conservative assumption would be that the full liquidation of an asset class might decrease its price to 75% of its initial value.

While previous sections of this report are based on partial (publicly available) U.S. data, that information is not sufficiently detailed to conduct a quantitative assessment of the third-round shock. However, qualitative insights relevant for the U.S. can be drawn from a previous collaboration [26] between CLIMAFIN and the Banco de Mexico, based on access to granular, non-public data (see Appendix D for full details of this analysis). This case study provides a useful illustration of how the three rounds of shocks aggregate together, a dynamic that would present similarly for U.S. banks.

For Mexican banks, the third-round (core-impact) shock is of approximately the same magnitude as the first- and second-round shocks combined, depending on initial market conditions. Given the lower liquidity in the Mexican system, this represents an upper-bound for the effect of climate-related fire sales on the U.S. financial system.

The **high sensitivity to financial market conditions** provides another key insight that is relevant for U.S. banks. The timing and strength of a policy response is not the only determinant of the banking system's potential losses. A milder climate policy shock occurring during poor market conditions can lead to larger losses than a more severe policy shock occurring during a stronger economic environment—a finding that is particularly relevant given the current instability related to COVID-19.

This also suggests an incentive, beyond what already exists, for banks to invest resources in maintaining the stability of the financial system overall. The largest U.S. banks have the power and the business case to invest resources in a **more stable and equitable economic system** and to encourage regulators and policymakers to work toward the same goal. Lower inequality, a better social safety net and a market that rewards long-termism will all help to lessen volatility, maintain liquidity and decrease losses in cases of default. That will make future shocks less catastrophic and easier to manage than the 2008 and 2020 crises have proven to be.

RECOMMENDATION

Banks should recognize the risk mitigation potential of constructing a more fundamentally sound, equitable and sustainable economic system.

SECTION FOUR
From Bank Climate Risk Assessment to Mitigation

Sections 1-3 make the analytical case that banks face substantial individual and systemic risk from their climate-related financing and that action is needed immediately. This section details how banks can fully measure the risks, capitalize on mitigation opportunities, establish public goals and incentivize the behavior needed to accomplish these critical actions.

Prior sections assume that banks' holdings have sector-average emissions profiles—meaning that banks have not changed their processes to mitigate climate risk in their portfolios. In reality, banks have begun to manage climate risk and disclose that to investors, although faster progress and a broader scope is needed.

Many banks have been leaders in the adoption of voluntary climate-related disclosure frameworks, including the **Task Force on Climate-related Financial Disclosures** (TCFD), the leading framework for climate risk disclosure that is seeing widespread global adoption (as of February 2020, the TCFD had more than 1,000 supporting organizations representing a market capitalization of over $12 trillion). [1] Other voluntary disclosure frameworks developed by the **Sustainability Accounting Standards Board** (SASB) [2] the **CDP** [3] and the **Global Reporting Initiative** (GRI) [4] are also helpful for banks to consider.

Additionally, most global banks have disclosed Environmental and Social Risk Management **(ESRM)** policies that mandate enhanced due diligence for a wide range of transactions in certain climate-relevant sectors and some have restricted financing in some of the riskiest areas (e.g., coal mining and Arctic oil and gas development). These policies have become more stringent over time [5] [6]. And more work is being done behind the scenes than is apparent in public disclosures.

Despite these restrictions, there is very little evidence that transition risk has been priced in as a consistent portfolio-level risk involving a broad range of actors and sectors for the full scope of climate policy relevant sectors [7] [8].

Is Transition Risk Priced In?

Looking at the structure and size of risk premiums (or the additional return required to make a more risky investment worthwhile) in these sectors suggests that transition risk has been applied as a reputational environmental risk that is specifically linked to particular companies. Studies that investigated the cost of capital for firms exposed to climate risk generally show that the risk, measured through historical emissions, increases the cost of debt. This effect is consistently observed globally, including in the U.S. [9], Australia [10], India [11], Canada [12], China [13] and Europe [14]. However, simply demonstrating awareness of the risk (through voluntary emissions disclosure) negates the premium, reducing cost to where it would be without any climate risk at all. This is not consistent with a systemic view of climate risk as a driver of future financial results across affected industries.

This idiosyncratic view of climate risk is also supported by strong evidence from multiple studies about the impact of environmental risks on firms' market value [15] [16] [17] [18]. These studies also suggest that the market is misleadingly considering transition risk as a simple environmental externality.

Overall, banks have expanded their lending to fossil fuel-related sectors in recent years [19], the opposite of what might be expected if climate risk was being fully considered at the portfolio level. No public action has been taken that would materially affect the results of the stress tests in earlier sections. There is also some evidence that ESRM policy changes are being driven by banks' perception of reputational risk rather than of direct financial risk—particularly given that the large U.S. banks tend to move in quick succession to emulate the actions of peers on ESRM. Just as critical, the sub sectors where banks have implemented the strongest restrictions are ones that have declining financial importance to banks rather than ones that might present the greatest climate risk (although coal does fit into both categories).

Banks have a strong financial incentive to manage risk effectively, especially when that risk has the potential to materially impact their financial performance. The mispricing of climate risk described above is something that banks are almost certainly moving to fix, just not at the speed required by the problem.

In fact, several of the largest U.S. banks have publicly stated a need for better climate risk assessment - JPMorgan Chase, Bank of America and Citigroup all mention it in their TCFD disclosures [20] [21] [22] . Citi, [23] Bank of America [24], Morgan Stanley [25] and Wells Fargo [26] have announced they will measure the carbon footprint of their lending portfolio, Wells Fargo noted that that process is expected to lead to target-setting, and Morgan Stanley [27] and JPMorgan Chase [28] recently became the first major U.S. banks to make net-zero and Paris-aligned financing commitments, respectively. Rather than recalcitrance, the lack of sufficient public disclosures on climate risk by banks is likely due to a combination of the following factors:

1. A lack of fully tested tools and methods for robust **portfolio-level risk** assessment
2. A lack of fully tested tools, methods and data for robust **firm-level risk** assessment
3. A perception that the risk is **impractical** to mitigate and/or that there is a lack of investable opportunities to mitigate the risk

4. An inability or unwillingness to **talk externally** about internal risk management initiatives
5. Insufficient **internal incentives** within organizations to take action
6. A perception that the risk is beyond banks' risk management **time horizon** and that it can be dealt with quickly once that changes

As the findings of this report make clear, there are now tools for portfolio-level scenario analysis and stress testing that are forward looking, take into account the unique characteristics of climate risk, examine the potential for indirect risk and produce the quantitative outputs required by risk management teams. There is an **overwhelming business case** for banks to conduct and disclose portfolio-wide risk assessments immediately.

In terms of time horizons, the relevant unit of analysis is not the maturity of individual financial instruments, but the length of the relationships between banks and their clients, encompassing not just lending but the entire food chain of banking services. There is substantial value embedded in these relationships and it will take banks time to reevaluate them if it becomes necessary due to climate risk. Ceres' future work on this issue will delve into the complexities of **relationship banking** and the need for longer time horizons than the nine- and 20-quarter view that is currently being used.

This section provides a brief overview of how each of the four remaining issues are currently approached by banks and makes suggestions for improvement within the context of a portfolio-wide risk management effort aligned with Ceres recommendations.

Firm-Level Risk Assessment

While an assessment of overall climate risk is the most crucial climate-risk-related output for banks, many of the mitigating actions a bank might take require firm-level analysis, as bank products and services are provided at the firm level. ESRM can be very effective at assessing individual firms but doesn't aggregate quantitatively. This means additional work is needed to bridge the gap to portfolio-level analysis.

As an example, the utilities sector is made up of firms that use low-carbon technology, high-carbon technology or some combination of the two. Some of the firms using a combination are strategically decarbonizing while others are not. These differences matter in terms of understanding how sectors—and companies within those sectors—adapt in scenarios characterized by a disruptive energy transition. Such differences also have the potential to substantially change banks' exposure to risk. Ideally, banks need to be able to **compare firms' economic activities** based on their current climate and sustainability risk profile—and their forward-looking strategies to improve it. However, several important problems currently stand in the way of robust firm-level approaches, including:

- **Backward-looking data** Current analysis is largely based on past records (such as reported emissions). It often does not consider the strategy of a firm or its future capital spending plans, which are important when evaluating risk.
- **Comparability** While scope 1 and 2 emissions data are generally comparable between

firms, the scope 3 accounting guidelines are not designed to compare firms (except to their own past). As a result, where scope 3 emissions are the key driver of climate risk (such as in oil and gas), alternative methods are needed.

- **Policy relevance** Current analysis does not provide information about the cost or feasibility of reducing emissions for a particular company, or how it might be affected by policy change [29]. This information is important for banks looking to help clients transition and for policy advocacy.
- **Data availability** Carbon intensity is available for a set of about 3,000 large (typically public) firms worldwide. The information comes from a small set of sources, based on firms' self-declared estimates. The data are not available for most mid-size and small firms and, for large firms, all aspects of the business may not be covered. Additionally, practitioners have found that data from companies often do not match data generated by third-party providers using estimation methods.
- **Hidden balance sheet risks** In some industries, emissions and capital spending data alone might not show the full scope of risk. For example, the oil and gas industry has hundreds of billions of dollars of outstanding liabilities related to the clean-up of old assets, such as abandoned wells. In a transition scenario, abandonment would accelerate, substantially increasing the present value of those liabilities [30]. In parallel, a transition would require fossil fuel companies to make different commodity price assumptions, affecting the value of reserves and investment opportunities. As some European companies have made their price assumptions more transparent, substantial write-downs have occured [31]. These effects and others like them could have a sizeable negative impact on company balance sheets and create risk in banks' energy portfolios.

There is no silver bullet for these problems for banks. However, the suite of available tools combined with the internal tools that banks have at their disposal can facilitate firm-level assessment within each climate-relevant sector. An **"all-of-the-above" approach**, combined with bank **sector collaboration** to fill any remaining gaps, can provide the information required. There will still be areas where optimal data and methods may not be available, but this is the case for almost every major business decision and should not stand in the way of progress in this area.

Banks should approach firm-level analysis in an **iterative** manner and focus on learning by doing as opposed to trying to get everything right in advance. The UNEP FI TCFD implementation guidance [32] for banks provides a helpful starting point in integrating borrower-level analysis with scenario planning and stress testing with respect to transition risk. Banks could start by disclosing the scope 1 and 2 emissions intensity (and forward-looking metrics like % of CAPEX flowing to sustainable projects) of their top 100 clients (by revenue) rather than attempting to be comprehensive initially. Most of these clients have public emissions disclosure (circumventing data problems) and it would provide a reasonable snapshot of the portfolio for investors and other stakeholders.

This approach could gradually be broadened out into true portfolio **carbon accounting**. This would help to standardize information about the energy technologies used by companies to assess complex businesses and compare them. The Partnership for Carbon Accounting Financials (PCAF) is an emerging standard for portfolio carbon accounting focused on historical emissions (with nearly 80 members holding more than $13 trillion of assets worldwide) [33]. Morgan Stanley [34], Bank of America [35] and Citi [36] recently became the first major U.S. banks to commit to using PCAF. The transparency and accountability that this approach provides is extremely valuable. PCAF also contains estimation methods that help to deal with data availability problems. Practitioners have flagged these methods as an area where continuing improvements are critical.

Emissions-based approaches are also used by regulators, including the Bank of England and the Dutch National Bank, for risk assessment. They will form an important part of firm-level climate risk analysis going forward. On their own, however, emissions-based approaches do not deal with the challenges described above. They should be supplemented with forward-looking measures of risk and opportunity for each firm.

Forward-Looking Risk Assessment Tools

One forward-looking approach is the European Commission's "Taxonomy for Sustainable Activities." It identifies which kinds of economic activity (not firms) pass a sustainability threshold based on their contribution to climate mitigation, climate adaptation and a "do no harm" principle [37]. Banks can use the Taxonomy to identify the economic activities that can be considered sustainable in several sectors, including energy intensive ones such as cement production. However, while the Taxonomy can help identify which activities are sustainable, it cannot be used to compare two activities in terms of their relative sustainability score. Similarly, the Taxonomy does not cover high-carbon or carbon-intensive activities, so it cannot be used to assess a firm's different high-carbon activities. Many banks have proprietary sustainable finance methodologies that could serve a similar purpose, but an industry-wide approach would certainly be preferred by investors and other stakeholders.

On the other side of the coin, the 2 Degrees Investing Initiative has collected information on asset- and firm-level energy technology mixes in the energy, utility and transportation sectors in several countries. This information is used in the Paris Agreement Capital Transition Assessment (PACTA) [38] tool to allow banks and investors to assess the alignment of a portfolio to a 2°C target based on current and future energy profiles at the firm level. This can be an important source of forward-looking information for risk analysis. However, the coverage of economic activities and sectors is limited to high-carbon activities (i.e., aviation, automotive, cement and steel, coal, oil and gas, power and shipping) and only a few asset classes. In addition, PACTA considers individual, governmental and financial activities as "not climate relevant," which makes it difficult to consider the possibility of indirect risk. Finally, PACTA does not consider the financial risk profile of the bank using it, nor the structure of the financial network in which it is involved.

Taken together and supplemented by additional tools banks themselves are developing, the challenges of firm-level analysis can be overcome. **Data availability** is likely to be the highest hurdle. Data gaps lower the accuracy of risk-return assessment and require decisions to be made with only partial information. Companies that are financing both high-carbon and low-carbon assets using the same financial instruments are particularly hard to assess without good data.

There is a strong case for a public entity filling this gap by collecting, validating and making available climate-relevant financial data. In the absence of that, banks do have the ability to collect these data themselves. Prospective clients already provide significant information as part of the **due diligence** process, especially when subject to enhanced due diligence. The banking industry should make climate-relevant financial information a normal condition of lending—data on energy technologies and capital spending plans are likely easily available, while emissions disclosure is a good launching point for ongoing engagement with clients around climate transition plans.

RECOMMENDATION

Banks should achieve industry agreement to use their market power and relationship leverage to incentivize clients to voluntarily disclose additional forward- and backward-looking climate data.

Once firm-level data is obtained, whether through carbon accounting or through forward-looking analysis, it has to be deployed in a way that **drives decision-making** effectively. Improving climate stress testing and understanding the sensitivity of the portfolio to firm-level characteristics is critical, but to make climate risk a part of day-to-day decision-making, it cannot be analysed in isolation. Instead, it has to be integrated into non-ESG tools that influence how banks interact with their clients.

Every major service banks provide (including loans, underwriting, advisory services, equity research and asset management) is based on the forecasted financial statements of the client involved—forecasts made using an **earnings model**. For banks to understand firm-level climate risk, these models must factor it in. This will begin to move banks' understanding of climate risk beyond the balance sheet and into the income statement. The tools used in this report make this modeling easier for banks, as changes in market share and profitability are more easily (and usefully) modelled at the firm level than a carbon price is. Once the full scope of risk is understood, banks can move to effectively mitigate it.

Risk Mitigation Opportunities

Banks' relationships with their clients must be at the heart of any strategy for climate risk mitigation. Arguments that large banks "bank the entire economy" and as a result have no pathway to reduce their climate risk miss the critical role of **client engagement and transition**. While full divestment from climate-relevant sectors would theoretically eliminate a bank's climate risk, this would require banks to exit over half their business in many cases, something that's not feasible except perhaps in the long term. It is also not clear that divestment-only strategies result in widespread emissions reductions in the real economy [39]. Due to the systemic nature of many climate risks, blanket divestment in some ways "kicks the can down the road,"—a reduction in risk for the individual bank is offset by a delay in the mitigation of systemic risk, increasing risk for all banks and the impact on society more broadly.

RECOMMENDATION

Banks should publicly state that they will use engagement and leverage to accelerate client transition plans and wind down relationships that do not include such plans.

It is important to recognize that client engagement will look different in different sectors due to differences in the cost and feasibility of decarbonization. Ceres is a partner in the Rocky Mountain Institute's Center for Climate-Aligned Finance, which is working closely with the financial sector and their clients to develop global sectoral decarbonization strategies and agreements for hard-to-abate and high-emitting sectors [40]. All banks should participate in initiatives like this, and use them to **collectively drive client action** and to develop tailored engagement strategies for each sector. Investment within a sector can then gradually be shifted towards companies with robust transition plans. If particular companies prove uninterested in transitioning, banks should start with changes in capital allocation or pricing to compensate for the additional risk and gradually move toward divestment.

An illustrative example of how a bank could mitigate its climate risk through a focus on sustainable finance is shown in Figure 15. The wide-impact scenario discussed in Section 3 (18% loss for the average bank) is shown, broken down into its sectoral components (based on CPRS classification). It is contrasted with a "wide-impact green" scenario, which is identical except that its exposure to the utility sector consists only of renewable electricity and its exposure to the transportation sector consists only of electric mobility assets.

In this scenario, continued risk in the fossil and energy-intensive sectors are more than compensated by the de-risking of green investments [41]. This shows the extent to which a bank's vulnerability to transition risk is extremely sensitive to the choice of clients in climate-relevant sectors.

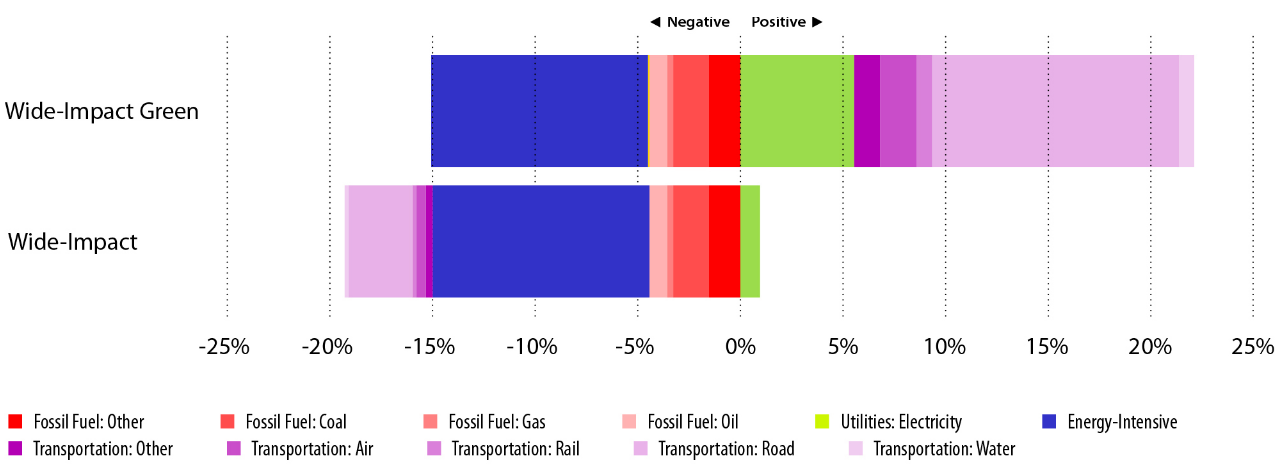

Figure 15: Potential for sector-based risk mitigation.

While in reality a mitigation strategy would not focus single-mindedly on only two sectors (even if sufficient green opportunities were available), the example is meant to illustrate that banks are able to decarbonize their sectoral portfolios at different rates and substantially mitigate risk even if some high-carbon assets remain in the portfolio.

The availability of "**investable opportunities**" is an important factor in how easy it is to mitigate risk through sustainable finance. The current structure of the economy will mean that most banks, particularly the largest ones, will have a "long" exposure to the business-as-usual case and a "short" exposure to the transition scenario. Although the largest U.S. banks have committed more than a trillion dollars in sustainable finance between now and 2030 [42], this is not enough to shift the overall balance, and a larger pipeline of opportunities will take time to develop.

One possible solution to the current shortage of green opportunities is the development of internal infrastructure within banks (staffing, data, valuation tools, etc.) to capture a greater share of the opportunities that do exist. While this investment may not be fully justified by current revenue, it sets banks up to take advantage of a future "mitigation short squeeze." [42]

Mitigation Short Squeeze Explained

If a sentiment shock occurs where markets become much more confident in the direction of the transition, banks that are "short" the transition will have to scramble to mitigate their risk. This will cause a spike in demand for green assets, potentially paying off many times over for banks that have acted proactively [43].

Such a play is reminiscent of a call option, where an initial investment creates a possibility for **significant future upside**. This upside could offset much of the risk banks face while circumventing the current lack of investable opportunities. Option pricing models can be used to quantify the value of this upside [44], which would have the added benefit of further developing the business case for banks' sustainable finance targets. Being able to show mathematically that such targets capture value beyond the immediate revenue from the deals themselves would help sustainable finance become a strategic business driver.

This approach also recognizes the reality that banks don't just "bank the economy" as it is, but have a role in helping create the economy that society needs in order to stabilize the climate.

RECOMMENDATION

Banks should communicate to employees and investors any risk-mitigation value they ascribe to their sustainable finance programs.

Risk evaluation tools described in previous sections may present another solution to the problem of investable opportunities because they allow tradeoffs between climate risk and other kinds of risk to be considered quantitatively. Once a bank is confident in its climate risk assessment, it may be able to justify taking additional risks of another kind to offset it. For example, developing countries may offer a large set of investable green projects, but may present additional political or economic risk as well. Such investments are hard to justify without a quantitative measure of the climate risk the investment may offset.

External Signals: Target Setting

Because risk management is both complex and proprietary, there is often more going on behind the scenes than is publicly disclosed. When it comes to climate risk, this opacity is a problem. Because of the early-stage nature of climate risk management, the potential systemic and societal implications and the level of investor interest, disclosing information externally is critical. The TCFD recommendations, which the largest U.S. banks have all committed to implementing, ask for the **disclosure of targets** because they are important indicators of future financial performance.

However, it is not obvious what kind of targets banks should set when it comes to climate risk - other than that they should be focused on the high-carbon financing that is the main source of such risk. This makes sustainable finance targets—though important—inadequate for this purpose. Targets around the percentage of clients engaged on climate might be useful internally but don't measure the risk directly, and Value-at-Risk targets would be problematic to disclose and too complex to communicate effectively. Commitments to net-zero financed emissions (such as Morgan Stanley recently made) [45] are laudable but need to be supplemented with additional detail.

From an impact perspective, what is needed is a **specific target aligned with the objectives of the Paris Agreement**. Such a goal reduces reputational risk and creates credibility with clients. If a bank does not have a Paris-aligned target, it will have a harder time asking its clients to set one as part of a risk mitigation strategy. A Paris-aligned target will also position a bank to adapt easily to any future regulatory requirements, whether they are risk- or impact-oriented.

However, in order to link Paris-aligned target setting directly to transition risk and give investors decision-useful insight into risk reduction, the target has to be applied in a way that minimizes leakage [46] and provides temporal and sectoral information related to risk exposure. While Paris-aligned targets generally focus on the 2050 time horizon, some sectors (and portfolio segments) will need to reach net-zero emissions as soon as 2030 or 2040. Additionally, banks should move to exit some subsectors (like coal) in the near future in order to reduce risk. Banks may also implement the risk mitigation strategies from the previous section in different ways and on different timelines.

All this will require a Paris-aligned target that is nuanced, treats different sectors differently and contains detailed interim milestones that investors can use to understand and compare banks' risk reduction strategies. JPMorgan Chase recently announced [47] a Paris-aligned financing commitment that contemplates many of these details for three key sectors, showing that banks are beginning to make progress in this area.

RECOMMENDATION

Banks should set and disclose financing portfolio targets that are aligned with the goals of the Paris Climate Agreement and include detailed interim targets and specific timelines for sectoral portfolios to reach net-zero emissions—some sectors as soon as 2030, others by 2040 or 2050.

Any additional context that is required to link the goal with risk management objectives can be provided qualitatively to investors. For some banks, it may be useful to validate their goal through the Science Based Targets initiative [48], which recently launched a methodology for banks to set targets that include financed emissions. Aligning with this methodology will enhance comparability, but banks should focus first on a goal that will incentivize action internally and reflect their risk management strategy to the greatest possible extent.

Creating Internal Incentives

The value of sustainable finance and climate risk management is often poorly understood by bank employees outside the sustainability function. Messaging that climate risks are "non-financial" gives employees the perception that sustainability is primarily a reputational exercise. This contributes to the siloing of sustainability initiatives within banks—impeding them from becoming true business drivers.

The problem starts at the top. Analysis of 20 leading U.S. and European banks [49] shows that only four of 600 board members have previous experience in clean energy, while at least 73 come from the world's highest-emitting companies. Ceres' research [50] shows the need for **climate-competent boards** that can ask management difficult questions and represent investor interests with respect to climate risk.

Similar dynamics are at work at every level of a bank, where the historical importance of high-emitting sectors means many bankers and risk experts are familiar with those industries but far less knowledgeable about the sustainability issues associated with them. Ceres research indicates that the size of ESRM teams within large U.S. banks ranges from four to 11 full-time employees. All these teams must rely on the broader risk function and partners in the business, in many cases they have neither the capacity nor the skillset to implement the risk management tools recommended in this report. Anecdotally, it appears that many research analysts and bankers do not invest the time to integrate climate risk into their analytics because it takes time away from revenue producing activities and the internal need is not well understood.

Integrating climate into the day-to-day activities of these employees is a partial solution to this problem, but the most important way to address it is through **compensation** and performance management. This is another reason why having clear targets is critical. Without them, there is nothing to focus performance around. Ceres' governance work [51] has built the business case for linking executive compensation to sustainability goals, but in this case the key employees are not typically at the executive level. Valuation experts and modellers need to be able to focus on this problem, and industry banking teams need to be incentivised to prioritize deals that reduce climate risk over deals that increase it—deals that may have a greater long-term upside but less immediate revenue.

RECOMMENDATION

Banks should internally prioritize and reward their employees for integrating climate considerations into day-to-day decision-making.

Some Approaches to Creating Internal Incentives

A useful example here is how workplace safety is managed in extractive industries. Like climate, safety has long been thought of as a "non-financial" risk, even though it can have severe financial consequences (unlike climate, safety is not a systemic risk). Recently, substantial progress is being made across the industry as companies set (impact-oriented) organizational goals such as "Zero Fatalities" or "Zero Lost-time Injuries" and created internal safety cultures to support those goals [52]. At many companies, employees are now required to have a personal safety goal linked to their compensation, meetings begin with "safety moments," and executive compensation [53] incentivises leadership to reinforce the message constantly, both inside and outside the company. The climate focus within banks might not need to be quite as expansive to be effective, but changing the mindset of relevant employees who do not work in a sustainability function is almost certainly a prerequisite for progress.

Conclusion

Averting the most severe impacts of climate change is the critical challenge of our time. Doing this will take proactive, concerted leadership from the private sector, policymakers and civil society.

Though daunting, these challenges are surmountable, and how banks move forward is critical. The largest U.S. banks are moving in this direction, but too slowly. The lack of urgency may stem from the long-term nature of climate change itself, when the focus should be on the potential for short-term climate shocks. It may stem from the view that lending is a small part of banks' business, when the focus should be on the entire suite of banking services provided to high-carbon clients. Or, it may stem from the belief that the short-term nature of lending reduces risk, when it has taken a full decade to wind down lending to the uneconomic coal sector.

Whatever the reasoning, short-termism is dangerous for people and the planet. Ceres' future banking work will focus on this topic, but by then the most prescient banks will already be moving. The next year could easily be the year of the first major climate shock, with a U.S. election, a major UN climate conference and places from Hong Kong to Minsk to Minneapolis reverberating with calls to rebuild societies damaged by oppression and disease. A new world is coming that is more sustainable and more just, and banks have no time to waste if they want to avoid being left behind.

RECOMMENDATION

Within the next year, banks should publicly commit to (and begin work on) implementing the recommendations of this report.

Appendices

APPENDIX A: CLIMAFIN Methodology Details

The CLIMAFIN methodology provides a transparent and science-based approach to quantitatively assessing and pricing forward-looking climate risks and their characteristics (i.e., deep-uncertainty, non-linearity and endogeneity) in the value of individual financial contracts and investors' portfolios [1]. More specifically, it can embed scenarios of forward-looking climate transition risks provided by climate science and climate economic models in:

- Probabilities of defaults of contracts and securities (i.e., embedding climate risks in financial pricing models for equity holdings, corporate and sovereign bonds);
- Quantitative metrics of financial risks (e.g., Climate VaR, Climate Spread);
- A full-fledged climate stress test rooted in financial network models.

This methodology can answer two questions:

1. How can banks carry out a quantitative assessment of climate transition risks at the individual and systemic financial levels that makes best use of the available scientific knowledge?
2. How to price climate risk characteristics (deep uncertainty, non-linearity, endogeneity) in the probability of default of financial contracts and banks' portfolios, considering counterparty risks?

The major challenges in addressing these questions are related to the nature of climate risks that renders standard finance approaches to risk pricing and valuation inadequate.

The CLIMAFIN framework is a quantitative assessment arranged in a workflow of four modules. Figure 16 shows the interplay of the four modules in the CLIMAFIN workflow.

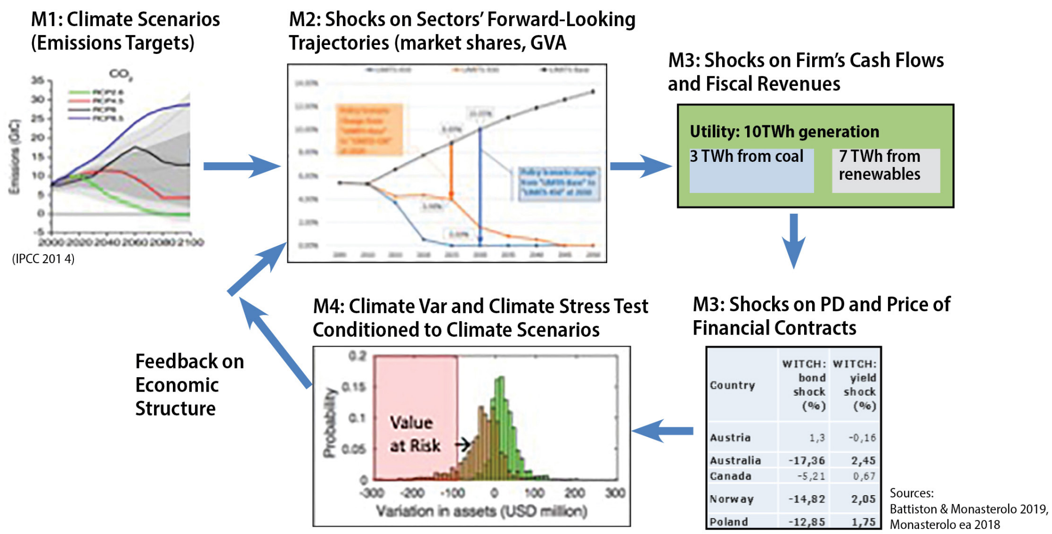

Figure 16: CLIMAFIN climate-financial risk assessment workflow. Module 1 provides the information set combining science-based knowledge and market data to be used in the analysis. Module 2 provides information on the economic shocks (positive and negative) associated with the climate transition scenarios, at the level of economic activity. Modules 3 and 4 provide metrics and methods to measure financial risks and support investment and policy decision making in the transition to a net-zero-carbon economy.

Module 1 gathers and consolidates a database of climate science scenarios and climate transition scenarios, e.g., those provided by the IPCC [2].

Module 2 uses the information from Module 1 to derive impacts of economic shocks (market share, gross value added) in particular climate scenarios by region and sector of economic activity. Integrated assessment models (IAMs) are used to do this. The core of the feedback mechanism is the following:

1. The forward-looking climate transition scenarios imply a shock on the low-carbon and carbon-intensive economic activities (respectively positive and negative) based on their energy technology (i.e., renewable energy or fossil fuels based).
2. The shock affects the economic activities' output and contribution to gross value added.

It is important to note impacts are measured as differences in sectoral output between the business-as-usual and the climate scenario-conditioned economic trajectories for the same IAM. In particular, the disorderly transition is intended as a temporary out-of-equilibrium shift of the economy between two separate equilibrium trajectories based on the energy technology that drives the transition. This formulation makes the exercise familiar to economists because they are consistent with traditional economic models' rationale. Multiple models and scenarios are used to construct a probability distribution that feeds Module 3.

Module 3 defines the information set of a risk-averse investor or bank who aims to minimize the largest climate-related losses to her portfolio. It defines an information set that can accommodate incomplete information and deep uncertainty [3] [4] [5] and can cover a time-horizon that is relevant both for investment strategies and for the low-carbon transition (from 2020 to 2050). The model carries out a valuation adjustment and a risk adjustment of individual financial contracts, i.e., in their default probability based on the scenarios of economic shocks (by activity and its energy technology) obtained from Module 2. First, the model computes the adjustment on the default probability conditioned to the climate policy shock on firms and individual financial contracts (e.g., equity holdings, corporate and sovereign bonds, loans). Then, it computes the adjustment to key financial risk metrics (e.g., the Climate VaR) [6] for gains and losses at the portfolio level, which represents the worst-case loss for a chosen confidence level, conditional to forward-looking climate policy shock scenario. The Climate Spread is then defined as the change in the spread of a corporate or sovereign bond contract conditional to a given climate policy shock scenario, thus introducing future climate risks in the assessment of firms or countries' financial solvency. Overall, Module 3 takes the outcome of the economic shock on each economic activity and asset, and prices it into the default probability and value of the financial contracts (loans, equity holdings, corporate and sovereign bonds) associated with that activity.

Therefore, conditional on a scenario and on the timing of the shock, losses on a portfolio of loans can be computed using the CLIMAFIN methodology. The methodology provides a linear approximation of the impact of a sectoral economic shock on the default probability of an entity within the sector (see Battiston et al. 2019 for more technical details). The value of a (zero-coupon) loan with nominal value **X** and maturity **T** given a climate policy scenario **s** and a date t for the shock is then given by $X_{s,t}$ such that:

$$X_{s,t} = (1 - Q - P_{s,t})\, e^{-rT} X + (1 - LGD)(Q + P_{s,t}) e^{-rT} X$$

where ***Q*** is the idiosyncratic (non-climate related) default probability, $P_{s,t}$ the climate-induced change in default probability, ***LGD*** the loss-given-default and ***r*** the risk-free interest-rate.

In a stress-testing context, worst-case assumptions are made about the timing of the shock and the loss-given-default. Thus, the most prudent/ambiguity averse valuation of the loans is used [7], i.e., consider ***X*** is valued at $min_t\ X_{s,t}$, and assume a loss-given-default ratio of 1. The latter assumption about the loss-given default ratio means that there is zero recovery of debts from clients that default (at least in the short-term). For this to happen, the transition would have to lead to a systemic financial crisis in which financial actors repeatedly and substantially reevaluate the book value of their assets.

In **Module 4**, the information on the repricing of the contracts is used to run the climate stress test. This is rooted in financial valuation in network models and allows assessment of the losses for individual portfolios conditioned to climate scenarios, considering risk amplification and reverberation driven by financial interconnectedness and the implications on systemic financial risks [8]. The financial risk part of the climate stress test consists in translating the macroeconomic shock into shocks on the value of the securities and loans that financial institutions have invested in. The transmission channel works as follows:

1. During a disorderly transition, the firms in the energy sector that have not adapted their business to the climate targets face unanticipated costs and reduced revenues.
2. In contrast, firms that have invested in low-carbon technologies face unanticipated profits via changes in production costs, prices and revenues.
3. Accordingly, the positive/negative shocks on the energy firms are reflected in shocks on the value of the associated financial contracts. The relation between changes in economic output and changes in values of financial investments depends on the type of asset class considered (e.g., equity, sovereign bond, corporate bond, loan), and the valuation approach used.

APPENDIX B: Second-Round Losses

Recent research on financial networks [1] has shown that the magnitude of second round effects is determined by two features of the balance sheet of banks: external leverage, i.e., the ratio between the assets they hold on non-banks that are exposed to external (climate) shocks and their equity, and interbank leverage, i.e., the ratio between the assets they hold on other banks and their equity. Then, second-round effects faced by a bank are proportional to the product of its interbank leverage and of the external leverage of its bank counterparties. Namely, the second-round losses λ_i^2 of bank ***i*** can be approximated as:

$$\lambda_i^2 = l_i^b l^e \lambda^1$$

where l_i^b is the interbank leverage of bank ***i***, l^e is the average external leverage in the system and the λ^1 average first-round loss in the system, as relative share of equity.

Less formally, first-round losses correspond to losses on the loan portfolio of banks. The relative impact of these first-round losses on the equity of a bank depends on its external leverage, i.e., as emphasized above, the ratio between the assets it holds on non-banks that are exposed to external climate shocks and its equity. In a context of systemic crisis, there is rapid reevaluation of the value of the assets and liabilities of financial institutions [2]. The balance sheet deterioration induced by first-round losses thus decreases the value of its assets, and consequently affect its liabilities to other banks. This decrease impacts in particular its bank counterparties proportionally to its interbank leverage, i.e., the ratio between the assets the bank holds on other banks and its equity. CLIMAFIN analysis uses leverage data from the company *BankRegData* and an approximation [3] [4] of interbank leverage based on the CPRS analysis in Section 1.

APPENDIX C: CPRS Classification System

Figure 17 provides a detailed description of the classification at two different levels of granularity (CPRS1 and CPRS2). Figure 18 provides a mapping to the NACE classification system (the EU standard for classifying economic activities). Assessing exposure in terms of CPRS allows for direct evaluation of investments in relation to climate policy objectives and makes the portfolio measurable with respect to climate policy scenarios.

CPRS1	CPRS2
Fossil Fuel	Fossil Fuel: Coal Fossil Fuel: Gas Fossil Fuel: Oil Fossil Fuel: Other
Utilities	Utilities: Electricity Utilities: Electricity & Gas Utilities: Waste Utilities: Water & Sewage
Energy-Intensive	Energy-Intensive
Buildings	Buildings
Transportation	Transportation: Air Transportation: Paths & Bicycles Transportation: Railways Transportation: Roads & Vehicles Transportation: Space Transportation: Water Transportation: Other
Agriculture	Agriculture: Agriculture Agriculture: Fishing Agriculture: Forestry
Finance	Finance
Scientific R&D	Scientific R&D
Other	Other: Non-Climate Relevant

Figure 17: List of CPRS sectors following Battiston et al. (2017) [1]

Sectors	NACE Rev. 2 Four–Digit Codes
Fossil Fuel	B5.1–B6.2 B8.9.2 B9.1 C19.1–C19.2 C20.1.1 C28.9.2 D35.2 F43.1.2 F43.1.3 H49.5
Energy-Intensive	B7.1 B7.2.9 B8.9.1 B8.9.3 B8.9.9 C10.2 C10.6.2 C10.8.1 C19.8.6 C11.0.1 C11.0.2 C11.0.4 C11.0.6 C13.1–C15.2 C16.2.9–C17.1.2 C17.2.4 C20.1.2–C20.2 C20.4.2 C20.5.3–C22.1.9 C23.1.1 C23.1.3–C23.5 C23.7 C23.9.1 C24.1–C24.2 C24.4–C24.4.6 C24.5.1 C24.5.3 C25.4 C25.7 C25.9.4–C28.9.1 C28.9.3–C29.1 C29.3.1 C30.3 C30.9 C31.0.9–C32.9
Buildings	C23.6.1 C23.6.2 C31.0.1–C31.0.3 F41.1 F41.2 F43.1–F43.9 I55.1 L68
Utilities	D35.1 F42.2.2
Transportation	H49.1–H49.4 H50–H51.2.1 H52.5–H53.2.0
Agriculture	A1.1–A3.2
Finance	K
Scientific R&D	M72.1 M72.2
Other	Other

Figure 18: detailed composition of CPRS sectoral categories.

DealScan provides data on syndicated loans, including identity of lenders, amount provided by each lender, identity of the borrower, and SIC sectoral classification of the borrower. Combining this data with the CPRS classification system, the exposure of each bank is determined through the following steps:

1. Match SIC sectors with Climate Policy Relevant Sectors. This requires intermediary matching between SIC and NAICS and between NAICS and NACE.
2. The matching allows each loan to be assigned to a CPRS sector (including Other).
3. For each bank, sum the loan amounts by CPRS sector in order to determine its exposure.

Appendix D: Case Study of Mexico

This case study builds on a collaboration [1] between CLIMAFIN and the Banco de Mexico, based on access to granular, non-public data. Although the detailed results are specific to Mexico, the qualitative insights are globally applicable. In quantitative terms, the multiplicative effect of fire-sales (green wedge in Figure 19) observed for Mexico can be taken as an upper bound of the potential effect in the U.S. (given the higher liquidity in the U.S. financial system). The discussion is meant to provide an illustration of the effects and their order of magnitude [2].

A system-wide analysis of this nature requires assumptions about the financial market conditions prevailing at the time of the shock, including the average liquidity, volatility and loss-given-default. Figure 19 shows the losses on initial equity for Mexican banks triggered by a disorderly transition from business-as-usual to a specific 2-degree scenario [3]. The core-impact sectors (fossil fuel and electricity) are shown here; the wide-impact view would show a more severe estimate of losses.

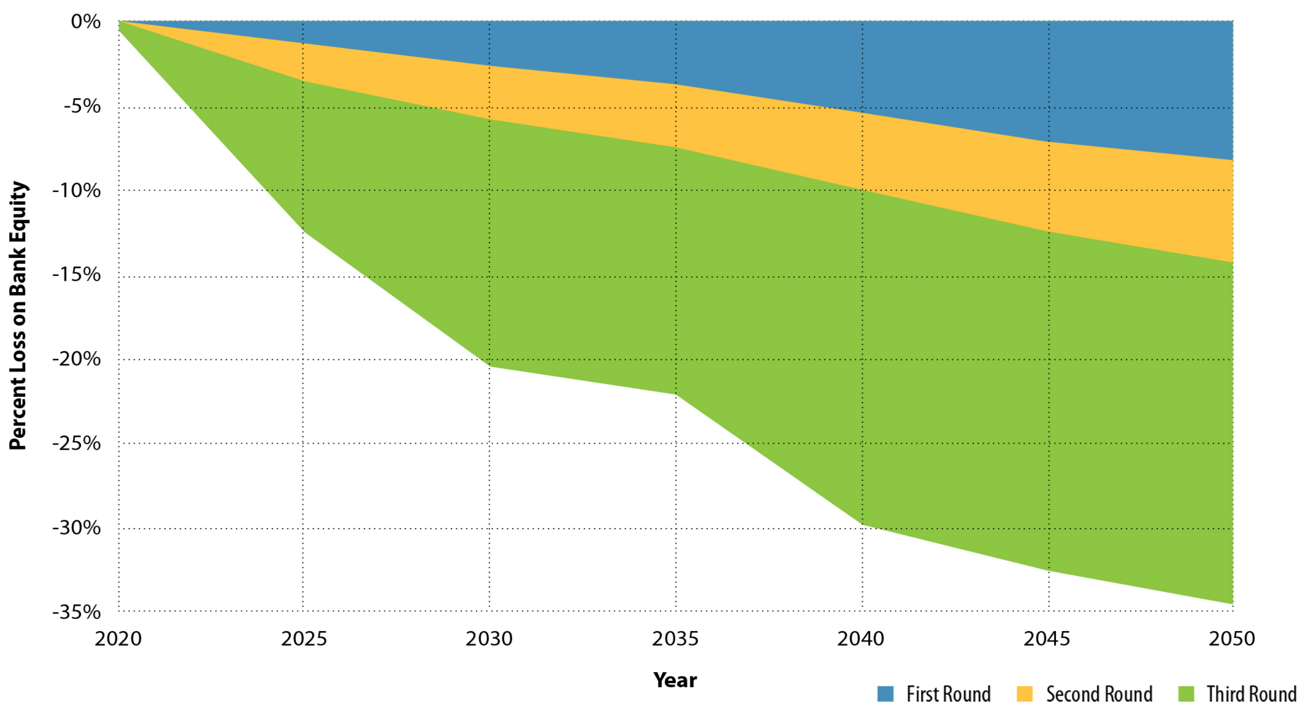

Figure 19: Banks' losses in shock scenarios arising from a disorderly (unexpected) climate transition at different points in time. [4, 5]

It is important to understand the correct meaning of the time dimension in Figure 19. It represents the time at which the climate policy shock occurs, across blocks of five years. Given a climate policy scenario, the magnitude of the shock depends on the date at which the disorderly transition is assumed to occur. The later the transition, the larger the shock.

This should not be confused with the time of the propagation of the losses, which happens on the timescale of months once the shock occurs. For instance, for a shock occurring in 2030, the first-round loss (due to the direct impact of the shock, in blue) amounts to about 3% while the third-round loss (due to fire sales, in green) amounts to about 14% (the magnitude of the green portion).

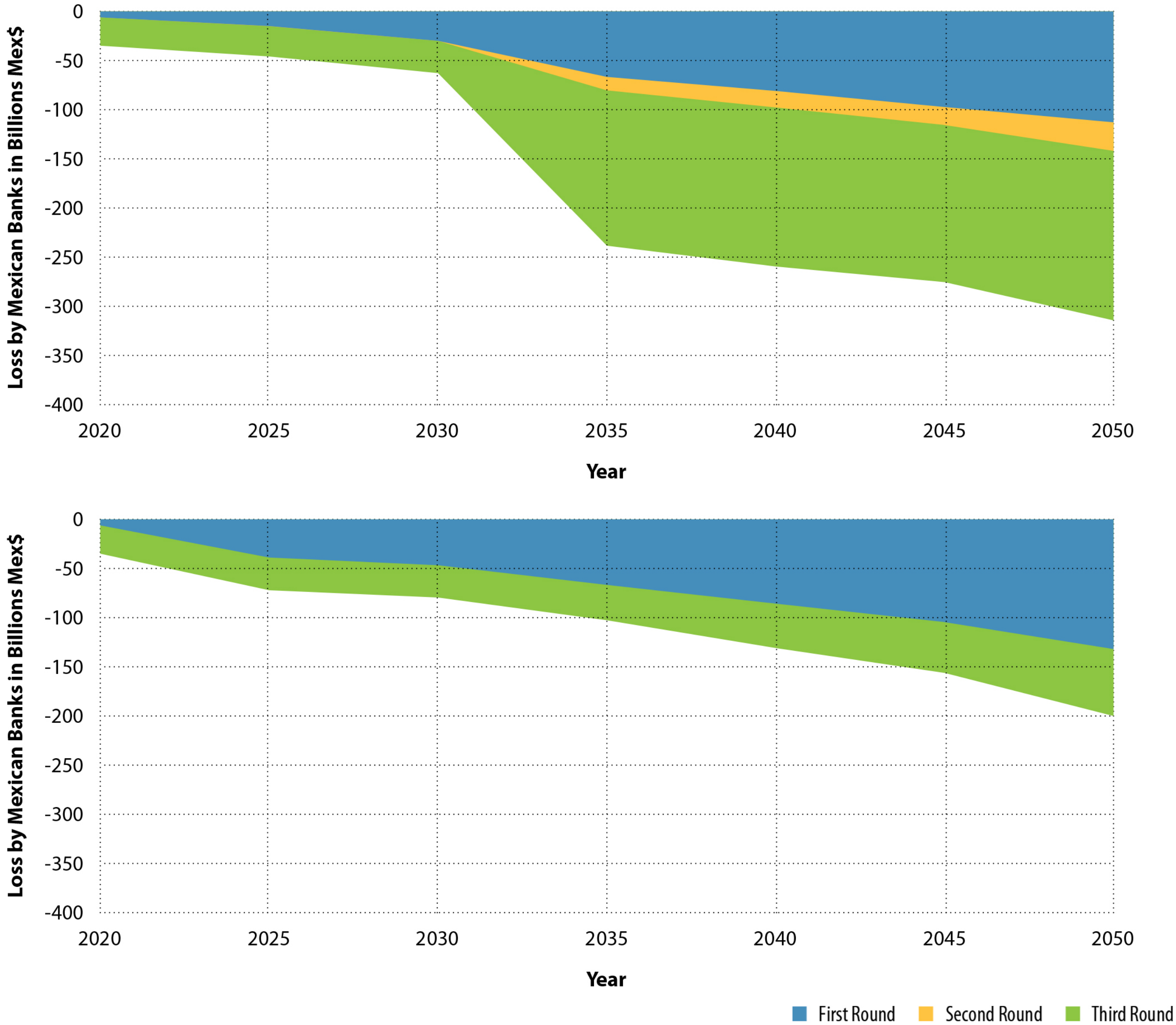

Figure 20. Comparison of shock suffered by the Mexican financial system in two selected policy scenarios [6, 7, 8].

Figure 20 shows an example of the interplay between policy and market conditions. On the bottom, the climate policy shock is harsher (expected temperature rise of ~1.8°C, 66% chance to stay below 2°C) but the market conditions are more favorable. Overall, losses are systematically smaller in that case: the losses triggered in the year 2035 by the milder climate policy in weaker market conditions are about twice as large as the losses triggered in the same year by the stricter climate policy under stronger market conditions. The effect of market conditions is intuitive, but the size of the effect is noteworthy. It suggests that variations in market conditions, and their interplay with climate policy, need to be considered in the climate risk analysis of banks.

Appendix E: Data, Scenarios & Models

Syndicated loan data pertaining to the following 28 banks were used (ordered by total loan value in the Dealscan database): Bank of America, JPMorgan Chase, Citigroup, Wells Fargo, Goldman Sachs, U.S. Bank, Morgan Stanley, PNC Financial Services, Truist Financial, Fifth Third Bank, BNY Mellon, Regions, Citizens Bank, Capital One, Huntington Bancshares, Comerica, BBVA, State Street, People's United Bank, CIT Group, Silicon Valley Bank, Northern Trust, TIAA, Synovus, Zions Bancorporation, New York Community Bank, Ally Financial and Mutual of Omaha.

This analysis is based on the economic evaluation of climate policy performed in the projects LIMITS [1] and GREENWIN [2]. LIMITS uses five integrated assessment models: IMAGE, MESSAGE, REMIND, TIAM-ECN, WITCH. GREENWIN uses the computable general equilibrium model GEM-E3. Comparative analysis was performed using IO-NET and an additional unnamed model.

Scenario Name	Project	Characteristics
RefPol	LIMITS	Baseline scenario for weak short-term target
StrPol	LIMITS	Baseline scenario for strong short-term target
450	LIMITS	Benchmark scenario for 450ppm target
500	LIMITS	Benchmark scenario for 500ppm target
RefPol-450	LIMITS	450 ppm target with weak short-term target
StrPol-450	LIMITS	450 ppm target with strong short-term target
RefPol-500	LIMITS	500 ppm target with weak short-term target
StrPol-500	LIMITS	500 ppm target with strong short-term target
RefPol-2030-500	LIMITS	500 ppm target with weak short-term target until 2030
RefPol-450-PC	LIMITS	RefPol 450 with burden sharing targeting per capita convergence
RefPol-450-EE	LIMITS	RefPol 450 with Equal Mitigation Effort
Carbon Club	GREENWIN	2°C target through a climate club
Carbon Club+ Finance	GREENWIN	2°C target through a climate club involving common financing
Carbon Club + Finance+Tech	GREENWIN	2°C target through a climate club involving common financing and technology spillovers
Club +Finance+ Tech+Trade	GREENWIN	2°C target through a climate club involving common financing, technology spillovers and trade policy measures.

Ceres Accelerator for Sustainable Capital Markets

In the last three decades, Ceres and our influential networks have achieved significant progress in integrating sustainability into the capital markets. However, private and public sector progress is not happening fast enough or with the right level of ambition to tackle not only the global climate crisis, but the growing threats around deforestation, water scarcity and pollution.

Building on our more than 30 years of leadership and impact, the Ceres Accelerator aims to transform the practices and policies that govern capital markets in order to accelerate action on reducing the worst impacts of the climate crisis and other sustainability threats. It will spur capital market influencers to act on these systemic financial risks and drive the large-scale behavior and systems change needed to achieve a net-zero carbon economy and a just and sustainable future.

The Ceres Accelerator will initially focus on four flagship initiatives that aim to accelerate large-scale capital markets behavior and system changes needed to address the climate crisis.

- **Regulating Climate Change as a Systemic Risk**
- **Achieving Paris-Aligned Portfolios**
- **Financing a Net-Zero Carbon Economy**
- **Board Governance for a Sustainable Future**

This report is the first in a series of studies and initiatives that aims to shed more light on the ways in which climate risk affects the roles of critical capital market actors, influencers and regulators.

For more information about the Accelerator, and previews of our upcoming work, please visit ceres.org/accelerator

ENDNOTES

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APPENDIX A: CLIMAFIN Methodology Details

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6. The VaR, despite being well known and used by investors, has two main limitations in this context. First, the VaR is computed under an assumption of knowing how the loss will be distributed, and this leads to model risk. Second, the VaR depends linearly on the PD of underlying assets, thus implying that small errors have small consequences. However, the PD of leveraged investors depends non-linearly with PD of underlying assets, thus implying small errors can have big consequences. But, importantly, the VaR does not consider leverage. This means that to assess the financial risk implications of climate change, we need to go beyond the VaR and consider interconnected financial actors, leverage financial agents with overlapping portfolios, i.e. the conditions for systemic risk in financial networks (Battiston et al. 2016). This is a main feature of CLIMAFIN, as well as the possibility to be applied to other risk metrics, such as the ES. This is the average of all the losses above the VaR (i.e. of the largest losses), and gives us a measure of what we can expect in terms of losses from our portfolio.
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APPENDIX B: Second-Round Losses

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APPENDIX C: CPRS Classification System

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APPENDIX D: Case Study of Mexico

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APPENDIX E: 2 Degree Scenarios & Models Used

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