

**Pathways for Investor Climate Action:
Trade-offs and Synergies under the
Banner of Net Zero**

By

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Abstract

Climate change is a critical issue for financial markets because of physical risk to assets from extreme weather events, and risks and opportunities arising from the world's transition to a low carbon economy. This transition can be understood as a wave - a metaphor in which investors use different logics in response, resulting in them making the wave, riding the wave, or being hit by the wave. The latter means investors are at risk of shocks from technologies, policies and regulations affecting their portfolio. Riding the wave represents mitigating portfolio risk and tapping into opportunities for improved financial performance, while making the wave is about finding opportunities to drive impact and mitigate systemic climate risk. We dive into how asset managers and asset owners make sense of the transition wave through qualitative means including interviews and case studies. We show how investors are using Net Zero as an overarching goal and explore how they justify their strategies under that banner and what resulting actions are. Using a system dynamics approach we explore interactions from combining certain investor mechanisms for action, such as shareholder engagement, flexible capital provision, and divestment. We interpret these emerging effects as synergies or trade-offs between making the wave and riding the wave and chart the course for future research to understand the interactive effects of investor climate actions.

Thesis Supervisor: Jason Jay

Title: Senior Lecturer, MIT Sloan School of Management & Director, Sustainability Initiative at MIT Sloan

Acknowledgments

The work on this project at the MIT Sloan Sustainability Initiative started in the fall semester of 2020, as a part of the Climate Pathways Project¹ - a joint effort with Climate Interactive² to engage top global decision-makers in interactive simulations to advance the adoption of ambitious, evidence-based climate policy and strategy. This thesis plays a part in the investor engagement work, for which I conducted interviews with investors and related key informants, and co-facilitated workshops around En-ROADS³. These efforts are important to the Climate Pathways Project as well as to the research methods employed here.

This thesis is submitted for my master's degree completion in the Technology and Policy Program at MIT⁴. I was involved in the Climate Pathways Project as a research assistant to Jason Jay, who was also my thesis advisor. I joined MIT and this effort from a background in engineering and computer science, as well as limited experience in qualitative research work. The research setting allowed me to quickly get up to speed in the climate investment space, contribute to the project, and tackle our research from a social science and policy perspective - considering the specific views and rationales of finance, economics, or climate science.

I would like to acknowledge the support I received from the Sustainability Initiative, Climate Interactive, and individual mentors - Jason Jay, John Sterman, Bethany Patten, Susan Silbey, Hazhir

¹ <https://mitsloan.mit.edu/sustainability-initiative/climate-pathways-project>

² <https://www.climateinteractive.org/>

³ En-ROADS (Energy Rapid Overview and Decision Support) is a climate solutions simulator which allows people to choose which policy and technology levers to pull, and see the climate results for themselves in real-time. In workshops facilitated by the MIT Climate Pathways Project team, participants use the En-ROADS simulator to explore and clarify the socio-economic and political dynamics of different climate solutions.

⁴ <https://tpp.mit.edu/>

Rahmandad. I am especially thankful for the opportunity given to me by Jason and to Dwight Poler who provided both intellectual and financial support to the project, having first proposed this work on investor engagement around En-ROADS with a System Dynamics approach.

Another important acknowledgement is about how dramatically the field of climate finance has evolved since this project started in 2020 and how it continuously reshaped our research efforts. Over the last two years, the mainstream climate conversations in the finance sector quickly moved from broad Environmental, Social, and Governance (ESG) target setting to strong pressures on disclosure, worldwide commitments on making portfolios have net zero emissions, and a shared sense of urgency - if not for climate change risks, for transition risks. This was seen from academic papers published all the way to real action from institutional investors and policymakers.

As a result of how we perceived the field evolving, this research effort - culminating in this thesis - can be seen in two distinct stages. The first year of the work was predominantly centered on making sense of how the financial community perceives and discusses climate change and the climate transition. The work evolved as the “net zero” movements quickly rose throughout 2021. Our approach became more normative as we explored how this change took place and materialized. At the time of this writing, there are diverse levels of commitment, inconsistent scopes, and significant uncertainties around how plans will be implemented. While there is strong work done on the impact of individual actions investors can take, questions remain about the effect of integrating different actions when turning a portfolio net zero is the objective. We want to generate insight into how certain approaches can reduce risk to investors as well as drive real economic changes. Our perspective focuses on investors leading efforts but does not ignore the importance of public policy’s role in this challenge. Key complementary effects, such as standard setting, carbon disclosures, and benchmarking, are critical to the approaches outlined here.

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Glossary

AUM - Assets Under Management

CA100+ - Climate Action 100+

CDP - Carbon Disclosure Project

CREO - Clean, Renewable, and Environmental Opportunities

ESG - Environmental, Social, and Governance

IEA - International Energy Agency

IPCC - Intergovernmental Panel on Climate Change

NREL - National Renewable Energy Laboratory

SRI - Sustainable Responsible Investments

TCFD - Task Force on Climate-Related Financial Disclosures

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Introduction

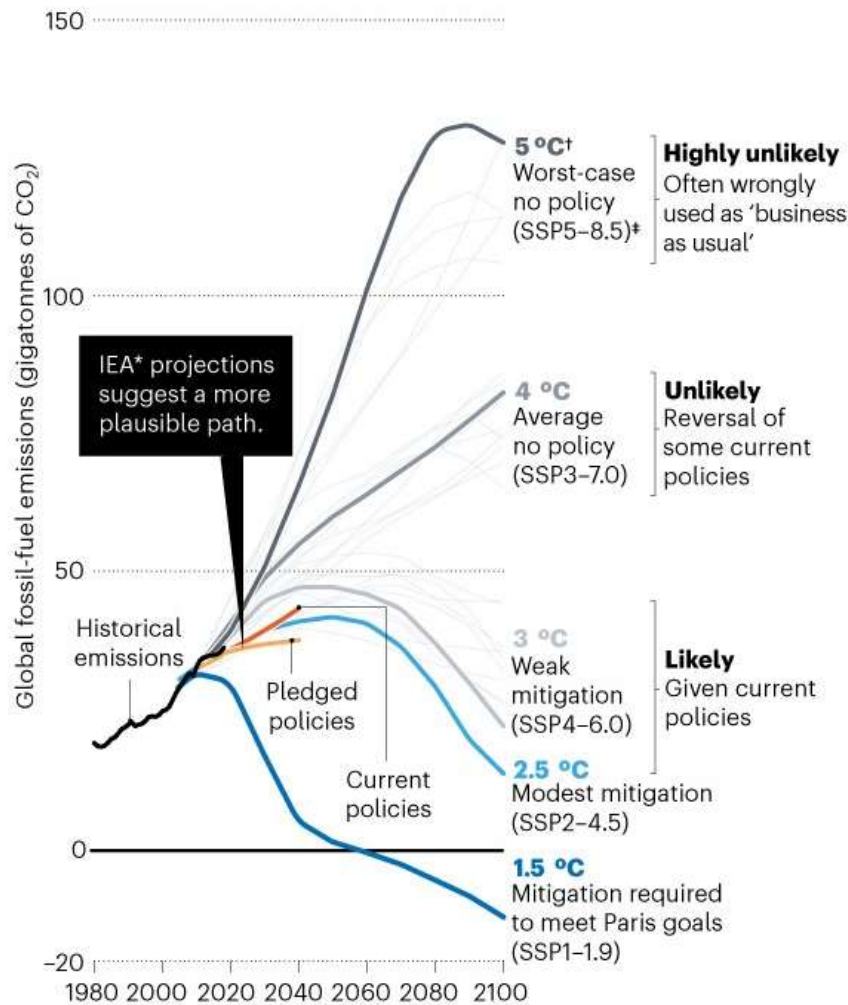
Climate Risk

The increase in Greenhouse Gas (GHG) emissions from human activities is responsible for worldwide temperature increases, subsequent weather pattern changes, sea-level rise, and many other disruptive climate effects (*The Big Picture On Climate Risk*, 2020). It was projected in 2020 that the average world temperatures will increase to 3.6 degrees Celsius above pre-industrial levels by the end of the century (*The Paris Agreement | UNFCCC*, 2021). This scenario comes with heavy social, economic, and environmental impacts. To combat the climate crisis, the Paris Agreement was signed by 197 parties and now influences the decisions of businesses and policy-makers worldwide (Melissa Denchak, 2021). Its main goal is to keep global temperature rise below 2 degrees Celsius, with an additional target of reducing that increase further down to 1.5 degrees (*The Paris Agreement | UNFCCC*, 2021).

The combined efforts of different countries and markets in the past decade have been accelerating and starting to show results. The 4+ degree Celsius scenarios with catastrophic outcomes seem less likely month after month. More scientists, such as in the International Energy Agency (IEA), are looking at 3 degrees Celsius of warming by 2100 as the most likely outcome given current policies (Hausfather & Peters, 2020). This however is still far from the Paris Agreement targets and would mean significant economical and physical risks.

Failure to hit those targets would lead to physical damages around the world, productivity changes, labor market frictions, overarching socioeconomic changes, other impacts on international trade, government revenues, fiscal space, output, interest rates, and exchange rates (*NGFS Climate Scenarios for Central Banks and Supervisors*, 2020). There can be direct damages to physical assets in extreme weather events as well as disturbances to supply chains which affect prices globally. Each degree

Celsius of temperature increase could mean 1-3% of productivity loss for billions of people without weatherized work environments. This means that even a 1.5 degrees Celsius scenario (Paris target) would cost the global economy 2.4 trillion USD by 2030 (Kristen Sullivan et al., 2021).



*The International Energy Agency (IEA) maps out different energy-policy and investment choices. Estimated emissions are shown for its Current Policies Scenario and for its Stated Policies Scenario (includes countries' current policy pledges and targets). To be comparable with scenarios for the Shared Socioeconomic Pathways (SSPs), IEA scenarios were modified to include constant non-fossil-fuel emissions from industry in 2018.
 †Approximate global mean temperature rise by 2100 relative to pre-industrial levels.
 *SSP5-8.5 replaces Representative Concentration Pathway (RCP) 8.5.

Figure 1. Shared Socioeconomic Pathways (SSPs) showing emissions until 2100 under different policy scenarios (Hausfather & Peters, 2020)

The precise magnitude of climate-related damages around the world is uncertain, even under specific emission scenarios. The physical risks are unprecedented, their materialization is path-dependent and uncertain, endogenous effects are at play, and are characterized by fat tails (Battiston et al., 2019; Chenet et al., 2019; Karydas & Xepapadeas, 2019; Weitzman, 2011).

Understanding the socioeconomic impacts of climate is even more uncertain than just estimating physical risk (Bingler & Colesanti Senni, 2020; *NGFS Climate Scenarios for Central Banks and Supervisors*, 2020). This type of analysis often comes with several assumptions about how governments, companies, investors, and individuals will react - where commonly used sets of assumptions are referred to as “Shared Socioeconomic Pathways” (SSPs) (Bingler & Colesanti Senni, 2020; O’Neill et al., 2017). Regardless of the assumptions, studies rarely comprehensively capture tipping points, feedback effects from physical to transition risks, socioeconomic responses such as changing preferences, economic sentiment, migration and adaptation, and other “unknown unknown” effects (*NGFS Climate Scenarios for Central Banks and Supervisors*, 2020). Tools fail to incorporate all their risk sources even though they are interdependent and reinforcing of each other (Bingler & Colesanti Senni, 2020). The interdependencies between economic and ecological systems make it challenging to integrate climate change in economic models (Bingler & Colesanti Senni, 2020). Understanding global welfare losses from temperature increases becomes unimaginable when considering regional and seasonal heterogeneity (Weitzman, 2011).

Despite this lack of clarity, few still question the significance of climate change. Political and economic changes have been taking place in response, from broad commitments to pioneering carbon pricing regulation.

Climate Transition

When it comes to the world taking action to transition, the IPCC has laid out overall economic milestones which need to be reached to limit global warming to 1.5 degrees Celsius. Whether through regulation or market forces, CO₂ emissions on average must be cut in half by 2030 and reach net zero by 2050 (*Summary for Policymakers — Global Warming of 1.5 °C*, 2019). This must come through a combination of lowering energy and resource intensity, decarbonizing the supply of said energy and resources, and carbon dioxide removal (Masson-Delmotte et al., 2019). These actions are expected to materialize through carbon prices and incentives to phase out fossil fuel use, as well as technology breakthroughs paired with increased spending on energy efficiency, electrification, renewable energy, and carbon removal.

As we remain perceiving climate change, economic development, and environmental protection so differently, it is unfeasible to know the extent to which we will respond to climate physical risk as well as how exactly we will transition to a lower-carbon economy. Taking action to mitigate climate risk, however, cannot depend on the accuracy and detail of scenario modeling. Waiting for better understanding fails because even the benchmark for said quality is unclear and because of the emergency and irreversibility of climate risks (Chenet et al., 2019). Despite limitations, models can improve theoretical understanding of economic climate relationships and can help by showing how changes in assumptions change policy and economic implications (Bretschger & Karydas, 2019). By exploring climate simulation tools such as En-ROADS, one can explore an indefinite number of pathways to reach the climate goals of the Paris Agreement. This enables scenario analyses of climate mitigation policies and economic actions - allowing different perspectives and assumptions to govern.

Financial Transition Risk

Climate change is a critical issue for finance because of physical risk but also because of how any transition would take place around the world. As discussed with policy and socioeconomic scenarios, how this transition will materialize is difficult to foresee (*NGFS Climate Scenarios for Central Banks and Supervisors*, 2020). This leads to a disorderly transition and instability of markets that currently underestimate climate-related financial risks (*Sixth Assessment Report — IPCC*, 2022). This is a key point addressed in the first ever IPCC assessment on *Investment & Finance*, within the latest report released on April 4th, 2022 (Group III of AR6). Despite initial efforts, it is highly uncertain whether or not the world will align financial flows with the Paris Agreement both in the short and long term (*Sixth Assessment Report — IPCC*, 2022).

Investors are exposed to transition risk when socioeconomic and policy changes affect their equities, loans, and bonds (Battiston et al., 2017). New information about climate change and climate policies results in changes in expected payoffs (Campiglio & Monnin, 2019). It is common to see asset prices adjusted following new climate policies being announced (Bingler & Colesanti Senni, 2020). On the equity side, cash flow and liquidation values are at risk. Looking at debt, interest rates and collaterals are sources of exposure (Campiglio & Monnin, 2019).

Stable, early, credible climate policies lead to no shock transition. Otherwise, financial impact is uncertain (Battiston et al., 2017). The more action is delayed, the more financial harm would come from shifting so many economic sectors to reduce their emissions in time (Gros et al., 2016; Roncoroni et al., 2021). Waiting increases the risk of a disorderly transition - when more aggressive changes are pushed with climate risk becoming more real and tangible. These would create economic shocks which would lead to financial crises, harm GDP, and thus impact individuals, governments, and industries at a much larger scale than an orderly transition (Battiston et al., 2017; Bingler &

Colesanti Senni, 2020; Gros et al., 2016; *NGFS Climate Scenarios for Central Banks and Supervisors*, 2020; Roncoroni et al., 2021).

In response, market-aligned policies might also become an important part of the transition to prevent financial crises (Chenet et al., 2019). One can expect central banks to make large-scale asset purchases, liquidity interventions, as well as implement tax credits, feed-in tariffs, rate recovery, construction or procurement mandates, grants, and other monetary policies like those implemented post-2008 (Chenet et al., 2019; Friedmann et al., 2020).

Investments and policies, in addition to the ways they react to each other, lay the foundation of how we will decarbonize - with both reacting to each other (Friedmann et al., 2020). While uncertain of how socioeconomic and policy changes will occur, we understand that the earlier we take actions to transition, the less it will cost to people, countries, companies, and investors (Battiston et al., 2017). Changes in policy, technology, and perception of physical risks will continue to prompt a systemic reassessment of costs and opportunities (Bolton et al., 2020; Brest & Born, 2013; Carney, 2015; *Sixth Assessment Report — IPCC*, 2022). Our interest in this research project is to explore how asset owners and asset managers are making sense of these uncertainties and disruptions, what risks and opportunities they perceive, and how their actions might affect the world more or less in pushing for the transition.

Research Questions

How do stakeholders in the financial market make sense of the climate transition, amid uncertainty and complexity?

Beyond growing perceptions of climate risk, we want to learn how asset owners and asset managers make sense of the climate transition - what they see as their risk, their role, and their goal. It is our objective to understand how the resulting perspectives then affect commitments, investment strategy, and decision making. Ultimately, we want to get a sense of how the climate transition is something investors react to, prepare for, or help drive.

How can we understand the integrated effects of investor actions in strategies under the Net Zero banner?

We want to delve into the mechanisms available to asset owners and asset managers to drive impact. Investors bring those together in various ways when they commit to bringing their portfolio to net zero emissions. The goal is to explore how some strategies can combine riding the wave with making the wave, by diversifying assets, mitigating systemic risk, and developing long-term sustainable practices. Pragmatically, we want to formalize the theory of how interactions occur by thinking with system dynamics and model integrated effects.

Qualitative Groundwork

To address the first research question, we undertook a mixed methods qualitative research project, drawing from a mix of archival and interview sources. Perspectives included academic scholars, financial institutions, coalitions of asset owners and asset managers, industry reports, and individual investors from the retail to the institutional level. The research included literature reviews, interviews, and observing participants in workshops. These efforts were concentrated in the first year of research but continued until the time of this writing as the field evolved.

Investor Journey Interviews

The individual interviews allowed us to deeper analyze an investor's journey or the expert perspective of a key informant. In a semi-structured format, we hoped to learn more about their own experiences in the investing world. For each interview, overarching questions were drawn on the following topics:

- Role and organization.
- Investment mandate.
- Perspective and approach towards climate transition.
- Perspective and approach towards net-zero goals.
- Positive investment experience(s) related to decarbonization efforts.
- Problematic investment experience(s) related to decarbonization efforts.
- Additional information related to promoting a low-carbon future.

Their insights informed our research on the risks perceived, role, and objective of asset owners and managers in climate-related investing. Every discussion was done maintaining notes, recordings, and transcripts confidential - thus we maintain anonymity when citing them and sharing quotes in the text below. The description of each interviewee cited with a code that can be found in Appendix A.

Twenty-four people interviewed:

- Ten network coordinators - labeled as COR-#
- Thirteen investors - labeled as INV-# from:
 - Family offices
 - Venture capital
 - Project finance
 - Institutional asset owners
 - Institutional asset managers
- One carbon-intensive corporate executive - labeled as EXEC-#

Participant Observation in En-ROADS Workshops

For the past two years, a series of workshops with family offices, pension funds, venture capital firms, and others were conducted to introduce the En-ROADS tool. Working with Jason Jay as the main workshop facilitator, I observed the participants as we shared a discussion around climate scenarios and high leverage actions. Investment analysts, portfolio managers, strategists, investment consultants, coalition builders, and even leadership at family offices were present. These workshops and discussions gave us further insight into how they understood climate science and where they saw the potential for investor action.

Eleven investor En-ROADS workshops, between 20 to 50 participants each:

- Intentional Endowments Network (IEN)
- Massachusetts Financial Services Asset Management (MFS)
- MIT's Renewable Energy Finance Roundtable (REF)
- CREO Syndicate US
- CREO Syndicate Europe
- Clean Energy Venture Group (CEVG)
- Investment Advisory Board, National Renewable Energy Laboratory (NREL)
- Group of family offices in Australia
- Prelude Ventures
- EFG Asset Management (EFGAM)
- Macquarie Group

Literature Review of Industry Reports

There are several organizations in the finance community organizing investor groups around climate-related issues. Those help investors align in principles, targets, and disclosure depending on the specific objective of the organization. We gathered reports which allowed us to get the latest quantitative information on carbon disclosure, ESG investments, venture capital allocations, shareholder engagement campaigns, as well as most recent commitments and strategy frameworks. Key examples are highlighted in the table below:

Table 1. Key examples of reports reviewed

Report Name	Organization
Climate Action 100+ Progress Update	Climate Action 100+
TCFD Status Report	Task Force on Climate-related Financial Disclosures
Taking Stock: A Global Assessment of Net Zero Targets	Energy & Climate Intelligence Unit
US SIF Trends Report	US SIF
Pathways to Sustainable Investments	CREO and Cambridge Associates
IPCC Assessment Report	The Intergovernmental Panel on Climate Change

Collection of Case Studies

Collecting stories of investors taking climate action - usually in the form of news. We built a wide range of case studies highlighting the actions of the different investor segments that we are not able to cover with interviews and observations. Examples of investors taking action were gathered across a wide range of approaches and mechanisms - such as shareholder engagement, capital allocation, and divestments. Using qualitative research tool NVIVO and library management software Zotero, these cases were organized by type of investor, approach, and where they were further described. These included reports, news articles, public letters, and interview transcripts. In addition, stories were collected of investors affecting all climate action “levers” as framed by En-ROADs. These examples of investor steering climate action were organized into a reference table that can accompany other En-ROADS workshop materials - as shown in Appendix B.

Qualitative Insights

The climate transition can be understood as a wave - a metaphor in which investors use different logics in response - resulting in them making the wave, riding the wave, or being hit by the wave.

In this analogy, being hit by the transition risk wave means not adjusting strategy in time and suffering financial losses from the political and macroeconomic changes described. Riding the wave means successfully accounting for these changes and risks, adapting strategies to avoid exposed carbon-intensive investments, and following new opportunities in the sustainable and responsible investment space. Making the wave, however, is staying ahead of macroeconomic changes and supporting a faster transition. Investors can drive impact through multiple mechanisms we will explore later and accelerate the implementation of policies compatible with a 1.5-degree future.

Investors have begun to use net zero as an overarching goal and justify their actions under that banner. But that term has interpretive flexibility between riding the wave and making the wave.

Climate finance goals have materialized in discussions about emission disclosures, ESG, and Net Zero. With the Glasgow Financial Alliance for Net Zero (GFANZ), a strong international framework is being set through which we hope to see the aggressive decarbonization necessary. There are different logics of justification behind certain approaches, some focused on reducing one's risk and others leaning towards driving impact. As a result, commitments are diverse, and often only pertain to one's portfolio. This means while we understand how isolated actions can ride or make the wave, it is challenging to understand what economic changes will be triggered under net zero strategies and what climate mitigation impact they can have.

The Wave

A pragmatic interpretation is that the climate transition can be understood as a wave, a metaphor in which investors use these different logics in response - resulting in them making the wave, riding the wave, or being hit by the wave. In this analogy, being hit by the transition risk wave means not adjusting strategy in time and suffering financial losses from the political and macroeconomic changes linked to public policy, changing consumer demand, and technological change. Riding the wave means prioritizing investment performance and adopting a portfolio risk mitigation logic. This means adapting strategies to avoid exposed carbon-intensive investments and following new opportunities in the sustainable and responsible investment space. An impact logic takes an ethical stand and wields the power of investors to change behavior and accelerate decarbonization - leading them to “make the wave” in this metaphor. It is important to note that making the wave does not sacrifice a risk logic - it means a shift from considering mostly portfolio risk to also thinking about systemic risk.

Collective investor action the way we observed can also come from collaborative constructions of shared values and guiding beliefs, beyond a rationalist risk or financial motivation, as exemplified by the “virtue” approach (McAdam, 2015). In the case of many endowments, for example, virtue means following public pressure from their constituents to divest from fossil fuels and high emitting assets - not driving impact unless it is done at a large enough scale to move asset prices or delegitimize companies in the political sphere. Alternatively, virtue can mean joining and leading efforts with other investors, helping these movements grow. These can be, for example, Climate Action 100+ campaigns, where shareholders do not divest but instead exercise engagement power to push companies to decarbonize - where risk, impact, and virtue logics are in play.

Getting Hit by the Wave

Companies at Risk

Companies can find themselves holding stranded assets - such as real estate, buildings, or equipment that had a sudden loss of value due to climate shocks in the economy and policy space (Battiston et al., 2017; Bingler & Colesanti Senni, 2020; *NGFS Climate Scenarios for Central Banks and Supervisors*, 2020). For example, consider the concentration of companies producing important materials on the gulf coast of the US in Texas and Louisiana. There are multiple steel, cement, and petrochemical production facilities southeast of Houston extending to New Orleans. These activities are heavy in emissions and often still depend on inexpensive coal and oil. A sudden policy reaction, due to a change in congressional seats or public pressure, might impose a tax on carbon emissions, costly regulations on the use of fossil fuels, or a full ban on coal. This can occur at the same time as insurance companies decide, with new climate reports, that they are not charging enough flood risk premiums for coastal properties considering new sea-level rise forecasts. Under this scenario, these companies might not be able to operate these gulf coast facilities without significant losses. They might be able to increase prices on its materials sold, but only if its competitors are also exposed to the same amount of risks and increased costs. In a worst-case scenario, the companies are liable for these assets but cannot find a buyer to liquidate them anymore. In a quick shift, much of the assets' value gets stranded and lost or many go through fire sales (Campiglio & Monnin, 2019).

This also becomes a problem for the companies supplying fossil fuels. Fossil fuels will be unburnable in most markets without expensive carbon capture technology (Brest & Born, 2013). It is estimated that in a 2-degree economy, this will mean around 82% of global coal reserves, 49% of global gas reserves, and 33% of global oil reserves are stranded (Battiston et al., 2017).

The challenges for companies do not stop there. Despite being more affordable, even preventing such shocks can lead to more spending and reduced revenue to fund a smoother transition. They might also face other risks, such as being liable for past cumulative emissions and pollution - something we might see companies and their insurers start to pay for in the future (Brest & Born, 2013; *NGFS Climate Scenarios for Central Banks and Supervisors*, 2020). This leads to firms with climate concerns paying higher insurance costs and being expected to pay higher returns to equity investors (Campiglio & Monnin, 2019; Chang, 2016). Climate transition risks for companies also go much beyond their own emissions and participation in climate-harming activities (Flammer et al., 2021). The combination of physical risk, transition risk, and liability risk through the entire economy can hurt supply chains, resource costs, economic growth, consumers, and thus any company's cash flow and its ability to pay interests and dividends to investors (Campiglio & Monnin, 2019; Gros et al., 2016). This could drastically reduce the company's equity value, increase its cost of capital, and even lead to shareholder exits or new loans being denied. It is challenging to estimate how far companies would have to go to mitigate all these risks with the least costs under uncertain climate scenarios (Campiglio & Monnin, 2019).

Investors at Risk

The described ways in which climate can affect companies extend to all investors. When returns and interests are not risk-adjusted, investors might find themselves facing significant losses when policy and economic shocks hit the market. The value of bonds and equities can crash, as well as an organizations' ability to pay dividends and interests. In some situations, even the value of liquidating assets or of the collateral on a loan can be affected if they become stranded (Campiglio & Monnin, 2019; Chenet et al., 2019; *NGFS Climate Scenarios for Central Banks and Supervisors*, 2020).

There are tools that allow the financial system to identify drivers of climate-related instability and which improve their ability to design and implement measurements (Battiston et al., 2019). Efforts to address financial risk, closely aligned with large financial institutions and central banks, include the Network for Greening the Financial System (NGFS) and the Taskforce for Climate-related Financial Disclosures (TCFD) (Bingler & Colesanti Senni, 2020; *NGFS Climate Scenarios for Central Banks and Supervisors*, 2020; "The Rise of the Taskforce for Climate-Related Financial Disclosures (TCFD)," 2021). Climate policy exposure started being priced by banks in 2015 and efforts in credit risk analysis are still working to better account climate risks, which is essential, especially for those issuing loans, bonds, and insurance (Campiglio & Monnin, 2019; Monnin, 2018). It is important to recognize where disclosure is now mandated by central banks and government regulatory boards. These efforts can quickly improve investor access to information and ability to assess risk better, while potentially presenting costs to companies not ready to gather all data necessary for reporting or to expose a lot of emissions not previously made public (Flammer et al., 2021).

A variety of scholars are looking at these efforts or estimating themselves how much risk investors are exposed to, but recognize the limitations of this area of work (Battiston et al., 2019; Huang et al., 2019; Karydas & Xepapadeas, 2019; Monnin, 2018; Pastor et al., 2020). Many investors are finding

themselves stuck with large disclosure datasets, ambiguous climate models, and wanting more accurate granular information of where their markets are going (COR-1, personal communication, January 22, 2021). Climate risks are both endogenous and systemic. Radical uncertainty is involved, so an efficient climate risk price is not discoverable. The probability of different outcomes is impossible to calculate despite the significant efforts described (Chenet et al., 2019). Discounting rates for future climate risks are not straightforward and small changes mean significant changes in what strategies make sense today (Weitzman, 2011). It is expected that financial agents won't fully internalize others' reactions to shocks, which would amplify damages (Roncoroni et al., 2021). Many compare the potential climate financial crisis to the 2008 financial crisis when it comes to foreseeing effects and reactions (Roncoroni et al., 2021). Transition risk may materialize in ways that are difficult to foresee when economic sentiment around it and other market amplification mechanisms can lead to significant transition shocks (Bingler & Colesanti Senni, 2020; *NGFS Climate Scenarios for Central Banks and Supervisors*, 2020). Since all announced and implemented policies so far are not considered enough to mitigate climate risk, full climate transition risks are also likely not considered yet (Bingler & Colesanti Senni, 2020). Some studies show the impact of the Paris Agreement on asset pricing as they consider carbon emissions more, but other studies show these adjustments are far from adequate for constantly emerging climate financial risks (Bingler & Colesanti Senni, 2020). The Network for Greening the Financial System highlights the following as risks all world's financial markets and investors are exposed to because of transition shocks:

- Invested capital depreciation
- Defaults by businesses and households
- Collateral depreciation
- Insurance losses
- Increased underwriting
- Refinancing risk

- Increase demand for liquidity

“Most equity markets don’t understand that the climate is non-linear, accelerating, and complex. So the risk is underpriced.” - “This will be the most complicated analysis I will do in my career. And I will do it wrong.” (INV-4, personal communication, September 2020)

Riding the Wave

Mitigating Portfolio Risk

“We want companies to make smart investments on a risk adjusted basis.” (INV-4, personal communication, September 2020)

Combining climate uncertainty with policy uncertainty, tackling transition risk has become one of the biggest tasks for any portfolio manager (COR-2, personal communication, March 8, 2021). Many investors find themselves today knowledgeable of the financial climate risks as discussed here and thus, to different extents, are implementing risk mitigation strategies (COR-2, personal communication, December 17, 2020). As stated before, significant progress in this direction has been made by institutions worldwide starting with understanding risks better. Even when not mandated by central banks and governments, investors and companies have voluntarily signed onto global efforts to improve disclosure - the Task Force for Climate-related Financial Disclosures (TCFD) and the Climate Disclosure Project (CDP). From the perspective of companies, improved disclosure can lead to improved valuations while for investors it enables more effective and targeted shareholder engagement (Flammer et al., 2021). Better disclosure also leads to better perception of systemic transition risk which reduces the delay of how markets react (Gros et al., 2016).

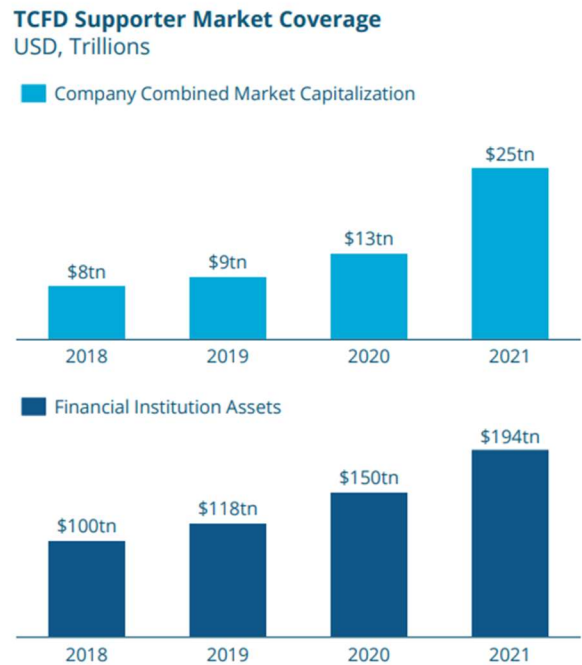


Figure 2. Market coverage of TCFD support from 2018 to 2021 (TCFD | Whats New in 2021, 2021).

“Having disclosure brings accountability to take action. It might not be efficient to drive impact but it is a step in the right direction.” (COR-10, personal communication, November 23, 2020)

The more risks are understood, financial institutions such as banks and insurers can appropriately adjust credit ratings, risk factors, and premiums charged. There is a growing consensus to find ways to penalize economic activities incompatible with decarbonization scenarios (Chenet et al., 2019). Some of the most frequently discussed actions are divesting from fossil fuel assets and stopping lending and insuring certain power plants and mining operations (Bingler & Colesanti Senni, 2020). This movement involves a significant amount of public pressure on banks, endowments, and other institutional investors with high visibility (Cometto, 2021; E360 Digest, 2020; Potter, 2019).

Removing one’s assets from high emitting industries and activities can be an effective way to reduce its own risk. (*NGFS Climate Scenarios for Central Banks and Supervisors*, 2020; Taylor, 2020). When it comes to certain industries and operations, such as oil and coal production, there is a growing understanding that they have no viable future if we are to reduce global warming to safer levels than current projections (INV-13, personal communication, October 21, 2021; Rogelj et al., 2021; Taylor, 2020). The bigger companies in this space, with a lot to lose, are currently juggling vague decarbonization promises and significant lobbying efforts to prevent climate policy or regulation from materializing into losses and stranded assets (INV-4, personal communication, September 2020; G. F. Jessop Simon, 2020). When it comes to these cases, divesting, screening these companies out of funds, and stopping financing new projects are less disputed actions among climate-conscious investors (COR-3, personal communication, November 23, 2020; COR-7, personal communication, December 22, 2020).

Tapping into New Opportunities

As investors perceive climate risks and mitigate their own risk by “cleaning” their portfolio, they also shift assets to new opportunities rapidly emerging. Renewable energy projects and electric vehicle securities are not alternative investments anymore and have become mainstream (INV-10, personal communication, November 23, 2020). Thematic investments became a widespread mechanism for individual retail investors all the way to institutional asset owners. As investors seek greener portfolios they can signal the market, improve the valuation of green investments, and enable companies already doing well environmentally to do more (Heeb & Kölbl, 2021).

In the space of ESG investing, climate-related attributes have been the center stage for screening out equities to build fossil-free funds, for referencing venture capital investing, and even for the creation of green fossil-free bonds (INV-4, personal communication, September 2020; Stevens, 2021). Several Exchange-Traded Funds (ETFs), also have attracted a lot of attention to groups of securities in the wind and solar energy, electric vehicles, and decarbonizing international markets (Bloomberg Intelligence, 2021).

Falling Short

“Major US institutions in their risk department say that climate is a long term risk, and don't need to act without regulation.” (COR-1, personal communication, December 1, 2020)

Companies are still falling short on their climate-related disclosures even though a majority of their investors are committed to align disclosures with TCFD recommendations (*Climate Action 100+ | Progress Update*, 2022). Climate disclosure comes with costs to companies - both to execute it but also from potential valuation shocks because of higher emissions reported. This creates short-term obstacles for improving disclosure despite long term potential value (Flammer et al., 2021).

Relying on disclosure efforts improving in the short term, the described investor strategies for mitigating financial risk may be the best approach to protect one's portfolio against climate damages, liabilities, and transition shocks in the economy. Divesting and reallocating capital to carbon-free investments are considered viable and sometimes critical for the economy to transition with reduced risk (Cometto, 2021; G. F. Jessop Simon, 2020). This approach, however, comes with costs and diminishing effectiveness the more passive it is, even if climate-related disclosures significantly improve.

Themed investing and screening as a solution can be harmful to returns, have limited risk mitigation effects, and might not be an option for all investors (Heeb & Kölbl, 2021; Mankikar, 2010; Pastor et al., 2021; Quigley, 2020). Problems arise as investors raise the threshold on how “green” their assets must be. The more one portfolio avoids equities in emissions or a bank refuses to issue debt to carbon-emitting projects, it loses diversification and becomes tied to fewer industries and companies (Bingler & Colesanti Senni, 2020; Pastor et al., 2020). Lower diversification increases risk which is not always compensated for with higher returns (Pastor et al., 2021). It is clearer now that in the last decade green funds and bonds outperformed comparable traditional ones (Pastor et al., 2021). It is however not

expected that the past performance of said funds indicates the same performance in the future. Their increase in value is heavily correlated to shocks coming from news about climate change and from the shift in investor preferences towards cleaner investments despite lower returns (Pastor et al., 2021). In other words, what led to a better performance of green investments was not necessarily the real performance of the assets in question. With more investors leaning towards green bonds and equity to reduce their climate risk, the market is expected to balance said interest with lower expected returns for green assets. This can be financially harmful to all who could be making more money with more diversified portfolios.

This investor shift - away from high emitting assets and towards green ones - also decreases ownership diversification of these more undesirable investments. This is understood to increase the expected returns of the more risk exposed assets, still under-evaluating climate risk but attracting more climate-agnostic investors to take over these equities, loans, bonds, etc. (Bingler & Colesanti Senni, 2020; Chenet et al., 2019; *NGFS Climate Scenarios for Central Banks and Supervisors*, 2020; Pastor et al., 2020). The last decade has shown that private equity comes to buy less desirable dirtier assets that public companies and investors divest from (Tabuchi, 2021). Consequently, high polluting assets and activities remain running, exempt from mandated disclosures and public pressure to divest (Tabuchi, 2021). Thus systemic risk of financial markets is not significantly reduced, as vulnerable assets are still traded, just by different investors (Campiglio & Monnin, 2019; INV-4 and INV-5, personal communication, October 26, 2020; Tabuchi, 2021). For these reasons, it is still hard to find evidence of divestments leading to any changes in company behavior and emission beyond cleaning one's portfolios (Kölbel et al., 2020).

“It (divestment) is definitely an issue. We will need regulation and policy. There will always be a buyer.” (COR-7, personal communication, December 22, 2020)

Purely risk mitigation strategies also lead investors to move away from high emitting industries which we cannot currently function without (*Climate Action 100+ | Progress Update, 2022*; EXEC-1, personal communication, December 17, 2020; INV-1, personal communication, February 3, 2021; INV-4 and INV-5, personal communication, October 26, 2020). For example, technologies that allow air transportation and metals production to be carbon-free are still further from being commercially available compared to the options available to energy production, healthcare, information technology, and ground transportation (*Climate Action 100+ | Progress Update, 2022*). Financial markets will need to in some way still own trade-related assets - even if state-run enterprises are in question and central banks are the asset owners (*Climate Action 100+ | Progress Update, 2022*; EXEC-1, personal communication, December 17, 2020; INV-1, personal communication, February 3, 2021; INV-4 and INV-5, personal communication, October 26, 2020).

Lastly, for larger investors, these risk mitigation and portfolio shifting strategies are not an option. Many institutional investors often have highly diversified and long-term portfolios which represent global markets (Mankikar, 2010). Making selective exclusions and exiting certain industries is not an option, meaning their portfolios are inevitably exposed to growing and widespread costs from environmental damage caused by companies (Mankikar, 2010). These are often public pension funds, central banks, or endowments. In the US public asset owners were for a long time discouraged from considering ESG metrics while in most of Europe they are required to (Tomlinson, 2016). To mitigate risk, these investors find themselves with no options but to also strategize for impact and think about the well-being of the global economy (Quigley, 2020).

Making the wave

The risk reduction and opportunity-seeking strategies described so far are only making investors ride the wave but not make any of it. Riding the wave relies on others to actually push changes and take the next actions necessary for a safer decarbonized future. As discussed previously, current climate regulations, policies, and government commitments alone are still far from triggering enough changes to reach the Paris Agreement goals (Huang et al., 2019). Finance has a role to play through aligning value and growth in markets with global climate goals, not necessarily sacrificing risk-adjusted returns which can still be prioritized (INV-4 and INV-5, personal communication, October 26, 2020; INV-11, personal communication, February 11, 2021).

“We sell market-rate and risk mitigated portfolios first - then climate benefits” (INV-11, personal communication, February 11, 2021)

Every year more investors are attempting to break this apparent trade-off between impact and risk mitigation. Investor impact can be understood as the changes one makes in the impact of companies, projects, and other economic activities. (Kölbel et al., 2020). Asset owners and asset managers can make the wave by influencing policy and the private sector which can then lead to the necessary economic transitions. Already 615 investor signatories representing \$65 trillion assets under management have signed onto the Climate Action 100+, pledging to use their shareholder power to influence the highest emitting companies to disclose and decarbonize (*Climate Action 100+ | Progress Update*, 2022). Coalitions of investors have lobbied legislators for mandating climate-related risk disclosures and directing incentives for environmental issues (Humphreys et al., 2012). Broadly speaking, asset managers and asset owners can invest or divest capital, exercise governance power through shareholder engagement, and exercise political power. These actions have an impact, however, only under certain conditions (Kölbel et al., 2020). For example, while divesting capital from “gray”

companies in liquid capital markets is unlikely to affect either share price or firm behavior, investing incremental capital in inefficient capital markets, or using shareholder power to influence corporations can be significant in changing a firm's or sector's emission and climate policy (Kölbel et al., 2020). In different ways, investors can tie a company's equity value or access to capital to new climate-related preferences - turning them into the company's interest as well (INV-4 and INV-5, personal communication, October 26, 2020).

“The sooner companies strategize decarbonizing the more they are likely to win.” (INV-4 and INV-5, personal communication, October 26, 2020)

Some large asset owners and managers - who are unable to diversify away from systemic risks like climate change - have adopted a "universal owner" perspective. This means recognizing that making selective exclusions and exiting certain industries is not certain to prevent growing and widespread costs from environmental damage caused by companies (Battiston et al., 2017; Mankikar, 2010). Assuming said ownership risk with emitting industries and activities our economy depends on, means all investor channels of influence can be used to push them to decarbonize as fast as possible. They can make the wave by shifting capital requirements, valuations, and even carbon pricing mechanisms which in aggregate can accelerate decarbonization for all economic sectors. This is only financially harmful if invested companies fail to change regardless of investor pressure. Additionally, those not divesting can also demand higher expected returns for these increased risks (Heinkel & Zechner, 2001).

“We should dive into the wave in the first place rather than waiting to be washed away by the wave.” (INV-8, personal communication, December 12, 2020)

The most common examples of institutions that adopt this “Universal Owner” perspective are pension funds, endowments, insurers, and some family offices with legacy funds (COR-3, personal communication, November 23, 2020; INV-8, personal communication, December 12, 2020; INV-10,

personal communication, November 23, 2020; Mankikar, 2010). The largest asset owner in the world, Japan's Government Pension Investment Fund (GPIF), is an important example of that with its \$1.56 Trillion in AUM as of Q3 2021 (*GPIF Q3 2021*, 2022). GPIF is required by law to maintain a large share of passive investments covering the entire Japanese market - regardless of industry and emissions (INV-8, personal communication, December 12, 2020). Despite this limitation, the pension fund pushed for improving climate-related disclosures and risk analysis adopted strong ESG preferences for equity investments and joined in active engagement campaigns as part of Climate Action 100+ (*Analysis of Climate Change-Related Risks and Opportunities in the GPIF Portfolio*, 2020). Similar logic has been used by institutions like Calpers, Calstrs, MIT's endowment, and even the UK government as it urged pension funds not to divest (Cumbo & Flood, 2022). As asset owners define their climate strategy and make these decisions, we also see asset managers and financial institutions working with them to reflect their approach (INV-8, personal communication, December 12, 2020).

“First thing is to engage with portfolio companies to make them aligned with net zero. Second thing is to look back and engage with asset owners who give mandates to us, to change the mandate to be aligned with net zero. We are in the middle of the investment chain. Portfolio companies, asset owners. Need to deal with both ways.” (INV-8, personal communication, December 12, 2020)

As the CEO of BlackRock, Larry Fink, argues in his annual letters to company CEOs, it is their duty as fiduciary to their investors - retail or institutional - to not divest but focus on ESG and engagement (L. Fink, personal communication, 2022). Questions remain on the extent they are trading off divestment to push strongly for decarbonization with their shareholder power, or if this logic is mostly being used to delay action and justify passive climate-related strategies. For example, BlackRock in the last year has justified many proxy voting decisions on climate-related grounds but many argue that it still approves corporate climate action plans which are not strong enough to meet the decarbonization goals it states

support for (*BlackRock Must Take Bold Action to Lower Global Emissions.*, 2021; Bradford, 2021; Reclaim Finance, 2021).

Net Zero

“Our decision was that all the winds are moving into net zero.” (INV-8, personal communication, December 12, 2020)

Investors have been evolving their approach to climate quickly in the last few years, but often it is not clear who wants to ride the wave and who wants to make the wave. To benchmark themselves and companies, net-zero commitments and coalitions have come to the center stage of discussion in climate finance worldwide. Net Zero alliances for both asset managers and asset owners are taking the lead in the paths to decarbonizing portfolios. Convened by the UN, the Net Zero Asset Owner Alliance continues to grow and set GHG emission reduction targets through 2050 - with 70 institutional investors with \$10.4 Trillion in AUM already in alignment at the time of this writing (About the Alliance – United Nations Environment – Finance Initiative, 2022; New Protocol Binds Net Zero Asset Owner Alliance to Halve Portfolio Emissions by 2030 – United Nations Environment – Finance Initiative, 2022). At the same time, the recently formed Net Zero Asset Managers Initiative already connected 236 signatories with \$57.5 Trillion AUM (*The Net Zero Asset Managers Initiative – An International Group of Asset Managers Committed to Supporting the Goal of Net Zero Greenhouse Gas Emissions*, 2022).

Most recently, around COP26, the Glasgow Financial Alliance for Net Zero (GFANZ) was formed. Bringing together all other initiatives and groups, this sector-wide coalition hopes to accelerate and improve net zero efforts worldwide. The alliance includes not only asset owners and asset managers, but also insurers, banks, other financial services providers, and investment consultants. In February 2022, GFANZ already grouped 450 financial firms across 45 countries and represented a total AUM of over \$130 Trillion (*About - Glasgow Financial Alliance for Net Zero*, 2022). The alliance is working to improve net zero strategies by incorporating sector pathways, economic transition plans, financial

transition plans, portfolio alignment measurements, private capital mobilization, policy advocacy, and solidifying commitments.

Investors are pushing and expecting net zero strategies and commitments to be made by companies, especially after COP26 and the formation of GFANZ. From 2018 to 2021, the number of companies targeted by CA100+ and committed to net zero by 2050 went from 5 to 111 (*Climate Action 100+ | Progress Update, 2022*). Energy and utility companies are committing to exit from natural gas and be net zero by 2040 and there are even refiners making progress on emissions reductions targets (*Climate Action 100+ | Progress Update, 2022*). Companies are voluntarily putting their net zero plans to shareholder votes, setting capital allocation targets, and aligning their lobbying activities to match (*Climate Action 100+ | Progress Update, 2022*).

Making net zero commitments, even if vague, can be a step in the right direction to mitigating risks of being “left behind.” Net zero by 2050 is also critical for any climate stability goal - the IPCC has also shown how halving emissions every decade from now on is essential for us to limit warming to 1.5 degrees Celsius (Friedmann et al., 2020). Despite guidelines improving, however, the granularity of commitments and plans seems to vary wildly case by case. Some discuss only CO2 emissions while others encompass all GHG emissions in their targets (Rogelj et al., 2021). Not enough attention is being paid by investors to how different sectors of the economy need different timelines for decarbonization, some earlier and some later than 2050 (*Climate Action 100+ | Progress Update, 2022*; Rogelj et al., 2021). This comes also because slight changes in scenario forecasting mean differences in sector decarbonization timelines which have significant implications considering the lifetime of physical assets (Bingler & Colesanti Senni, 2020). Sector-specific targets also raise the question of what is fair to expect considering different decarbonization costs to different industries and different countries (Rogelj et al., 2021). Overall, even less attention is given past the net zero benchmark -

cutting down emissions to this level is a zero-sum game, while in reality, we should look at all sectors and countries to be net-negative in the future (Rogelj et al., 2021).

Considering public pressure, commitments are being made without strategies fully being fleshed out. This is relevant for countries, investors, and companies, as setting net zero targets has become a frequent topic of discussion in shareholder engagement campaigns and international climate conferences as well (Rogelj et al., 2021). Portfolios can become Net Zero, for example, by simply exiting from any high emitting assets and purchasing carbon credits to offset the others - effectively “riding the wave” and not pushing any activity to decarbonize. In contrast, investors can maintain their current positions and use their shareholder power to move all their assets to truly decarbonize - “making the wave” by pushing changes that would not necessarily happen otherwise. As international governance over net zero improves, the challenge becomes understanding what individual institutions are implementing, the range of strategies, and how effective they are at mitigating risk as well as driving change.

Mechanisms for Investor Action

With our exposure to investment decision-makers and qualitative research, we understand most mechanisms for investor action as justifiable in different ways. The following table shows these logics of justification both looking at an action’s impact on portfolio performance - riding the wave - as well as its impact on the climate transition and systemic risk - making the wave. The table’s color-coding shows how we interpreted each justification as poorly empirically studied or well-studied - either seen as strong and effective or weak.

Table 2. Logics of justification for different investor actions:

Green for well-studied and strong; **Red** for well-studied and weak; **Gray** for poorly studied

	Logics of justification	
	Ride the Wave (impact on portfolio performance)	Make the Wave (impact on societal transition and systemic risk)
Thematic Investment	Reduce long term risks and get returns from sustainable industries	Attract attention and reduce cost of capital for sustainable industries
Shareholder Engagement	Improve company and investment value	Drive corporate decarbonization and improved performance relative to climate
Flexible Capital Provision	Tap into returns from underinvested growth industries and geographies	Increase capital availability to accelerate clean technology adoption and decarbonization
Emissions Alignment of Lending and Insuring	Compensate higher risks of assets being stranded or defaulting	Increase cost of capital and slow or even stop high emitting industries from developing new projects and growing
Equity Divestment	Protect from high long term risk investments and stranded assets	Reduce high emitting assets’ value as it catalyzes other investors to do the same
Non-market Signaling	Improve systemic understanding of risk and attention other stakeholders give to climate	Improve mandated disclosures to enable engagement better

Thematic Investment

Asset managers and banks have spent the last decade adapting their services to the reality of climate change and to the interests of asset owners by increasingly providing more investment opportunities that fit certain thematic categories. The space of Sustainable and Responsible Investing (SRI) broadly includes any investment that considers both financial return and social/environmental good. This is taking place both in equity with thematic indexes and funds, as well as in fixed income with green and social impact bonds - often with competitive market-rate returns.

The Sustainable and Responsible Investing Forum highlights key descriptive information about investments being made that fit certain thematic categories, mainly in Environment, Social & Governance (ESG) issues. Out of all \$46.6 trillion of U.S. professionally managed assets (AUM) at year-end 2017, 26% (\$12 trillion) fit its SRI categorization (The Forum for Sustainable and Responsible Investment, 2018). Within ESG criteria, climate change was a top issue directly linked to \$2.24 trillion of institutional assets (The Forum for Sustainable and Responsible Investment, 2018). ESG-guided investment strategies “have largely outperformed” conventional indexes in, for example, passive exchange-traded funds (ETFs) (“A Tipping Point in ESG ETFs?” 2020). In line with tapping into these opportunities, global ESG assets are on track to exceed \$50 Trillion by 2050 after surpassing \$35 Trillion in 2020, so far mostly managed in Europe (Kishan, 2022). Just in 2021 assets in sustainable mutual funds and ESG ETFs, available to retail investors, rose globally by 53% to \$2.7 trillion while “sustainable debt” saw another \$1.6 Trillion being issued - bringing the total size of this market to \$4 Trillion since inception (Kishan, 2022).

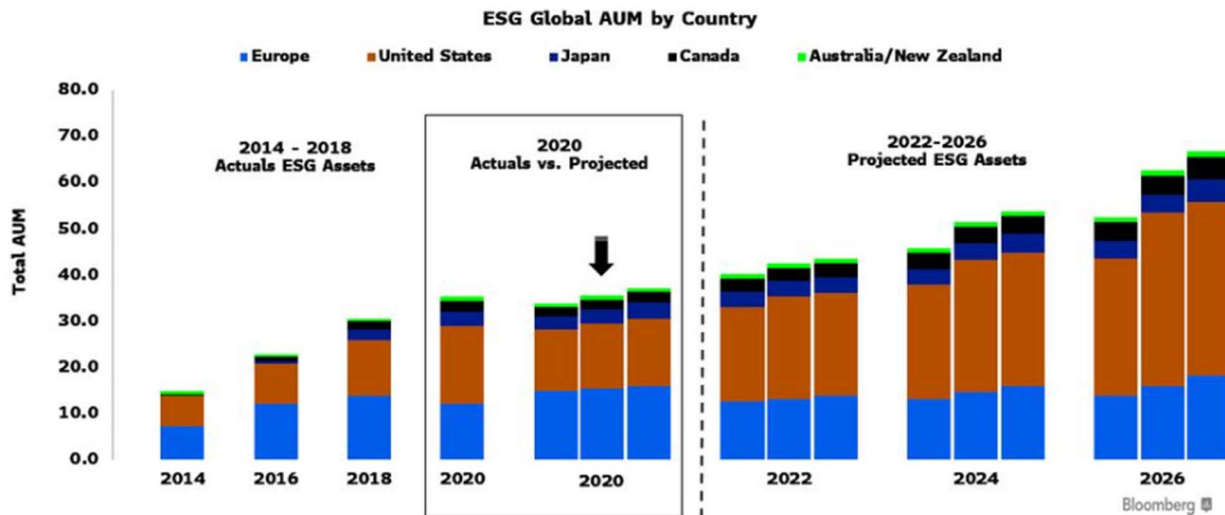


Figure 3. ESG Global AUM by Country (Kishan, 2022)

Adapting funds and bonds to fit within “green” or ESG criteria is not always simple. According to an ESG integration expert at a large pension fund, more often than not when institutional investors buy ESG data they have trouble figuring out how to analyze it in a way it can inform their investment decisions (INV-10, personal communication, November 23, 2020). This leads to many relying on 3rd party ESG metrics, which have been found to be divergent at the least (Berg et al., 2020). When facing these barriers, it becomes a challenge for investors to not only integrate ESG but to adapt their material strategy, evaluate companies with carbon in mind, and move away from conventional performance indexes that have been well established (COR-4, personal communication, December 1, 2020).

Allocating capital thematically can certainly reduce a portfolio’s exposure to transition risk as well as let opportunities in new industries be capitalized. However, when it comes to driving impact, this approach depends on a significant share of the market to value how “green” an asset is or how well it performs in ESG in alignment. Because ESG metrics being used have a very low correlation with each other, the non-financial worth they try to capture is not materially reflected in asset value (Heeb & Kölbel, 2021).

“Qualitative information is useful as well and investors don’t always go to deep into the data or quantitative models - especially in active management investments” - “It’s the problem of focusing on data and losing the wisdom.” (INV-9, personal communication, November 23, 2020)

Shareholder Engagement

Investors can exercise influence by engaging companies as their shareholders (Kölbel et al., 2020). A widespread theme in engagements is the effort to improve GHG emissions disclosure of all assets. This first allows investors to understand portfolio emissions and transition risk. This can help investors mitigate risk under a “ride the wave” logic but can also be impactful because it allows them to better pressure their holdings and industries to decarbonize. In alignment with active ownership goals, 870 institutions are also signed up in support of the UN's TCFD initiative. Both the US and the UK are headquarters for 159 of these public and private organizations. Europe however is the leading region for signatories, with 394 institutional supporters of TCFD. Worldwide, asset management organizations correspond for more than half of organizations (455), followed by banks (123), and pension funds (93).

There is already concrete empirical evidence that investors, as shareholders, can engage with corporations on ESG issues with significant results - both to mitigate risk and to drive impact (Kölbel et al., 2020). When exercising governance power through continuous engagement, communicative action, and relationship-driven interactions, investors have been able to push corporations toward climate-related financial disclosures and subsequently climate impact through net zero targets and technology development (Ferraro & Beunza, 2018). Shareholder engagement can also be a strong tool to intervene in companies that might - concerning high emissions - have inferior governance, operational efficiency issues, reputational concerns or stigmatization, and high climate-transition risk. Not only are successful engagements in these situations more likely, but companies that have gone through this process on environmental and social issues have shown improved financial performance and institutional ownership afterward (Dimson et al., 2015).

Active private investors as shareholders historically have had less influence in passing resolutions than larger institutional investors (Gillan & Starks, 2000), so high net-worth individuals and families are also resorting to other channels of impact. Retail investors can often indirectly participate in engagement efforts by allocating capital with larger asset managers with commitment and the potential to act themselves. A recent study focused on the effect of shareholder engagement with the “Big Three” asset managers - BlackRock, Vanguard, and State Street Global Advisors (\$16 Trillion assets under management and 20% of the shares of the S&P 500) (School, 2021). It found that the higher the carbon emissions from one of the eight thousand global firms analyzed, the more likely the “Big Three” were to engage around ESG issues. Most importantly, it found that the higher the ownership by these asset managers, the higher were the CO₂ emissions reductions (Azar et al., 2020). In some cases, however, even smaller investors have been able to negotiate and build coalitions with other investors to increase their influence in shareholder campaigns. In 2021, small hedge fund Engine No 1 was able to push one of the most aggressive climate shareholder resolutions to date with ExxonMobil by bringing larger institutions on board with them. With only holding 0.02% of assets, the activist fund tapped into disappointed shareholders and successfully argued for deep changes to the company structure starting with the board and higher-level strategies (Brower & Aliaj, 2021).

Examples of shareholder engagement on climate issues:

- ArcelorMittal is a steel and mining company headquartered in Luxembourg. Engagement with the company was led by Aegon, LAPFF, and Ruffer, and coordinated by IIGCC. Beyond general decarbonization and other similar goal setting, one of the results was the commitment to transition into clean steel making using electricity generated from renewables and hydrogen as an energy carrier and reducing agent. This approach electrifies the overall process and eliminates the need for coal and natural gas (*CA100+ 2020 Progress Report*, 2020).

- State-run power giant NTPC and upstream oil firm ONGC have planned to boost the development of offshore wind energy in India. The agreement aims at 60GW offshore wind capacity built by 2032 (NTPC, ONGC to boost development of offshore wind energy, Jul 2021). Even though the companies are majority state-owned, these companies were engaged through a Climate Action 100+ campaign - led by SBI Funds Management Private Limited and supported by the AIGCC and the PRI (*CA100+ 2019 Progress Report*, 2019).
- AkademikerPension, along with three other funds representing a total AUM of \$235 billion, approached Toyota after it was falling behind fuel efficiency standards and was politically opposing new regulations in the US. Toyota has since stopped undermining climate policies and has been investing more in efficiency improvements (Sheldrick, 2021).
- Like many consumer goods products, Nestle's most significant emissions come from its supply chain and product distribution. Nestle can have a big impact on optimizing its transportation emissions even when the distribution is conducted by another company (scope 3). The Climate Action 100+ engagement with Nestlé has been led by Ethos Foundation and APG Asset Management, along with 18 other collaborating investors. The company has since set targets related to disclosure and committed to net-zero by 2050 including its scope 3 emissions (*CA100+ 2019 Progress Report*, 2019).

Flexible Capital Provision

A wide variety of investors, from high net-worth individuals to project financing organizations in the private or public sector, can directly place capital, at multiple stages, in companies and/or technology that might help combat climate change. An investor can drive impact when it focuses on gaps not filled by the market today, considering the existing thematic investing. This can mean scaling renewables in underfunded regions, providing flexible capital to develop carbon capture technology, supporting more electrified and energy-efficient infrastructure, and funding “greener” corporations to gain market share.

“Infrastructure investors have become significant sources of capital in well proven areas of solar, wind and other large scale projects, supplemented by subsidies and cost advances from technology.” (INV-1, personal communication, February 3, 2021)

Within the landscape of capital placement for the development and deployment of clean technologies, prior analyses have identified two critical arenas where more investment may be needed, corresponding to two “valleys of death” (Monk et al., 2015). The first “innovation valley of death” helps bridge between government financing of basic science and the commercial development of technologies. Efforts like the PRIME Coalition work to catalyze this kind of investment, for example, with first-loss high-risk capital deployed by foundations and family offices. The second “commercialization valley of death” addresses the difficulty in securing project or equipment finance in the early stages of deployment when perceived technology risk is high. An “aligned intermediary” - a mechanism for helping long-term institutional investors place capital in resource innovation ventures - was proposed to enable this type of project financing (Monk et al., 2015).

“Prime is purpose-built as a public charity to absorb disproportionate risk(s) that finance-first investors cannot. We are able to go earlier and riskier than others, but aspire to do so with terms

that will "crowd in" finance-first investors, while also holding each portfolio company or project accountable to our impact-first mission." (S. Kearney, personal communication, May 2, 2022)

Because of the flexible decision-making structure of high net-worth individuals, foundations, and families, they are able to frequently evolve their investment mandate to fill in the gaps described (COR-3, personal communication, November 23, 2020). These private investors are working with venture capital, growth equity, late-stage private equity, project finance, and public market strategies on sustainability sectors such as cleantech, afforestation, and energy transition (COR-3, personal communication, November 23, 2020).

"We are on the borderline of what a CIO can reasonably see against the concessionary philanthropy capital." (COR-3, personal communication, November 23, 2020)

By September 2020, PWC estimates that globally at least \$60 Billion is invested in early-stage technology aimed at a net zero transition (*Climate Tech Investment Grows at Five Times the Venture Capital Market Rate over Seven Years*, 2020). Although cleantech only represented 6% of the venture capital market in 2019, it saw growth from \$418 Million to \$16.3 Billion per annum from 2013 to 2019 (*Climate Tech Investment Grows at Five Times the Venture Capital Market Rate over Seven Years*, 2020). The distribution of all these funds is heavily skewed towards the US (\$29 Billion) and China (\$20 Billion), followed by Europe (\$7 Billion) (*Climate Tech Investment Grows at Five Times the Venture Capital Market Rate over Seven Years*, 2020). Looking at global climate technology investments is important as efforts must be made towards expanding electrification, decarbonizing the energy supply, and improving energy efficiency in emerging markets just as much as in developed countries ("Chronic Underinvestment in Clean Energy Putting Millions at Risk as They Continue to Be Left behind in Energy Transition," 2020). In 2018, only one-third of residential electrification efforts - \$16 Billion - were made in high-impact countries in Asia and Africa, which are considered to

need the most help in the energy transition challenge (*Energizing Finance: Understanding the Landscape*, 2020).

In the logic of impact, it is important to differentiate where capital caps need to be filled and where certain technologies and projects are not as efficient or as established as others to have a timely impact in alignment with the Paris Agreement goals (INV-1, INV-2, and INV-3, personal communication, March 17, 2021). “Clean Tech,” as it is usually referred to, also faces challenges outside the venture stage when they become public. Several IPOs in this area have performed poorly or gone bankrupt in the 2000s and early 2010s (Oran, 2012). The hesitancy that comes from these recent experiences, under a risk logic, poses a challenge to scaling potentially revolutionary technology.

“The VC world a couple of years ago used to be allergic to cleantech because of this. More intelligent financial mechanisms needed to be developed to unlock growth.” (INV-2, personal communication, August 26, 2020)

This is critical to consider as technology costs and risks affect all investors, from early-stage and growth, all the way to large shareholders who need to understand what decarbonization pathways are available to the companies in their portfolio (INV-2, personal communication, August 26, 2020; INV-4, personal communication, September 2020).

Fixed-income investors can also drive impact through capital provision by targeting specific underfunded projects as well as providing flexible rates. Most capital deployed to decarbonization projects come at market rates and fit the thematic investment category - unless provided by private investors with flexible mandates (INV-6, personal communication, November 4, 2020; INV-12, personal communication, November 4, 2020). However, institutional investors have recently started using new bond structures to deploy large sums of capital with flexible rates and targeted impact. Sustainability-linked bonds, which were projected to reach \$50 billion in 2021, can be issued with

coupon rates linked with the issuer’s “green” performance (Sanne Wass, 2021). This bond structure allows investors to provide capital at lower rates for high emitting or polluting industries to transition conditioned on them doing so - with coupon rates increasing if targets are not met. From an impact perspective, this enables certain capital gaps to be filled and transition be accelerated. The taxonomy for concretely defining and measuring these “green” targets is still evolving, and there is potential for greenwashing risk (Kölbel & Lambillon, 2022).

Examples of flexible capital provision in climate issues:

- BlocPower created an innovative financing solution that enables small and medium sized building owners to bring much needed energy efficiency improvements to their properties with no out-of-pocket cost. Backed by up to \$50 million from The Goldman Sachs Urban Investment Group and \$5 million from Inclusive Prosperity Capital, this structured financial product covers the installation and maintenance of air source heat pumps, a proven high-efficiency technology that uses electricity to cleanly provide both heating and cooling, and which is more cost effective than even natural gas systems. Louis Kang, Managing Director of AccelR8 (one of the VCs backing the company), adds, “BlocPower’s success will demonstrate equitable climate change mitigation can be achieved in a financially sustainable and thoughtful manner.” (*BlocPower*, 2022).
- PRIME Coalition invested \$3 million in Noon Energy (seed round) to develop battery technology and \$1.5 million in Leading Edge Equipment Technologies (seed round) to develop solar panel materials (*PRIME Coalition - Investments, Portfolio & Company Exits*, 2021).
- The NY Green Bank raised \$314 million with Bank of America to accelerate the development of the state’s energy supply infrastructure. This is in line with the state’s targets of having 70% energy from renewables by 2030, and net-zero electricity by 2040 (Asad, 2021).

- A \$3 million prize, launched by the Rocky Mountain Institute, the Indian Government, and Mission Innovation was carried out in the last three years and resulted in innovations leading to over 5x reduction in the climate impact of air conditioning units (“Breakthrough, Climate-Friendly ACs,” 2021).

Emissions Alignment of Lending and Insuring

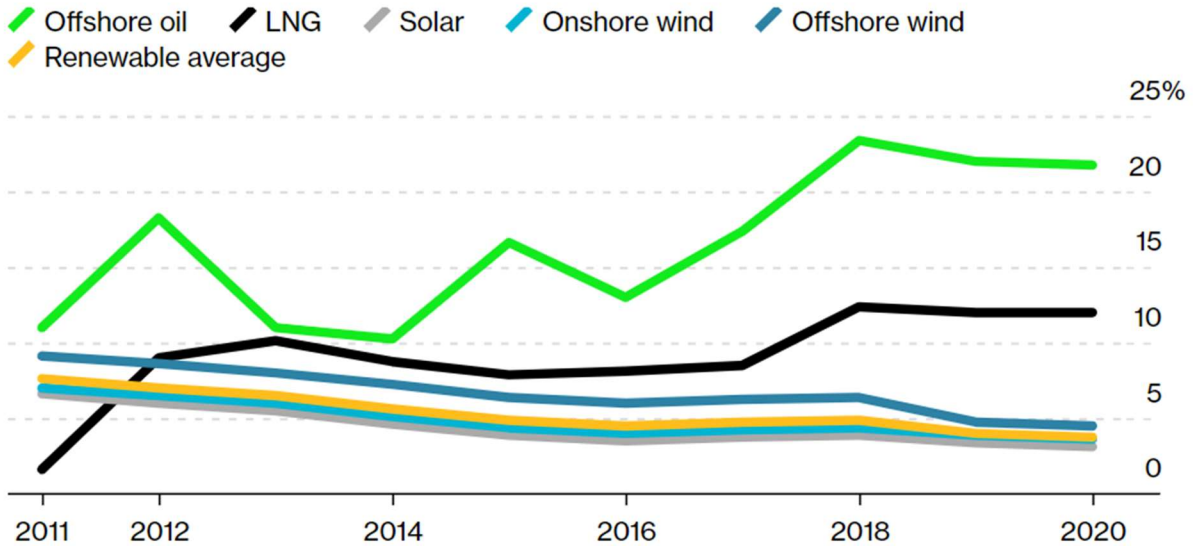
Fixed income and insurance, due to their long-term nature, are critical areas in finance when thinking about climate transition (Bingler & Colesanti Senni, 2020; Carney, 2015). Climate policy exposure started being priced by banks in 2015 and efforts in credit risk analysis are still working to better account climate risks, which is essential, especially for those issuing loans, bonds, and insurance (Campiglio & Monnin, 2019; Monnin, 2018). However, those lending and insuring have been doing more than just accounting for marginal risk adjustments, further penalizing economic activities incompatible with decarbonization scenarios (Chenet et al., 2019).

The cost of issuing debt is a determining factor when companies want to expand operations and spend capital in new infrastructure. We have already gone over ways in which flexible capital provision can accelerate climate mitigation and green activities, but it is important to understand the influence financial institutions have through limiting capital and insurance to new fossil fuel assets and unnecessarily high carbon emitting activities (*Net-Zero Insurance Alliance, 2022; NZBA Commitment Statement, 2022*). Members of the Net-Zero Banking Alliance have committed to transition all operational and attributable GHG emissions from our lending and investment portfolios to align with pathways to net-zero by mid-century or sooner (*NZBA Commitment Statement, 2022*). Similarly, members of the Net-Zero Insurance Alliance have committed to “Transitioning all operational and attributable greenhouse gas (GHG) emissions from its insurance and reinsurance underwriting portfolios to net-zero emissions by 2050” (*Net-Zero Insurance Alliance, 2022*).

The effects of aligning lending and insurance policies are already evident - while cost of capital for renewable projects have dropped under 5%, now rates for new oil projects are at 20% for long-cycle developments (Quinson, 2021). It is expected that this spread will increase, with renewable energy

investments peaking around 2040 at up to \$2 Trillion per year. Given this trend, it is feasible to expect markets to stop all new fossil fuel before governments do (Quinson, 2021).

Cost of Capital: Fossil Fuels vs. Renewable Energy



Source: Goldman Sachs
 Note: Figures for 2020 are estimates.

Figure 4. Cost of capital change from 2011 to 2020 for developing different energy sources (Quinson, 2021)

Examples of emissions alignment of lending and insuring:

- Several U.S. banks have stopped providing equity or debt capital to new thermal coal mines and plants world-wide, as well as a phaseout of financing thermal coal mining for companies not planning to diversify energy sources (Beals, 2019).
- Central banks around the world have been modifying mandates around funding polluting projects. The European Central Bank (ECB) looks at commercial banks sitting on over 2 trillion euros (\$2.4 trillion) worth of loans from them and could rapidly raise capital requirements on polluting assets. Meanwhile, People's Bank of China (PBOC) governor Yi

Gang aims to control investments in high-pollution assets - further reducing the amount funding in bonds can go to projects related to coal (John et al., 2021).

Equity Divestment

Investors can act by moving capital away from current investments to remove the support to businesses, operations, and projects that contribute to GHG emissions. As capital is placed through different investment vehicles, divesting comes with significantly different implications and effects depending on the scenario. While divesting from coal power plants might be necessary to accelerate the energy transition, many large shareholders of high emitting companies are found to often expect better financial and environmental results from not selling out their shares but instead engaging with their holdings aiming at reducing their emissions and risk exposure. However, recently more investors are looking at this alternative as not effective or fast enough, either from a climate impact or transition risk mitigation perspective (COR-6, personal communication, January 15, 2021).

“For us, divestment is really the last resort... we would like to stay as long-term investors and responsible owners, and engage with the companies. But clearly, at a certain point, the risk of staying invested may become too high.” - Jan Erik Saugestad, CEO of Storebrand Asset Management (Taylor, 2020)

It is hard to see immediate changes in companies that were divested from, and evidence is still narrative. At the same time, it is believed that an investor making a public divestment sends signals to the market for others to reconsider their positions and maybe divest as well.

In a data-gathering effort on fossil fuel divestments, 1308 institutions are found to be responsible for over \$14.50 Trillion fully or partially divested from all fossil fuels or just coal. Among 58,000 individuals, these efforts are measured at around \$5.2 Billion (*Divestment Commitments*, 2021). While faith-based organizations represent the largest percentage of these institutions (34%), philanthropic foundations (15%), educational institutions (15%), government (13%), and pension funds (12%) have also made significant divestments. 416 of the institutions were US-based, out of which only 22 are

categorized as “for-profit” corporations (*Divestment Commitments*, 2021). We have previously explored what divesting or exiting means from a risk mitigation perspective. The evidence is still limited, but this approach can drive impact if it signals others to shift their strategies faster and also divest. With more than \$600 Billion in AUM, university endowments in the US have started moving and pressuring each other to divest from fossil fuels (Cometto, 2021). Only 72 US-based universities have made divestment commitments as of February 2022 but big names have been responsible for cascading effects, such as Harvard’s public divestment in September 2021 (Cometto, 2021; *Global Fossil Fuel Commitments Database*, 2022).

Examples of equity divestment in climate issues:

- The world’s largest sovereign wealth fund, Norway’s Government Pension Fund Global, with over \$1 Trillion in AUM, has moved to dispose of about \$7.5bn in holdings of oil and gas companies (Cumbo & Flood, 2022).
- In December 2019, New York City Employees’ Retirement System (NYCERS) and the New York City Board of Education Retirement System (BERS) announced successful divestment of over \$3 Billion from all fossil fuel securities (*Office of the New York City Comptroller Brad Lander*, 2021).
- Teachers, scientists, and civil servants participating in ADP, Europe’s largest pension fund, have been campaigning for fossil fuel divestment since 2014. With the pressure and market changes, it has now announced it will divest from fossil fuel producers by 2023. (*Huge Win for Climate Campaigners as Europe’s Largest Pension Fund Announces Divestment from Fossil Fuels*, 2021).

Non-market Signaling

Another avenue for investors to drive impact indirectly is by influencing public policy. Government, as a stakeholder, can implement policies, incentives, and regulations to push the industry to reduce emissions, invest in clean technology, and orchestrate climate action. Private investors can intervene in support of such efforts, for example, by embracing and enabling more aggressive carbon pricing policies, demonstrating public support for political action, or financing politicians who align with this agenda. Ceres, for example, expects institutional investors, as part of their responsible investment efforts, to work with policymakers and lobby for actions towards decarbonizing the economy (*Investor Expectations on Corporate Lobbying on Climate Change*, 2019). Ceres outlines principles under which investors can positively lobby in alignment with the Paris Agreement, transparently, and with robust governance procedures (*Investor Expectations on Corporate Lobbying on Climate Change*, 2019). Justification for such efforts can come from the concept of a “universal owner” who faces systemic risks that cannot be mitigated through other investor action and must work toward internalizing externalities through policy (Quigley, 2020).

In practice, climate-related lobbying has been growing in the past few years, representing over \$2 billion spent in the US from 2000 to 2016 (Brulle, 2018). These efforts however are not one-sided for positive climate pathways. Lobbying is often stronger by the fossil fuel sector trying to stop or slow regulation from passing (Evers-Hillstrom & Arke, 2019). Despite efforts to combat fossil fuel companies and balance out their influence on policymakers, the discussion about when and how to regulate industry GHG emissions offers other layers of complexity to these arguments (*Lobbying for and against Climate Solutions*, 2019). Even when corporate boards are in favor of climate-related policies, they often see their specific industry or sector as not ready for regulation. For investors, this can translate to an argument against aggressive political action until they can handle their portfolio transition risk better (INV-4 and INV-5, personal communication, October 26, 2020).

Examples of non-market signaling on climate issues:

- Investors and companies, with combined AUM of \$41 Trillion, issued separate calls to world leaders to accelerate efforts to implement climate regulation, highlighting carbon pricing (S. Jessop, 2021).
- Citizens' Climate Lobby (CCL) is a nonprofit, nonpartisan, grassroots advocacy climate change organization focused on national policies to address climate change. CCL's proposed climate solution is centered around carbon pricing and taxes with dividends. CCL is primarily supported by individual donors and foundations. While the precise breakdown varies year-to-year, in the last two years 65% of support has come from individual donors, 32% from foundations, 3% from event revenues (*Citizens' Climate Lobby Annual Report, 2020*).

The Missing Piece

There are varying levels of evidence, as shown here, of the impact of different investor actions on our future climate. Most of the existing literature looks at isolated actions and does not yet explore the integrated effects of shareholder engagement, different forms of capital provisioning, and market signaling. This is critical as most asset owners can pursue combined strategies to achieve net zero and fulfill their financial goals. For example, Storebrand is the largest Norwegian financial institution and a founding member of the Net Zero Asset Owner Alliance. It has been developing its climate strategy with a heavy focus on shareholder engagement but in combination with green allocation, new lending, and insuring standards, lobbying policies, divestment criteria, and channels of communication to policymakers and individual clients.

Cases of Integrated Strategies

Most often previous research and reporting highlights asset owners and asset managers tackling climate change and transition risk through a single strategy or mechanism. Here are highlighted different stories, where an investor or group of investors combined different mechanisms.

Table 3. Highlighted cases of integrated strategies

Investor(s)	Type	Approach
Storebrand	Insurer, Pension Fund, Asset Management	Engagement and divestment
Allianz Group	Insurer, Asset Manager	Engagement, stop financing coal, non-market signaling
JP Morgan Chase, Wells Fargo, Citigroup, Morgan Stanley, Goldman Sachs, Bank of America	Banks	Green capital provision at large scale, stopping to finance of fossil fuels, and brokering for green funds
AllianceBernstein	Investment Manager	Private Engagement, ESG fund management, and non-market signaling

Storebrand

Storebrand is Norway's largest private institutional investor. In 2019, Storebrand was one of the founding members of the United Nations-convened Net-Zero Asset Owner Alliance. In early 2022 they managed over \$110 Billion (NOK 1000 Billion) in insurance, pensions, fixed-income, equity funds, private equity, and real estate (*The Storebrand Group, 2022*). Storebrand adopts an integrated approach to climate transition risk mitigation and climate impact. They have committed to use the full range of tools at investors' disposal to drive companies to meet several expectations it has set. They are using different investing solutions, sustainability ratings, divestment, and active ownership (*Our Climate Strategy, 2020*).

Storebrand committed to no longer invest in organizations that derive more than 5% of their revenue from coal or oil sands. It will make exceptions where clear and rapid transition pathways are laid out and committed to. However, Storebrand has demonstrated it will divest from any companies working against the goals set in the Paris Agreement (*Our Climate Strategy, 2020*). It has publicly divested from ExxonMobil, Chevron, Rio Tinto and BASF citing their lobbying practices regarding climate and slow response to engagement efforts (G. F. Jessop Simon, 2020).

The primary tool for mitigating risk and driving impact is through active ownership. It has set clear criteria for high emitting industries as well as for oil and gas. It requires companies to publicly disclose scope 1-3 GHG emissions, integrated climate in their investment planning, risk management and reporting - in line with internationally recognized standards like CDP and TCFD. Storebrand also expects holdings to set scientifically verifiable targets that support a 1.5°C scenario (*Our Climate Strategy, 2020*). When it comes to oil and gas companies, they are expected to clearly outline their risk in different energy transition scenarios and increasingly invest more in low carbon technologies and less in new fossil fuel exploration (*Our Climate Strategy, 2020*). While the institution divested from

ExxonMobil and Chevron, it still has assets invested in Shell and BP - in line with the criteria for target setting and Storebrand's expectations outlined above (Nicholls, 2021).

Allianz Group

The Allianz Group is a multinational financial services provider based in Germany. Its core services are on insurance and asset management. With activities in 70 countries, it concluded 2021 with over \$2.1 Trillion assets under management (*Allianz | At a Glance*, 2022). Allianz was the first global insurer to set concrete interim targets to reach net zero by 2050 - including a 25% reduction in portfolio emissions from 2019 to 2025 (Olano, 2021). The institution is a founding member of United Nations-convened Net-Zero Asset Owner Alliance and has been setting the pace for other investors to develop their commitments and strategies (COR-2, personal communication, March 8, 2021; Olano, 2021).

Allianz extensively defines their climate strategy integrating policies in all asset classes as “risks but also opportunities arise from the cross-sectoral structural change stemming from the transition towards a low-carbon economy” (*Climate Change Strategy*, 2021). The institution advocates for the TCFD recommendations and for greater transparency of climate risk reporting in the entire industry. Also as a non-market signal, Allianz calls for regulatory measures in the price of carbon and subsidies for fossil fuels (*Climate Change Strategy*, 2021).

Environmental, social, and governance (ESG) and climate guidelines are critical for their listed and non-listed assets. The latter is based on international best-practice for real estate and NGOs while equities and bonds are evaluated on carbon emissions, energy efficiency, and climate transition management (*Climate Change Strategy*, 2021). As one of the first investors to do so, Allianz has stopped financing coal-based business models since 2015. No new insurance is provided for coal infrastructure, no new investments have been allowed, equity stakes have been divested and fixed income investments made before 2015 are in run-off (*Climate Change Strategy*, 2021). Most recently,

it declared further reductions in provisions to new oil and gas exploration starting in 2023 along with a stronger benchmark for any hydrocarbon producer to meet by 2025 for Allianz to invest or insure them further (Allianz SE, 2022).

As a member of Climate Action 100+, Allianz has set up an engagement approach and a dedicated engagement function at Allianz Investment Management besides the Group ESG Office - “By actively engaging with companies to have them set measurable climate targets that are transparently pursued, we aim to not only reduce carbon emissions in our portfolio but also in the real world” (*Climate Change Strategy*, 2021).

Major US Banks

The major banks in the United States - JPMorgan Chase, Bank of America, Wells Fargo, Citigroup, Goldman Sachs, and Morgan Stanley - have evolved their position and commitments in climate finance very similarly in the last few years. What started with brokering of ESG funds and green bonds moved to committing to disclose under the TCFD framework, committing to Net Zero by 2050, and now more proactive actions with impact goals (Martinez et al., 2021).

These banks are adjusting their capital provisioning policies to provide more money to green investments than to fossil fuels, which happened for the first time in 2021 (Quinson & Benhamou, 2021). These major US banks have collectively committed to contribute at least \$6.75 Trillion to sustainable initiatives until 2030:

- JPMorgan Chase: \$2.5 Trillion (Beals, 2021)
- Bank of America: \$1 Trillion (*How Net-Zero Carbon Emissions Can Be Achieved by 2050*, 2021)
- Wells Fargo: \$500 Billion (“Wells Fargo Sets Goal to Achieve Net Zero Greenhouse Gas Emissions by 2050,” 2021)

- Citigroup: \$1 Trillion (Beals, 2021)
- Goldman Sachs: \$750 Billion (*Goldman Sachs | Sustainable Finance*, 2022)
- Morgan Stanley: \$1 Trillion (*\$1 Trillion in Sustainable Finance Solutions*, 2021)

These pledges in some cases are around five times what the banks invested on climate change mitigation between 2007 and 2020 (Martinez et al., 2021).

The institutions are also updating their approach to financing of fossil fuel extraction, such as fracking and Arctic drilling. Some have stopped providing equity or debt capital to new thermal coal mines and plants world-wide, as well as a phaseout of financing thermal coal mining for companies not planning to diversify energy sources (Beals, 2019). There is still a long way to go however, as these banks still provide a significant amount of capital that goes to fossil fuel projects (Brogger & Marsh, 2021). Since the Paris Agreement was signed in 2016, Morgan Stanley has reduced its fossil fuel investments by 14%, Bank of America by 19%, Citi by 8%, and JPMorgan by only 5% - still providing over \$60 Billion in 2021 (Brogger & Marsh, 2021).

Banks have also been advising clients on how to invest in the transition to net-zero, providing new ways to thematically invest, and even target-linked bonds (Martinez et al., 2021). Hoping to catalyze green technologies, JP Morgan Chase even has joined a Low Carbon Patent Pledge, through which it will start making technology patents important for decarbonization public (“Low Carbon Patent Pledge Announcement,” 2021). It is likely these US banks will continue adapting their climate strategy, as they are also expected to receive more pressure from shareholders to accelerate how they stop financing new oil and gas infrastructure (Prior, 2022).

AllianceBernstein

Asset Management firm AllianceBernstein is an example of strong integrated strategies related to climate risk mitigation and impact that has not made a net zero commitment as of December 2021 (Dunstan, 2021). The firm argues that a credible commitment as an asset manager comes from pushing its holdings to collectively committing to net zero first (Dunstan, 2021; Tsoupros, 2021). Not taking the same oath as others does not mean in any way it is doing less - as it shows to be aligned with the intermittent goals of the Net Zero Asset Managers Initiative and to be strongly pushing its assets to decarbonize and align with Net Zero themselves (Dunstan, 2021; Tsoupros, 2021).

With \$779 Billion in assets under management, it argues responsible investment are socially important as much as financially advantageous (*AllianceBernstein About Us* | AB, 2022). Iteratively through different assets, the firm selects the investment solution to be aligned with Net Zero. It then proceeds to set the metrics and climate related targets which will be pushed for in engagement, proxy voting, and non-market policy advocacy (Dunstan, 2021). This work expands multiple holdings as they are engaged to better report their emissions and start setting internal carbon prices. This is part of a trend where the carbon footprint of companies and projects is being evaluated and taken into consideration when making portfolio-level investment decisions (*The State of Internal Carbon Pricing*, 2021).

Thinking with System Dynamics

This phase of the research project is where we formalize the theory of how investor mechanisms interact with each other in the context of climate change. This contribution hopes to lay the foundations for future work, as more stories, data, and questions in the space of climate finance will keep emerging. We hope to gain insight into how equity allocations affect engagement campaigns, the effects of exits considering prior engagement, the balance between equity and debt for companies pushed to transition, and other indirect ramifications raised from varying strategies.

We believe system dynamics can help climate finance take the next step in understanding the investor's role in decarbonizing the economy and helping the world reach net zero emissions - not only their portfolio. System dynamics models have often been successfully used for integrated policy analysis, and we believe they can contribute to financial strategies and policies in the net zero challenge. En-ROADS, an interactive climate solutions tool built on system dynamics, has been brought to hundreds of policymakers, business leaders, and investors worldwide. It has been shown to improve discussions and mental models around different climate solutions and integrated pathways to limit global warming by the end of the century (Rooney-Varga et al., 2020). Similar to En-ROADS, we believe a tool can be built in a way that lets investors explore the effect of all actions available to them. In En-ROADS, actions available are based on public policy and technological progression. In this new model, we envision them being tied to shareholder engagement, capital allocations, equity investing or divesting, and non-market signals. The process outlined below is how we believe system dynamics can be used to bridge together the surging qualitative and quantitative information on how investors can be hit by, ride, or make the wave.

Starting with narratives. The first step of the modeling process is to find the stories that describe qualitatively what a model would need to replicate. These include well-evidenced effects of certain

actions on their own as well as the strategies being deployed by asset managers and asset owners with certain goals or justifications. Through the interviews, workshops, and case studies, several relevant narratives emerged - as described previously.

Constructing hypotheses. With reference stories in mind, we can build an understanding of how actions take place and effects are caused. These theories of change range from higher-level causal links between shareholder pressure and corporate effort to how we understand lending policies to affect access to capital. These hypotheses can be broad, conflicting, and not always comprehensive of the whole spectrum of investor actions. What is important here is to highlight the implicit causal relationships that can be seen in the narratives we start with, and then elaborate on how investor actions interact with each other - understanding the synergies and trade-offs present in net zero targets and strategies.

Future work. The goal of this project is to build a conceptual model of how pragmatic questions in climate finance could be tackled within system dynamics. Further work beyond this thesis can this process towards model building. Individual hypotheses and certain causal logics will be brought together in model structures that represent them in a systems framework. These can capture feedback effects, assets maturing and aging, delays, effect saturation, and other important dynamics. Separate model structures are abstracted from a specific industry or scale of investments. In addition to progress in building a cohesive model, they also serve as tools to iterate our thinking and hypotheses within our research community.

Separate model structures can be merged to tackle more material questions in the climate transition space. This process would involve setting boundaries, quantifying, and calibrating the model. Such work can start by analyzing the impact of investors in a specific industry. The industry can be chosen amongst the high emitting ones which are also core to our economies, such as steel, cement, mining, or transportation. These are potentially powerful contexts to start modeling with as they are potentially

steered by all kinds of investors - from the development of new clean technology to the shifting of corporate goals to reduce energy intensity as fast as possible. At a fully fleshed out stage, a model like this would hopefully show the scale of impact in the carbon intensity of a sector as a result of multiple investor actions together. The goal is to show the dynamics of feedback and interaction, and develop mental models, but not accurately predict any certain outcome.

Dynamic Hypotheses

Causal links, feedback effects, and dynamics emerge implicitly from the narratives and cases we looked at as well as from literature. We explore where trade-offs and synergies can be at play for companies and industries to decarbonize. Here we abstract this objective as “net zero performance” - a concept of tracking progress towards net zero relative to Science Based Targets⁵. The key determinants for action on the companies’ side are split into their effort - willingness to act - and their options - the capital and technologies available for decarbonization. While every industry and economic activity will vary in how effort, capital, and technology eventually can lead to net zero performance, here we are interested in how those are affected by combined investor actions. We also look at how these investor actions might change with net zero performance changing, and what feedback effects emerge.

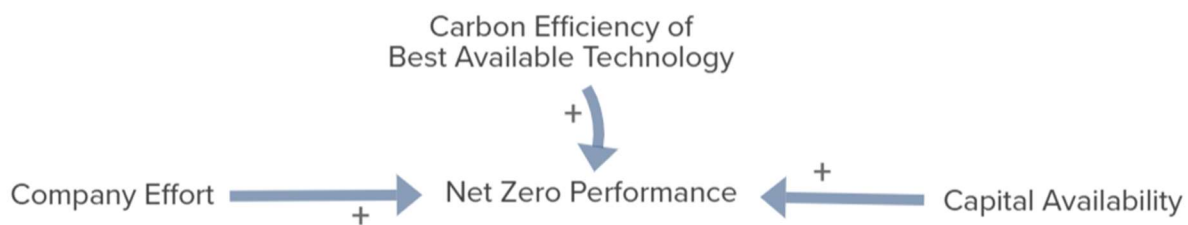


Figure 5. Role of effort, capital, and technology on Net Zero

⁵ Science Based Targets is a partnership between the Carbon Disclosure Project (CDP), the United Nations Global Compact, World Resources Institute (WRI) and the World Wide Fund for Nature (WWF). It defines and supports action on best practices to reduce emissions and set targets such as net zero in line with climate science (*Science Based Targets | About Us*, 2022).

Here we represented our hypotheses in Causal Loop Diagrams (CLDs)⁶. These are conceptual representations of causal relationships where we are interested in values increasing or decreasing with feedback effects. An aspect of this approach is to have a mixture of measurable variables with physical dimensions (e.g., GHG emissions) and in-principle-quantifiable but dimensionless variables (e.g. Shareholder pressure). Blue arrows mean positive causality - increases lead to increases and decreases lead to decreases. Red arrows on the other hand represent negative causality - increases lead to decreases and decreases lead to increases. Where loops exist, they are labeled on whether feedback is reinforcing or balancing - in other words, whether changes are reinforced, or the system tends to regulate itself and stabilize at certain values. What this specifically means for each diagram will be explained in more detail. The full systems diagram resulting from all the following combined can be found in Appendix C.

⁶ A comprehensive overview of system dynamics and using causal loop diagrams can be found in *Sustaining Sustainability: Creating a Systems Science in a Fragmented Academy and Polarized World* (Sterman, 2012).

Pressures for Company Effort

The role of shareholder engagement

We understand the pressure exerted by shareholders in engagement campaigns to play a significant role in the seeking of net zero goals. The poorer the company's performance relative to a set net zero target, the higher is *Shareholder Pressure* to adjust for it. That increase in pressure leads to an increase in *Company Effort* which can then improve their *Net Zero Performance*. As their performance relative to climate issues improves, *Shareholder Pressure* decreases, and the feedback loop balances itself out.

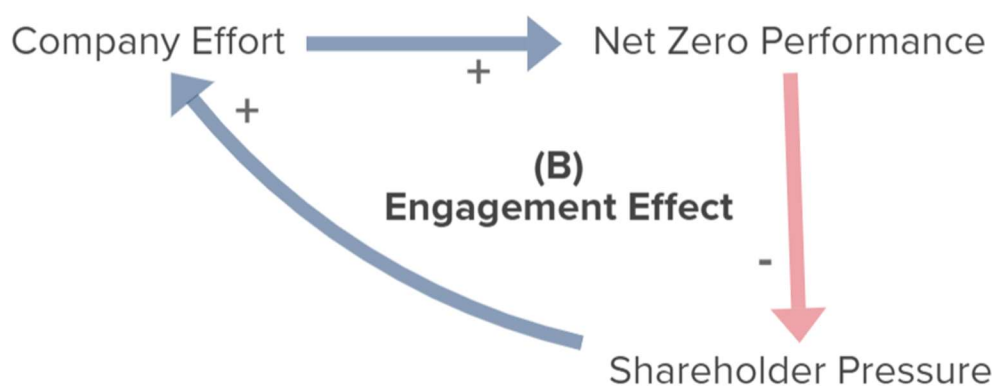


Figure 6. Engagement effect on Net Zero performance

The role of climate-related disclosure

We understand the level of climate-related disclosures from companies to be a key factor in the strength of shareholder campaigns and the subsequent company effort. The disclosure level improves from a combination of *Required Regulatory Disclosure*, and the already existing *Shareholder Pressure* to increase reporting requirements. This creates a reinforcing loop where improving disclosure leads to more engagement by shareholders on target issues as well as pressure to disclose further - for example including the full TCFD framework or wider scope of emissions. This effect is balanced by the

dynamic we described between company effort and shareholder pressure, meaning the better a company - or industry for this matter - performs relative to net zero the weaker this cycle of improving disclosure is.

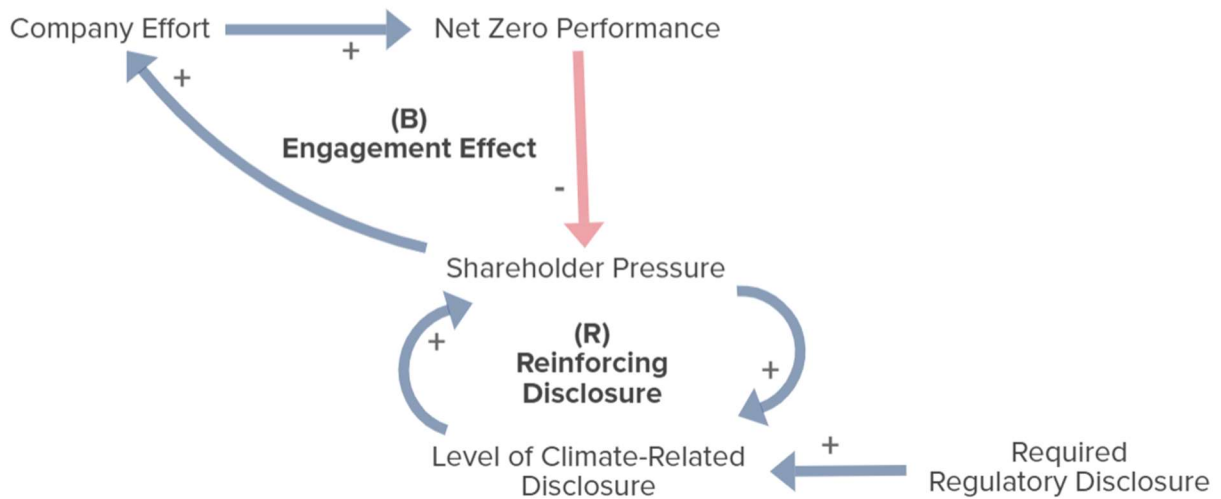


Figure 7. Relationship of disclosure with shareholder engagement

The value of net zero to shareholders

We can expect changes in how companies are evaluated - *Equity Value Adjustment* - to generate another similar goal seeking dynamic as we see with *Shareholder Pressure* - heavily weighted by the *Value of Net Zero to Shareholders*. This effect in equity valuation is expected as net zero performance is correlated with resiliency to transition risk and potential to grow and generate value by being aligned with climate-related socioeconomic changes. To the extent equity valuation matters for companies, variations derived from how they perform relative to net zero target leads them to act. If valuations decrease, companies are expected to react and increase their efforts in response. As their efforts lead to improvements in their *Net Zero Performance* and their valuations increase, the incentive to act diminishes, balancing this feedback loop.

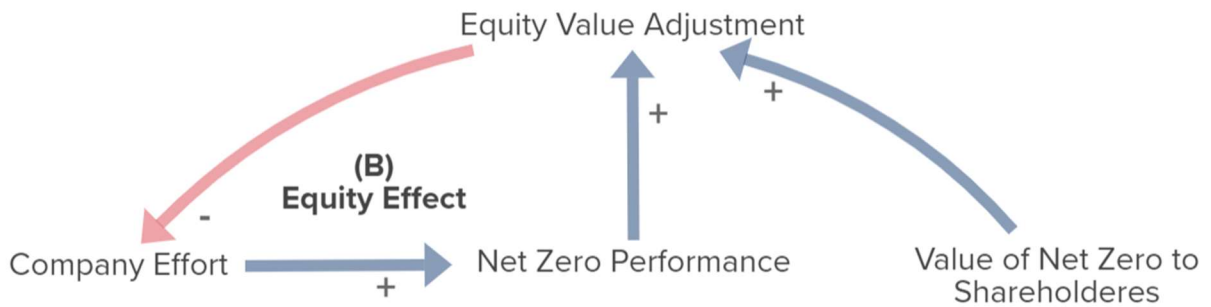


Figure 8. Equity value effect on Net Zero

The *Value of Net Zero to Shareholders* is also a critical factor to consider for *Shareholder Pressure* through engagement. As our empirical findings showed, the effectiveness of these campaigns strongly depends on the number of investors in support and their interest in passing net zero related resolutions over others. When this is taken into consideration, both the shareholder engagement pressure and equity value effects on *Company Effort* are stronger the more shareholders value net zero.

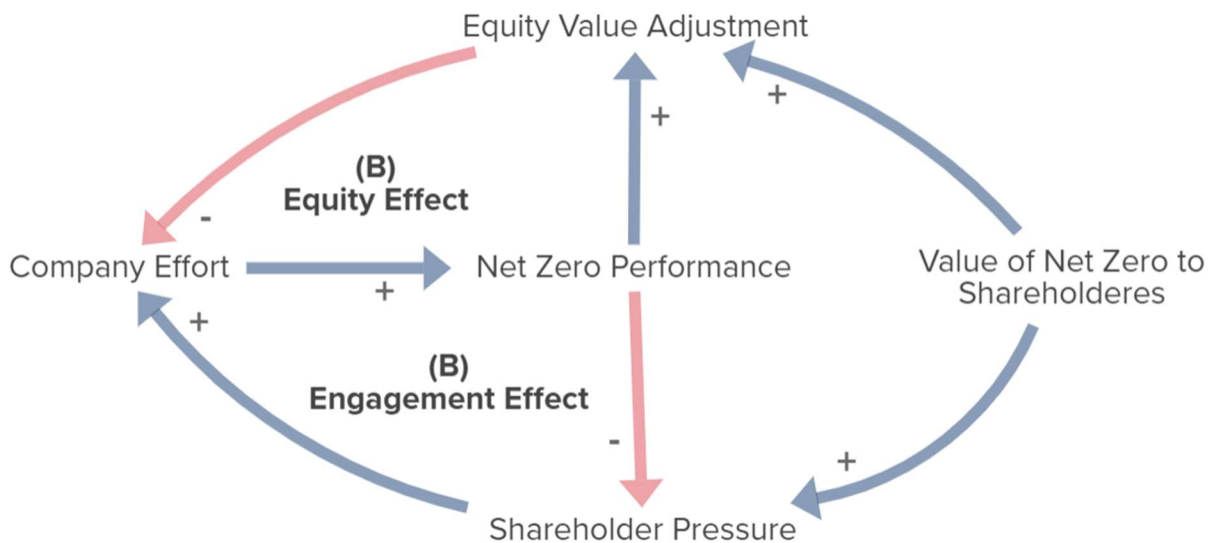


Figure 9. Value of Net Zero to shareholders effect on equity and engagement

The role of thematic investment and divestment

Understanding exactly how much investors care about net zero performance today and will care in the future is challenging, thus it is hard to estimate exactly how much equity valuations and engagement campaigns are affected by a company's net zero performance. However, we understand that the importance of net zero to shareholders in aggregate is driven by the share of investors who individually care - be it for financial or non-financial risks. Regardless of whether to reduce risk, tap into new opportunities for financial returns, signal others to shift market preferences, or out of virtue ethics, thematic investing and divesting directly change the presence of shareholders who care about net zero or who are agnostic to it.

Although not the only factors which would drive *Value of Net Zero to Shareholders*, here we represent how *Thematic Investment* and *Equity Divestment* play a role through changing the fraction of *Shareholders who care about Net Zero* and *Shareholders Agnostic to Net Zero*.

Thematic investments such as in ESG or carbon-free funds mostly reward and target the companies with already good *Net Zero Performance*. This attracts a larger range of investors - in passive strategies and who care about Net Zero - to these assets. Thus, an increase in *Shareholders who care about Net Zero* from *Thematic Investment* increases the *Value of Net Zero to Shareholders* for companies who already have good *Net Zero Performance*.



Figure 10. Effect of thematic investment on the value of Net Zero to shareholders

Meanwhile, divesting equity comes from investors who value net zero performance and penalize companies not doing well, selling out their shares to agnostic ones. Divesting can also play a role as a market signal, increasing what the perceived risk is. This change can lead to more divestments from investors concerned about Net Zero but also more interest from agnostic ones as *Expected Investment Return* increases to adjust for higher *Perceived Investment Risk*. As we described previously, divesting can be justified under an impact logic when it delegitimizes a company or industry across the financial sector but this effect is not well understood. In result we hypothesize that *Equity Divestment* reduces the fraction of *Shareholders who care about Net Zero* and increases the fraction of *Shareholders Agnostic to Net Zero*. Thus, from this perspective, *Equity Divestment* penalizing poor *Net Zero Performance* reduces the aggregate *Value of Net Zero to Shareholders*. We later explore the influence trade-off this means relative to shareholder engagement power and potential synergies equity

divestment has, together with limiting lending and insuring, to delegitimize and exclude companies working against the Net Zero transition.

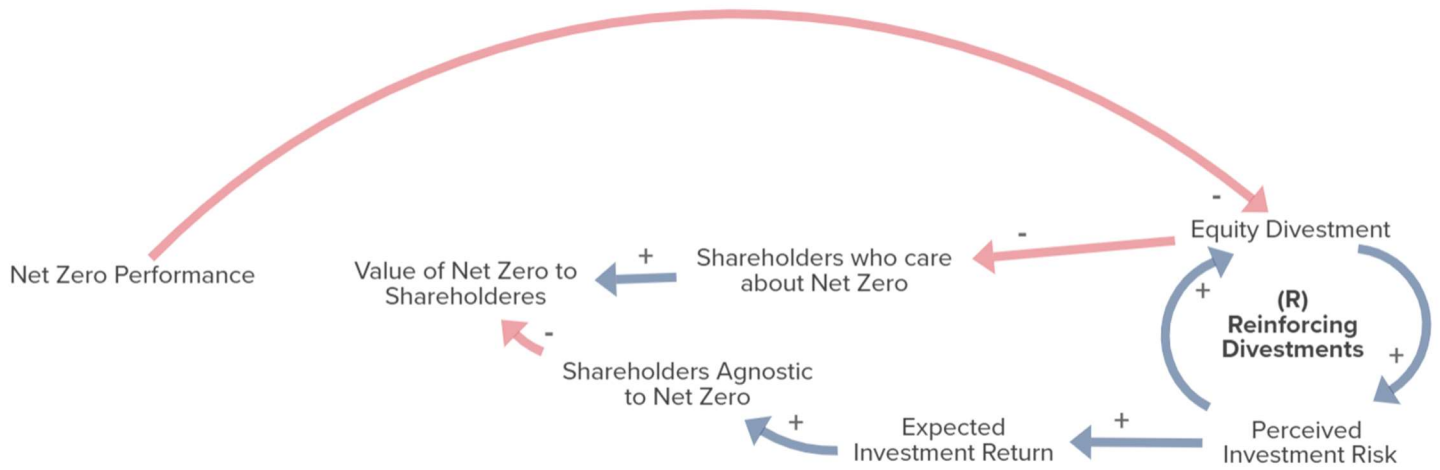


Figure 11. Effect of equity divestment on the value of Net Zero to shareholders

Access to Capital and Technology

The role of venture capital and capital provision

Ultimately, *Net Zero Performance* is heavily driven from capital-intensive efforts to replace and retrofit

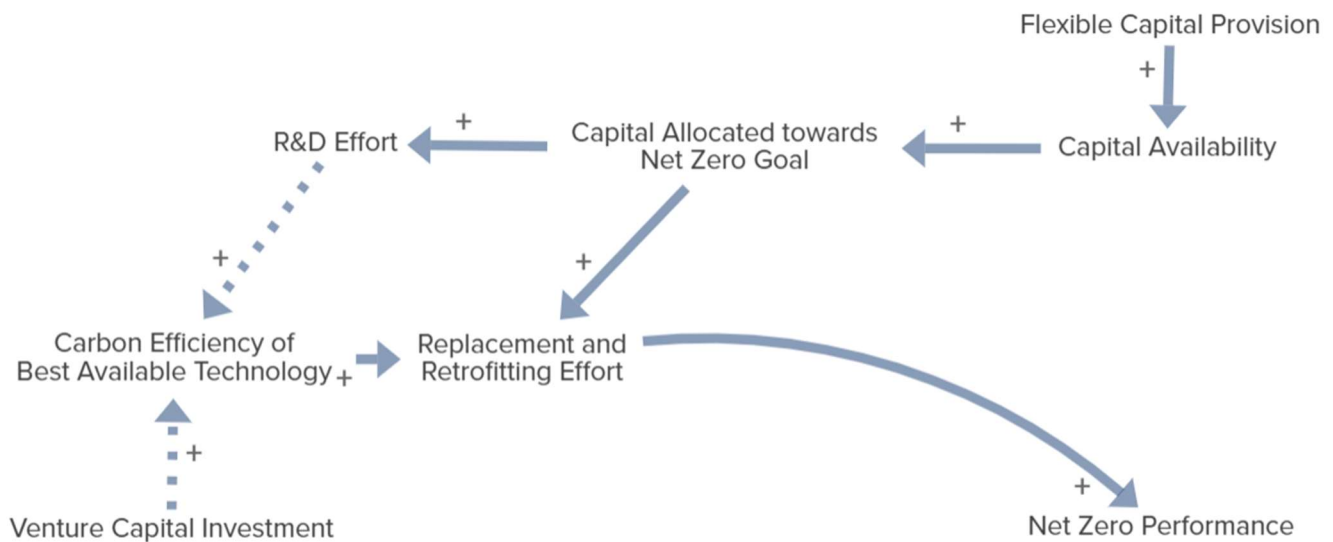


Figure 12. Effect of flexible capital provision on Net Zero efforts

current activities with the best available technology in terms of carbon intensity of output. The term “retrofit” is commonly used to refer to physical infrastructure but here we abstract it to mean any technology and process improvement to operations.

The *Carbon Efficiency of Best Available Technology*, considering significant delays in technology development denoted by the dashed arrows, is improved as a result of targeted internal *Research & Development (R&D) Effort* and *Venture Capital Investment*. It is important to make this distinction as venture capital and R&D vary in funding source, in motivation, and in agency. Venture investing, as a form of capital provisioning, can flexibly accelerate industry-wide technology development and usually attract a range of market-rate and philanthropic investors. *R&D Effort*, along with

Replacement and Retrofitting Effort, is driven by industries and companies increasing *Capital Allocated towards Net Zero Goal*. That total spending is derived from overall *Capital Availability*, adjusted by the *Company Effort* to reach net zero targets. If the effort is weak, capital is spent across all efforts without targeting net zero - while if the effort is maximized, most of the capital which can be feasibly raised at a competitive rate for the company is spent aligned with those net zero goals.

Beyond access capital at market-rate from any investor - whether they have their own net zero goals - *Flexible Capital Provision* can supplement a company's access to the resources they need to decarbonize. This can come from investors willing to accelerate growth of cleaner companies or enable the transition of companies with high emissions in need of improved technologies as well as stronger replacement and retrofit efforts. In our discussion of investor mechanisms for action, venture capital was included within flexible capital provision - however the distinction is made here because our reference point are companies taking climate action. Companies benefit from better access to capital directly as well as from the results of venture capital investments indirectly and with a delay.

The role of aligned lending and insuring

Beyond the effects of *Flexible Capital Provision*, *Capital Availability* is affected by the cost of raising capital through equity as well as how much it costs to loan, issue bonds, and insure. Cost of equity is understood to be negatively correlated with changes in equity value, including *Equity Value Adjustment* derived from *Net Zero Performance*. In our analysis we interpret insurance underwriting to affect a company's *Capital Availability* similarly to how lending costs do. Here we look at costs of insuring and re-insuring to also limit how much a company can allocate and spend on projects - especially when it comes to retrofitting and building new assets or operations. This assumption can be improved in the future with a clearer distinction of the dynamic effects of changing insurance costs relative to changing capital costs.

Aligning lending and insuring to Net Zero affects *Capital Availability* through the *Net Zero Adjustment to Lending and Insuring Costs*. This investor mechanism penalizes poor *Net Zero Performance* with higher costs while it rewards strong *Net Zero Performance* with lower costs. When we consider cost effects on *Capital Availability* and subsequently *Capital Allocated towards Net Zero Goal*, the *Net Zero Adjustment to Lending and Insuring Costs* creates a reinforcing feedback loop. Companies with poor performance are penalized and are further limited in what they can do while those doing well relative to net zero are rewarded with better access to capital and ability to grow further.

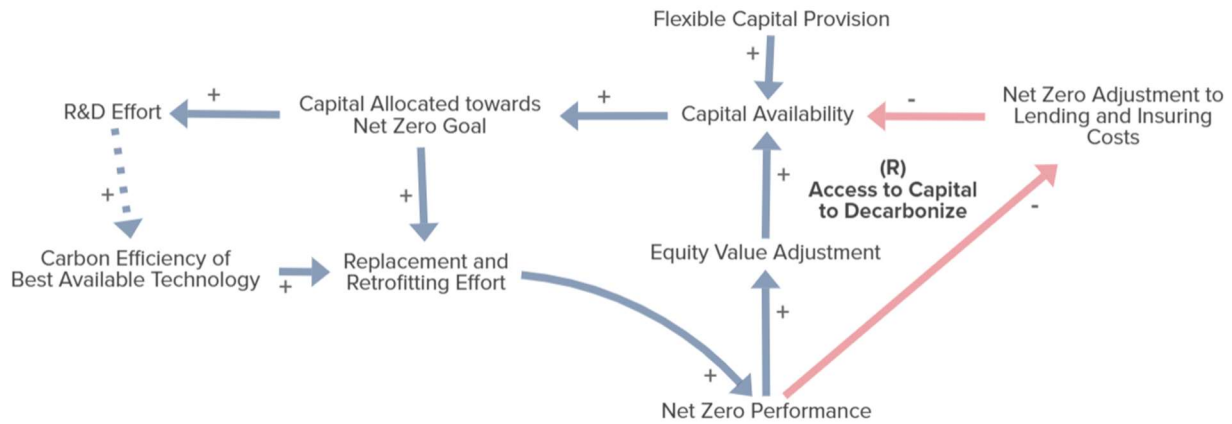


Figure 13. Effects on access to capital for decarbonization efforts

Trade-offs and Synergies for Net Zero

A critical insight we want to gain with this conceptual exploration is what might end up being the effects of integrating different investor actions under the banner of net zero, coming from impact, virtue, and risk logics. We want to search for interactions that result in synergies or trade-offs for investors. We focus on understanding effects on *Net Zero Performance* - which can be interpreted as the companies' progress within the climate transition, the wave. The key synergies and trade-offs we explore here are around the influence shareholders have on what companies do, the technologies and capital available for decarbonization efforts, and the ability investors have to suppress and delegitimize high emitting companies when it becomes necessary.

Influence Synergies and Trade-offs

Thematic Investment can synergize with shareholder engagement as it can drive up the number of *Shareholders who care about Net Zero* in the case of companies with good *Net Zero Performance*. The increase in *Value of Net Zero to Shareholders* that can come from it strengthens *Shareholder Pressure*, and subsequently *Company Effort* and *Net Zero Performance*. This creates a reinforcing feedback loop where thematic investors reward and can further improve how a company performs relative to Net Zero. *Thematic Investment* in our conceptualization, however, does not push high emitting companies to change and decarbonize the same way *Shareholder Pressure* can.

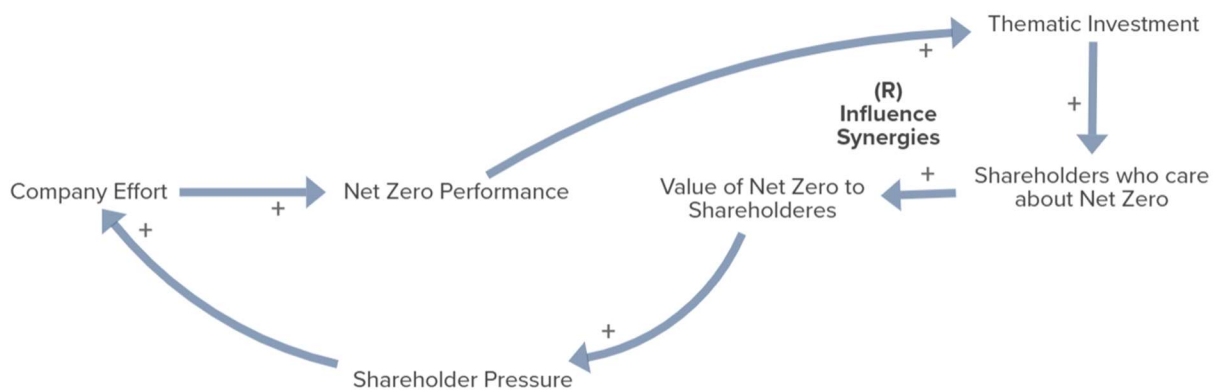


Figure 14. Influence synergies

In contrast, the influence power investors as a collective have through shareholder engagement conflicts with divestment efforts when there are pathways for companies to decarbonize. Private engagements with companies not in one's holdings is possible but rare and second in priority to engagements from shareholders (INV-4, personal communication, September 2020). We also understand the strength of *Shareholder Pressure* to depend on the collective *Value of Net Zero to Shareholders* and the share of them who would vote for net zero related resolutions. Thus, when choosing to divest, investors are giving up most if not all their influence in a company's actions and handing it off to others - who often pay less interest to climate transition issues. Therefore, through *Equity Divestment* investors also reduce the potential for impact of the remaining *Shareholders who care about Net Zero*. This further limits improvements on *Net Zero Performance*, drives increased *Perceived Investment Risk*, further *Equity Divestment*, and an overall reinforcing feedback loop driving *Shareholder Pressure* down. In cases where there are feasible pathways for poor performing companies to improve and decarbonize, investors can trade-off divesting to improve pressure through engagement instead. This can also be interpreted as a trade-off between mitigating portfolio risk - riding the wave - and driving impact - making the wave.

“They agree the private market can hide carbon - the public market just sells it to them. Sometimes you can do more impact by owning dirty companies.” (COR-2, personal communication, December 17, 2020)

Divesting can however be strongly justified under both a portfolio risk mitigation logic and under an impact logic in some cases. As seen with Storebrand’s case, there is a point where company’s efforts

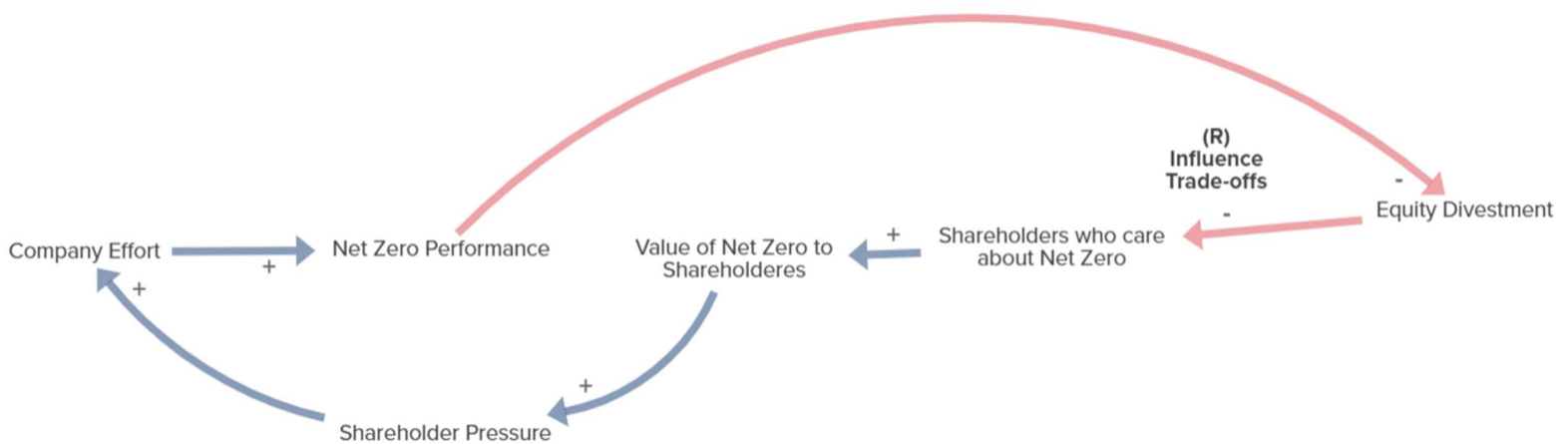


Figure 15. Influence trade-offs

against the economic transition are clear, such as with anti-climate lobbying, where companies are stuck to relying on fossil fuel exploration. Those are cases where divesting might be the best option - potentially signaling for others to also divest and overall devalue these companies. This is further explored when we discuss exclusion synergies.

Catalytic Synergies

Large asset owners and asset managers can catalyze the climate transition and achieve net zero targets by engaging with companies setting ambitious objectives that are matched with higher capital availability and more carbon efficient technologies. Investors most often engage with holdings and

pass resolutions which are first financially and technically feasible, thus *Shareholder Pressure* can synergize with *Flexible Capital Provision* and *Venture Capital Investment*.

Flexible Capital Provision can accelerate technology development and maturing as well as provide companies willing to decarbonize with better access to capital. When this occurs in the same environment as shareholder engagement, investors then see an unlocked potential for companies to improve their technologies and practices over time which they can all pressure for in engagement campaigns. Many institutional investors hold equities and invest in debt through fixed income, meaning they can tap into this synergy on their own.

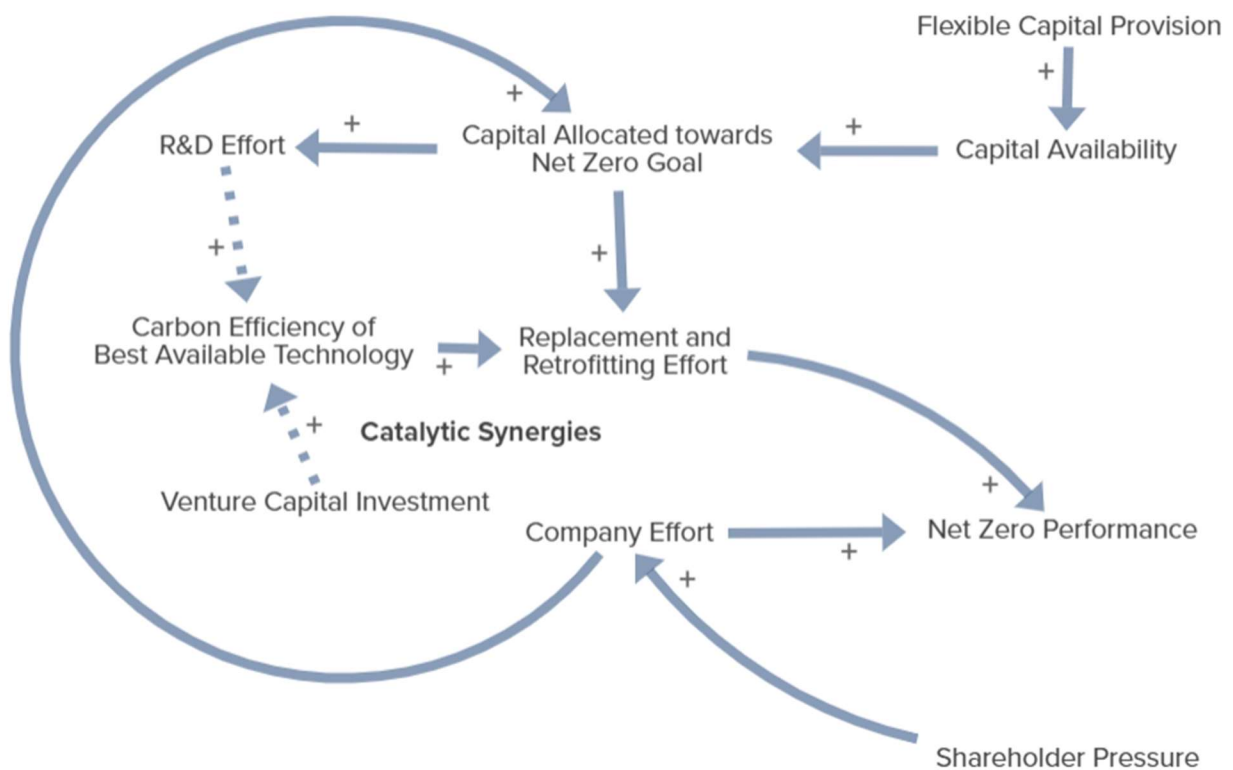


Figure 16. Catalytic synergies

There is yet potential for the financial market to align the perspective of *Venture Capital Investment* with the resolutions shareholders push for companies. In most of our interviews, institutional investors explained that their perspective of technical feasibility when engaging a company is conservatively constrained to only current mature technologies. However, with the importance of setting intermittent goals to reach net zero by 2050, a closer understanding of what future technologies could look like could significantly improve shareholders' power to push for certain actions. Engagement campaigns do not often call for specific technologies to be adopted but their understanding of technological feasibility over the next few decades can be enriched. This applies to cases such as the energy transition to include blue hydrogen - which depends on efficient carbon capture technology - all the way to engaging with steel producers to plan the phase-out of fossil fuel blast furnaces when electrified and cleaner alternatives mature.

Conversely, venture capital investments can also benefit from a closer outlook at what companies plan or need to achieve within their net zero goals, and thus align their venture investments. This communication channel is limited as even within institutions who might invest venture capital as well as engage with public equity holdings, the two are often done in separate departments and different managers. Investment analysts and consultants play a significant role in this communication channel, but there is also strong potential for direct partnerships.

Transition Cost Trade-offs

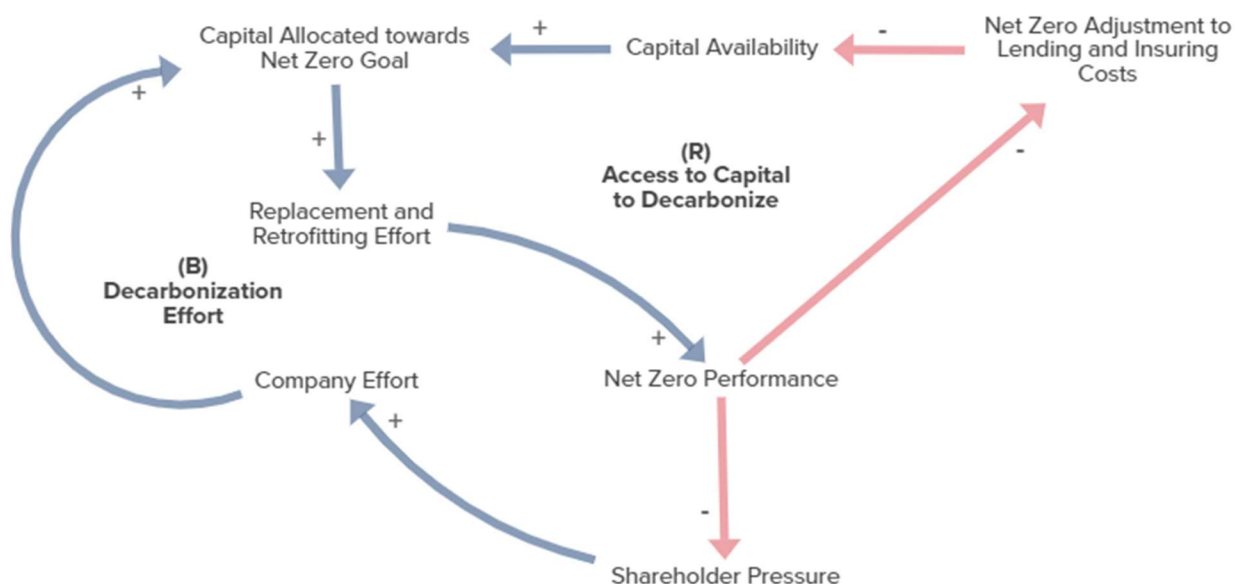


Figure 17. Transition cost trade-offs

Aligning lending and insurance costs, as we discussed previously, can penalize companies with poor *Net Zero Performance* and reduce their *Capital Availability*. Similarly with *Equity Divestment*, when there are feasible pathways for these companies to decarbonize and transition, the *Net Zero Adjustment to Lending and Insuring Costs* works counter to *Shareholder Pressure*.

For most high emitting industries which we still depend on as a society, these cost penalties from poor *Net Zero Performance* makes their transition more costly and limits the effects of *Shareholder Pressure* as less can be feasibly asked for by shareholders in engagement campaigns and in resolutions. This can then feedback and further worsen their *Net Zero Performance* despite *Shareholder Pressure*, depending on the strength of the *Net Zero Adjustment to Lending and Insuring Costs*.

“There seems very little external capital currently dedicated to this challenge of making the worst current emitters less bad, despite the immediate and verifiable high impact potential to reduce the current GHG output of the worst emissions offenders.” (INV-1, personal communication, February 3, 2021)

Alternatively, specific lending and insurance policies which target specific activities such as coal extraction might help shareholders make the case for the mining and energy companies to systematically shift away from the coal industry - in which case there are powerful synergies institutional investors can tap into.

Exclusion Synergies

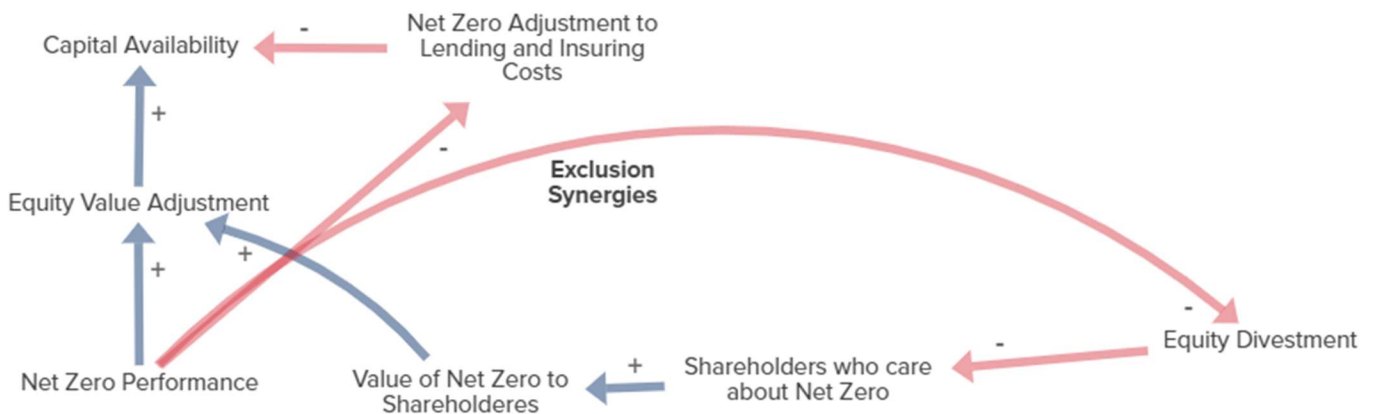


Figure 18. Exclusion synergies

Reaching net zero by 2050 and decarbonizing our economy to mitigate climate change is still incompatible with extensive fossil fuel use. While much can be done to transition fossil fuel consumers towards electrification and energy efficiency, the same can't always be said about fossil fuel extractors and suppliers. Several companies in the energy sector work to play an impactful role in the energy transition - by investing in cleaner energy sources and providing fossil fuels to the extent it is critical for energy justice but planning to phase them out in the long term. However, some parts of the industry,

as highlighted by Storebrand, actively lobby against climate regulation and work to maintain profitable exploration and emissions until it is too late. In these cases, the logics of mitigation risk, driving impact, and being virtuous align in trying to exclude and delegitimize said companies and activities.

In these cases, investors divesting equity and aligning lending and insurance policies can synergize and increase the potential impact. *Equity Divestment* can lead to at least temporary drops in asset valuation due to perceived risk, which in combination with *Net Zero Adjustment to Lending and Insuring Costs* can drastically increase a company's cost of operating and raising capital. This further limits their ability to operate and grow, as well as signal even higher risk for all other investors. Even those agnostic to net zero goals can then find themselves unwilling to assume such high transition risk as even the company's ability to generate revenue in the short term is impaired.

Future Work

The normative objective of this modeling effort is to show how investor actions can interact with each other and lead to different effects in the real economy. Grounding this formalization on a specific industry sector should be done to define context, boundaries, and quantitative scope. We believe the scope can be defined to initially look at how different investor actions, in combination, can push for industries to reduce their carbon intensity and reach net-zero faster.

Such modeling efforts could build on work done in the En-ROADS model, which considers the effect of energy source decarbonization, energy end-use efficiency and electrification, and non-energy emissions on climate change. Weaving together a complex model of investor impacts with such a complex climate model, however, will be prohibitively difficult. We recommend narrowly scoping the modeling effort to investor impact on the Energy Efficiency of Buildings and Industry lever in En-ROADS. Doing so would tackle an aspect of the economy which is critical to allow us to mitigate climate change and limit warming to safer levels. While significant work is being done on the energy supply side - to electrify all economic activities and decarbonize the global electricity grid, we still face long term technical and financial challenges. Because it is important for us to focus on reducing energy demand as well, a model can be valuable if it improves understanding of how investors can push energy-intensive economic activities to be more efficient. The paybacks for energy efficiency investment can be immediate for companies and investors, which has created enthusiasm for this space, and there is ample scope for investigating the relationship between venture capital investment in energy efficiency technology and shareholder engagement to reduce energy intensity.

Outside the scope of this thesis, an initial modeling process (but not yet ready to present in this thesis) has replicated the underlying structure for energy efficiency in En-ROADS as well as developing structures from the high-level concepts presented in the previous sections. This process was iterative

and done with support from the System Dynamics Group at MIT Sloan. To match the environment set up for En-ROADS, energy intensity is broadly defined as energy use per unit of capital for each year. Such denomination abstracts away the energy source and assumes a fixed capital-output ratio relationship. This approximation borrowed from En-ROADS allows us to model energy intensity relative to asset value and draw benchmarks that are cross-industry relevant.

It is important that sight on the larger goal is not lost while dealing with nuances from any specific market or economic activity. We believe it would be more valuable to expand a model to cover energy intensity over multiple different industries or even different levers in En-ROADS than to improve its accuracy on a single sector. This tool should not be prescribing investors how to approach industry but rather work with their mental models and strategies, allowing them to explore the dynamics and interactions of every approach available to them.

Nevertheless, work remains to make this model relevant for investors. Boundaries and calibrations are necessary to better define strength of effects, time and monetary scales, and technological constraints. We suggest that future efforts in this space start by choosing a specific industry where the following data is well disclosed and available (e.g., steel):

- Industry size and expected growth.
- Equity to debt ratio.
- Equity to asset ratio.
- Equity turnover rate.
- Capital-to-output ratio.
- Asset age and turnover rate.
- Average energy intensity of assets.
- Theoretical technological limit for energy efficiency.
- Scale of technology development under venture capital and R&D.

The model can also improve and be better integrated with En-ROADS if its scope includes electrification rates, energy price changes and incentives per carrier, scope 1 to 3 emissions, and GDP dependent on climate damages. Expanding this model to different industries later then does not need to change any core structure and simply include replicated instances for each sector with different parameters and calibration. We also propose that investors are considered independent participants of each industry and not making decisions to invest in one industry more while divesting from another - effectively following the “Universal Ownership” perspective discussed previously.

Conclusion

Climate change presents unprecedented risks. It is important for every government, company, and investor to understand potential physical and socioeconomic impacts. Whether through regulation or market forces, CO₂ emissions on average must be cut in half by 2030 and reach net-zero by 2050 to prevent the worst of damages (*Summary for Policymakers — Global Warming of 1.5 °C*, 2019). This must come through a combination of lowering energy and resource intensity, decarbonizing the supply of said energy and resources, and carbon dioxide removal (Masson-Delmotte et al., 2019).

Investments and policies lay the foundation of how we will decarbonize but any predictions of what action will look like are far from certain. Not knowing the extent to which we will respond to climate physical risk as well as how we will transition to a lower carbon economy translates into transition risks to the financial sector.

Investors are constantly analyzing trade-offs between short term costs of acting on climate and long-term risks of not doing so - with perceptions and approaches varying widely. We argue the climate transition can be understood as a wave - a metaphor in which investors use three different logics in justifying their strategy, which we label as making the wave, riding the wave, or being hit by the wave. Being hit by the wave simply means failing to account for how the global economy will transition, changes in valuations, carbon accounting, stranded assets, risks of defaulting, impact of climate on GDP, and resource pricing and availability. Riding the wave means successfully accounting for these changes and risks, adapting strategies to avoid exposed carbon-intensive investments, and following new opportunities in the sustainable and responsible investment space. Making the wave, however, is staying ahead of macroeconomic changes and supporting a faster transition. Investors can drive impact through multiple mechanisms and accelerate the changes necessary for a 1.5-degree future.

In practice, investors have begun to use net zero as an overarching goal and justify their actions under that banner. But that term has interpretive flexibility between riding the wave and making the wave. There are different logics of justification behind certain approaches, some focused on reducing one's risk and others leaning towards driving impact. We understand, with varying levels of evidence, how isolated actions can ride or make the wave, but here we tried to tackle how one can understand what economic changes will be triggered under the banner of net zero as actions are combined.

There are trade-offs and synergies. Actions can be evaluated and justified both in terms of portfolio risk/return and impact on climate to reduce systemic risk. Trade-offs can come, for example, when an investor can choose between taking risk by going into high emitting companies and trying to change them through engagement, or to divest and lose that power. On the other hand, synergies can come, for example when one provides venture capital to bring new technology to market that enables big companies to adopt and transition faster when engaged.

Our contribution hopes to explore these narratives, find implicit causal relationships, develop a conceptual model, and lay the foundations for future work. We believe system dynamics can help climate finance take the next step in understanding the investor's role in decarbonizing the economy and helping the world reach net zero emissions - not only their portfolio. We developed a framework to bridge together the surging qualitative and quantitative information on how investors can be hit, ride, or make the wave under the banner of net zero commitments and strategies. As more stories, data, and questions in the space of climate finance emerge this effort can evolve to provide stronger insights and empirical evidence.

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Appendix A

Table A - 1. Short description and codes used to anonymize interviewees in text

Code	Group	Description
INV-1	Investor	High net-worth individual with impact investing fund
INV-2	Investor	Investment manager at impact investing fund
INV-3	Investor	High net-worth individual with impact investing fund
INV-4	Investor	Executive at institutional asset manager
INV-5	Investor	Sustainability officer at institutional asset manager
INV-6	Investor	Executive at investing fund
INV-7	Investor	Relationship manager at investment fund
INV-8	Investor	Executive at institutional asset manager
INV-9	Investor	Sustainability officer at institutional asset owner
INV-10	Investor	Sustainability officer at institutional asset owner
INV-11	Investor	Sustainability officer at institutional asset manager
INV-12	Investor	Investment manager at investment fund
INV-13	Investor	Sustainability officer at institutional asset owner
COR-1	Network coordinator	Lead at international investor alliance
COR-2	Network coordinator	Program manager at international coalition of asset owners
COR-3	Network coordinator	Executive at international coalition of asset owners
COR-4	Network coordinator	Executive at international coalition of asset owners
COR-5	Network coordinator	Policy director at international investor alliance

COR-6	Network coordinator	Researcher at international investor alliance
COR-7	Network coordinator	Lead at international investor alliance
COR-8	Network coordinator	Researcher at international investor alliance
COR-9	Network coordinator	Researcher at international investor alliance
COR-10	Network coordinator	Researcher at international investor alliance
EXEC-1	Corporate executive	Executive at high-emitting corporation with over a billion in market capitalization

Appendix B

Table B - 1. Examples of actions investors can take connected to each lever in En-ROADS

En-ROADS Lever		
Energy Supply	Action	Description
Coal	Stop the financing of new coal mines worldwide	General: Several U.S. banks (e.g. Goldman Sachs in 2019) have stopped providing equity or debt capital to new thermal coal mines and plants worldwide, as well as a phaseout of financing thermal coal mining for companies not planning to diversify energy sources (Beals, 2019).
Coal	Engage with utilities generating to reduce the relative amount of power they generate from coal	The company will engage with and not further invest in companies generating at least 30% of their revenue from utility coal mining or at least 30% of their power from coal (Potter, 2019).
Oil	Engage with oil and gas companies to commit to high-level emissions reductions, either with carbon capture or transitioning to renewables	Oil and Gas company Repsol is the target of a CA 100+ campaign which started in 2017 and is led by BNP Paribas AM, EOS at Federated Hermes and UBS Asset Management. So far, the company has set net-zero targets including scope 3, incorporated the TFCF disclosure framework, and aligned its strategy with the Paris Agreement goals. It is expected to, in 2021, incorporate commitments and tie executive compensation to its performance (<i>CA100+ 2019 Progress Report</i> , 2019, p. 100).
Natural gas	Invest in the conversion of natural gas plants to produce blue hydrogen with carbon capture and storage	European energy companies Engie and Equinor, driven by governmental and public institutional investors, are leading the expansion of blue hydrogen in the continent, an approach which uses natural gas to produce hydrogen but captures its emissions (Books, 2021; <i>The Hydrogen Economy</i> , 2021).
Bio energy	Invest in utility companies in emerging markets to develop biofuel production as a large-scale alternative to oil	CVC Capital Partners, an European private equity firm, invested \$145 million during a post-IPO round for Cosan S.A. - the leading energy producer in Brazil of biofuels (<i>Cosan S.A. - Funding, Financials, Valuation & Investors</i> , 2021).
Bio energy	Invest in early-stage start-ups converting biomass from organic waste into electricity	Waga Energy was first invested by Starquest Capital on a seed round and now it has reached revenue generation from its energy production systems (“Waga Energy Raises 10 Million Euros,” 2019).

Renewables	Private investing and project finance to expand renewable capacity through green banks	The NY Green Bank raised \$314 million with Bank of America to accelerate to development of the state's energy supply infrastructure. This is in line with the state's targets of having 70% energy from renewables by 2030, and net-zero electricity by 2040 (Asad, 2021).
Renewables	Invest in target startups which are developing technology to support the growth of renewables such as batteries and key materials	PRIME Coalition invested \$3 million in Noon Energy (seed round) to develop battery technology and \$1.5 million in Leading Edge Equipment Technologies (seed round) to develop solar panel materials (<i>PRIME Coalition - Investments, Portfolio & Company Exits</i> , 2021).
Renewables	Engage with utility companies to invest in renewable infrastructure as they retire fossil fuel infrastructure	State-run power giant NTPC and upstream oil firm ONGC have planned to boost the development of offshore wind energy in India. The agreement aims at 60GW offshore wind capacity built by 2032 (NTPC, ONGC to boost development of offshore wind energy, Jul 2021). Even though the companies are majority state-owned, these companies were engaged through a Climate Action 100+ campaign - led by SBI Funds Management Private Limited and supported by the AIGCC and the PRI (<i>CA100+ 2019 Progress Report</i> , 2019, p. 100).
Nuclear	Provide capital for new frameworks for nuclear power which compliment renewable energy	Combined investments from Gates Ventures, PacifiCorp, the DOE, Energy Northwest, and Duke Energy on a new framework to develop nuclear energy. The objective is to develop 345 MW plants which can supplement the grid based on the demand and supply shortages from renewables (Gardner, 2020).
New zero-carbon	Provide capital for start-ups working on nuclear fusion technology implementation and scaling	TAE Technologies is leading the private sector for developing fusion technology, with \$750 million raised across high net-worth individual investors, VC firms, and even some institutional funds who invested after the company gained traction from retail investors (Kramer, 2020).
Carbon price	Actively lobby with policy makers to develop carbon pricing policy that aligns with transition risk planning of the private sector	Investor and companies, with combined AUM of \$41 Trillion, issues separate calls to world leaders to accelerate efforts to implement climate regulation, highlighting carbon pricing (S. Jessop, 2021).
Carbon price	Pressure companies and projects to evaluate internal carbon prices and use it in their valuation	Asset management firm AllianceBernstein has been engaging with holdings to better report their emissions and start setting internal carbon prices. This is part of a trend where the carbon footprint of companies and projects is being evaluated and taken into consideration when making portfolio-level investment decisions (<i>The State of Internal Carbon Pricing</i> , 2021).

Transportation	Action	Description
Electrification	Invest in the development of electric transport technology such as long-range batteries and key automotive materials	In January 2018, the Renault-Nissan-Mitsubishi car alliance said it had launched a \$1bn venture capital fund, with its first investment into Massachusetts-based battery company Ionic Materials. The total investments in related technology hit \$1 Billion in 2017 and were only showing signs of growth (Sanderson, 2018).
Electrification	Banks promoting investments on companies to electrify their transportation systems and supply chain with electric cars and trucks	In one of many investment banking reports which goes to clients - the asset owners who may trade with said bank as a broker - Morgan Stanley highlights the potential investment opportunities in electric power infrastructure which are necessary and current bottlenecks for companies to electrify large fleets of vehicles (<i>Plugging into the Electrification Megatrend</i> , 2021).
Electrification	Engage with car manufacturers to accelerate their transition to designing and producing electric cars and plug-in hybrids instead of gasoline powered cars	Investors are working through Climate Action 100+ campaigns to push auto manufacturers to convert production of internal combustion engine (ICE) vehicles into hybrids and electrics. The goal in addition to net-zero goals covering scope 3 emissions, is that companies are producing at least 9% BEV and 22% PHEV/HEV by 2025. Ford has signed on to those commitments and further publicly pressured the competition to do the same (<i>CA100+ 2019 Progress Report</i> , 2019).
Energy efficiency	Engage with car manufacturers to push them to improve energy efficiency standards for products and support tightening emissions regulations	AkademikerPension, along with 3 other funds and representing a total AUM of \$235 billion, approached Toyota after it was falling behind fuel efficiency standards and it was politically opposing new regulation in the US. Toyota has since stopped undermining climate policies and has been investing more in efficiency improvements (Sheldrick, 2021).
Energy efficiency	Engage with companies with large supply chains to optimize operations and reduce transportation emissions	Like many consumer goods products, Nestle's most significant emissions come from their supply chain and product distribution. Nestle can have a big impact on optimizing its transportation emissions even when the distribution is carried out by another company (scope 3). The Climate Action 100+ engagement with Nestlé has been led by Ethos Foundation and APG Asset Management, along with 18 other collaborating investors. The company has since set targets related to disclosure and committed to net-zero by 2050 including its scope 3 emissions (<i>CA100+ 2019 Progress Report</i> , 2019, p. 100).

Buildings & Industry	Action	Description
Electrification	Provide capital for technology development which improves the adoption and usability of electric heating and cooling	Cleantech startup Gradient, based in San Francisco, is developing heat pump technology which could be deployed in window mounted units by 2022 (Bekemeyer, 2021). The startup had its seed round backed by BoxGroup, Green Bay Ventures, and First Start Ventures (<i>Gradient - Funding, Financials, Valuation & Investors</i> , 2021).
Electrification	Engage with high emitting industry sectors to replace fossil fuels powered systems with ones powered by green hydrogen or electricity from the grid	ArcelorMittal is a steel and mining company headquartered in Luxembourg. Engagement with the company was led by Aegon, LAPFF and Ruffer, and coordinated by IIGCC. Beyond general decarbonization and other similar goal setting, one of the results was the commitment to transition into clean steel making using electricity generated from renewables and hydrogen as an energy carrier and reducing agent. This approach electrifies the overall process and eliminates the need for coal and natural gas (<i>CA100+ 2020 Progress Report</i> , 2020, p. 100).
Electrification	Invest in companies facilitating deep energy retrofits of urban housing	BlocPower created an innovative financing solution that enables small and medium sized building owners to bring much needed energy efficiency improvements to their properties with no out-of-pocket cost. Backed by up to \$50 million from The Goldman Sachs Urban Investment Group and \$5 million from Inclusive Prosperity Capital, this structured financial product covers the installation and maintenance of air source heat pumps, a proven high-efficiency technology that uses electricity to cleanly provide both heating and cooling, and which is more cost effective than even natural gas systems. Louis Kang, Managing Director of AccelR8 (one of the VCs backing the company), adds, “BlocPower’s success will demonstrate equitable climate change mitigation can be achieved in a financially sustainable and thoughtful manner.” (<i>BlocPower</i> , 2022).
Energy efficiency	Invest in startups scaling technology to make high consuming systems smarter and more efficient	A \$3 million prize, launched by the Rocky Mountain Institute, the Indian Government, and Mission Innovation was carried out in the last three years and resulted in innovations leading to over 5x reduction in the climate impact of air conditioning units (“Breakthrough, Climate-Friendly ACs,” 2021).
Energy efficiency	Engage with high emitting industry sectors to adopt more energy efficient technology and set targets for their energy intensity	Cummins Inc. is an engine, power systems and industrial machinery manufacturing company. The Climate Action 100+ engagement with Cummins has been jointly led by Wespath Benefits and Investments and AGF Investments, along with seven additional collaborating investors. Results have ranged from scoped net-zero commitments all the way to setting a 2030 target to reduce absolute lifetime GHG emissions from newly sold products by 25% (<i>CA100+ 2020 Progress Report</i> , 2020, p. 100).

Land & Industry Emissions	Action	Description
Deforestation	Invest in agroforestry and ecotourism businesses that create revenue streams from preserved forests and improve the incentives for forest preservation vs. deforestation	The Amazon Investor Coalition was created by foreigners to enable investment streams to protect the Amazon Forest when Brazilian regulation was affected by political complications. The organization is backed by philanthropy from retail investors but convenes summits and reports around impact investing opportunities, market analysis and other supporting resources to attract other investments to the area (<i>Impact Investing and Sustainable Entrepreneurship – Amazon Investor Coalition, 2022</i>).
Deforestation	Invest in ecosystem service preservation and nature-based solutions for climate resilience	The PE firm Quantified Ventures closed the first Environmental Impact Bond in Virginia, working with the City of Hampton and partners to finance \$12 million in nature-based solutions to fight flooding and pollution. Such approaches to mitigating the impact of climate come with co-benefits in nature preservation, biodiversity, and preventing deforestation (Letsinger, 2020).
Methane and other	Invest in new cattle feed and consumer meat-alternatives to reduce the methane intensity of food production	Footprint Coalition, led by actor Robert Downey Jr., is bringing investments and public attention into several new technologies related to meat production. Supported companies like Ynsect are looking at replacing cattle feed while Nobell and Atlast are creating plant-based alternatives to meat products. Total funding raised by this venture is around \$50 million (<i>FootPrint Coalition - Funding, Financials, Valuation & Investors, 2021</i>)
Methane and other	Engage with industries with high methane emissions to improve the measurement, control, and efficiency of their processes	PetroChina is a Chinese oil and gas company and is the listed arm of state-owned China National Petroleum Corporation, headquartered in Beijing. It is China's second largest oil producer. Engagement with PetroChina is being led by Hermes Investment Management. Lead investors had a face-to-face meeting with senior representatives and technical experts responsible for low-carbon transition technologies development in February 2019. As a member of Oil and Gas Climate Initiative (OGCI), PetroChina is collaborating with global peers to develop low-carbon technology and contributes to joint commitments in reducing methane emissions with time-bound targets (<i>CA100+ 2019 Progress Report, 2019, p. 100</i>).

Carbon Removal	Action	Description
Afforestation	Provide capital to programs developing land afforestation programs regulated to sell carbon credits	The carbon offset solution provider Carbonfund has been selling offsets at \$10/ton CO ₂ to major companies like Delta and Amtrak as well as to individuals. The company develops a series of offsets based on afforestation projects all over the world and its service has been developed with the help of unnamed incoming donations between \$100 and \$200 thousand per year since its formation in 2014 (“Financials - Federal Employee Donations,” 2020).
Technological	Invest in the technology development of Direct Air Capture systems	Climeworks is one of the global leaders in carbon dioxide removal. Its patented direct air capture technology removes carbon dioxide directly from the air. It uses clean, renewable energy, thereby providing a truly pure carbon dioxide removal solution. As of August 2020, Climeworks’ funding round has been completed with a total equity investment amount of CHF 100M (USD 110M) - the largest ever investment into direct air capture. This additional funding, from private investors, confirms the trust in Climeworks’ technology and its potential as a solution to reverse climate change (<i>Breaking the Record for the Largest Investment in Direct Air Capture</i> , 2020).
Technological	Invest in company projects doing land conversion to implement regenerative agriculture and soil carbon capture	Investors can influence the work done by companies or support efforts aligned with regenerative agriculture. Just in the US, related projects appear in 70 investment strategies with assets under management of over \$47.5 billion (Burwood-Taylor, 2019).
Technological	Engage with companies linked to the agricultural sector to promote regenerative agriculture in their supply chain	Unilever is a multinational consumer goods company headquartered in London, United Kingdom. The Climate Action 100+ engagement with Unilever is led by CCLA, along with six additional collaborating investors. The group was originally led by APG Asset Management until September 2020. Majedie Asset Management also engages Unilever as part of Climate Action 100+ on an individual basis. The company said it will use several digital technologies to increase traceability and transparency within its supply chain, as well as introduce a new Regenerative Agriculture Code for all its suppliers (<i>CA100+ 2020 Progress Report</i> , 2020, p. 100).

Growth	Action	Description
Population	Invest in women education and healthcare to promote their development into the workforce	The World Bank Group and the Global Financing Facility (GFF) are investing heavily in adolescent girls' health. The GFF, a multi-stakeholder partnership hosted by the Bank, is helping countries tackle the worst health and nutrition issues affecting women, children, and adolescents (Kim, 2018).
Population	Engage with companies to empower women's career development and improve gender diversity on executive and management positions	Vanguard, one of the largest asset managers in the world, consider market expectations for disclosure on DEI-related matters continuing to expand and evolve. Risks to shareholder value associated with diversity, equity, and inclusion (DEI) remain a top engagement priority for Vanguard with their funds' portfolio companies. Increased focus—from companies, regulators, investors, and employees—on racial and ethnic discrimination has heightened scrutiny of public companies' DEI-related risks and opportunities, as have the COVID-19 pandemic and challenging economic conditions (Galloway, 2021).
Economic growth	Donate towards lobby groups that push for policies that enable equitable economic development and reducing social inequalities	Citizens' Climate Lobby (CCL) is a nonprofit, nonpartisan, grassroots advocacy climate change organization focused on national policies to address climate change. CCL's proposed climate solution is centered around carbon pricing and taxes with dividends. CCL is primarily supported by individual donors and foundations. While the precise breakdown varies year-to-year, in the last two years 65% of support has come from individual donors, 32% from foundations 3% from event revenues (<i>Citizens' Climate Lobby Annual Report, 2020</i>).
Economic growth	Target investments in renewables, energy efficiency, electrification, and similar in emerging markets and low-income areas	CapZone is an investment management company, the cornerstone company of CapZone Group, founded in May 2018 to connect profits to purpose by bringing together financial, intellectual, and human capital to benefit low-income communities and generate ESG + Resilient investing at scale. Founded in 2018, they claim to be working on agriculture, renewable energy, water & power supply, and affordable housing projects (<i>CapZone Impact Investments, 2021</i>).

Appendix C

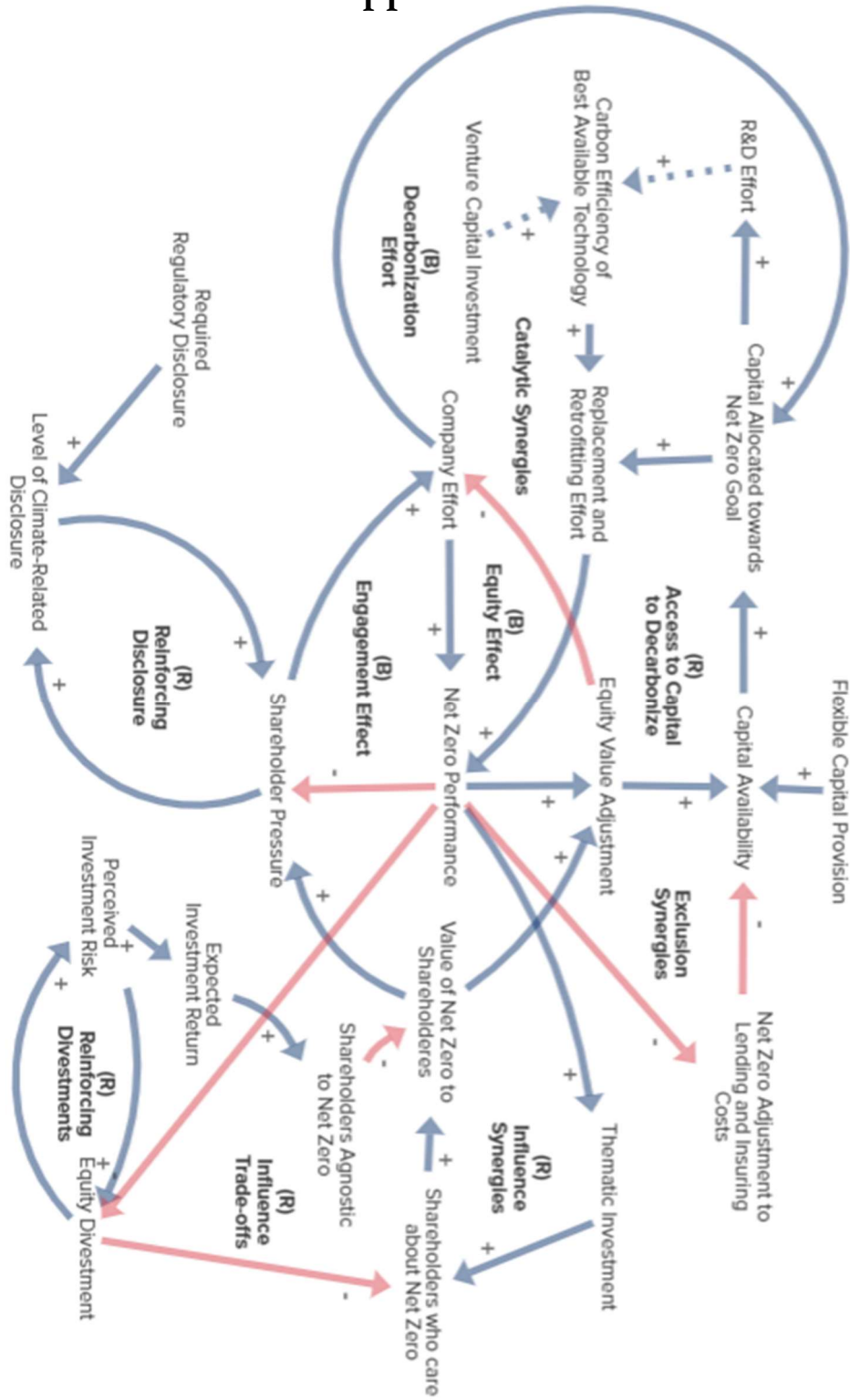


Figure C - 1. Systems diagram combining all effects shown in "Dynamic Hypotheses"