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ARTICLE

Climate Risk and Corporate Rescues

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Abstract
Climate risk poses a significant threat to economic actors across the world. Given the (systemic) nature of this risk, governments stand ready to rescue or extend relief to distressed firms in various ways. As in the case of the COVID-19 pandemic, widespread government rescues or targeted interventions in firms deemed 'too important to fail' are a real possibility in the case of climate-change-related impacts. While such interventions may be *ex-post* efficient or rather politically driven, they do not prevent deadweight losses and may create moral hazard in the sense that firms, *ex ante*, do not identify and/or address the climate risks they face. This ultimately means that climate change adaptation – a policy goal whose importance increases as climate change remains unmitigated – will not reach socially optimal levels. A better strategy involves adaptation policies where the relevant framework guides, incentivizes and pushes firms to build resilience to climate risks. Stress testing coupled with proactive adaptation measures that respond to revealed vulnerabilities appears to be the best option among various risk management strategies. In cases where government relief remains inevitable, there is a further need to ensure that it is fair and efficient.

Keywords Systemic risk · Climate change · Systemic firm · Bailouts · Climate change adaptation · Moral hazard · Distress · Insolvency

1 Introduction

Climate change is one of the most pressing issues of the century. As alarm bells ring louder, policymakers around the world are attempting to contain the worst effects of climate change while also adapting to the new reality. The goals of the Paris Agreement constitute a signpost: keeping a global temperature rise this century well below

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2°C above pre-industrial levels and pursuing efforts to limit the temperature increase even further to 1.5°C.[1]

It is, however, highly acknowledged that some effects of climate change are unavoidable. The world has already warmed by approximately 1.1°C due to greenhouse gas (GHG) emissions from human activities,[2] and current policies that are presently in place around the world are projected to result in about 3.2°C.[3] While the current impetus will likely reduce global temperature rise further, it is uncertain to what extent current and future policies will be successful. However, it is certain that risks and projected adverse perils along with related losses and damage from climate change rise with every increment of global warming, and compound and cascading risks are to be expected due to interactions between risks.[4] The effects of climate change have been increasingly visible in recent years, with widespread adverse impacts and related losses and damage to nature and people.[5] Across the world, whether from floods, droughts or heat-driven fires, climate change impacts now dominate the daily life of many households, businesses and governments.[6]

Therefore, it is imperative that, similar to mitigation efforts, households, businesses and municipalities identify and address the risks to which they are exposed due to climate change, namely that they 'adapt' or build 'resilience'. Based on vulnerabilities revealed through forecasting various scenarios (which, in turn, depend on specialized climate models), a variety of adaptation methods can be considered: enhancing risk processes (via, e.g., planning, knowledge generation, early warning systems), putting in place technical standards and capabilities to ward off adverse impacts, and for companies, additionally, adjusting supply chains and dealing with uncertainty around inputs for production, energy, transport and insurance.[7]

Climate risk has become a major agenda item for companies.[8] Acute weather events and long-term shifts in climate pose substantial risks to economic actors around the world. While there is a significant focus on how businesses should mitigate their contribution to climate change, their adaptation to climate change is given

[1] On the Paris Agreement, see https://unfccc.int/process-and-meetings/the-paris-agreement (accessed 12 Feb 2025).

[2] See IPCC (2023), p 4.

[3] Ibid., p 23.

[4] Ibid., p 15.

[5] Ibid., p 5. See also Clarke et al. (2022) (showing the direct damage of different types of disaster between 2000 and 2020 and the attributable influence of climate change on each hazard).

[6] See, e.g., Millan (2023); DePillis (2023).

[7] See Engel et al. (2015). See also Goldstein et al. (2019), pp 19–20 (discussing soft adaptation approaches, hard adaptation approaches and ecosystem-based adaptation).

[8] While climate risk has traditionally been understood to indicate potential adverse physical impacts of climate change, in the current parlance influenced by the widely used framework of the Task Force on Climate-related Financial Disclosures (TCFD), climate risk is categorized into two groups: (i) physical risks, and (ii) transition risks. The former can be event-driven or result from longer-term shifts in climate patterns (such as extreme weather events, rising sea levels and the risk of flood and drought). Transition risks largely stem from the changing legal and policy sphere for the purposes of the decarbonization of the economy and also include technological, market-based, and reputational consequences. See TCFD (2017), pp 5–11. Unless the context suggests otherwise, this article uses the term 'climate risk' to indicate 'physical risks.'

less attention and remains under-examined. Despite some progress, adaptation gaps exist across sectors and regions and will grow with the current rate of implementation.[9] Companies, even large ones with resources and capabilities to adapt, are no exception.[10]

A lack of resilience building or adaptation to climate change means that, ultimately, governments may have to intervene to mitigate the adverse impacts on economic actors in the case of a climate change-related event. Climate risk is a systemic risk, namely a risk with a propensity to propagate disruptions or losses to multiple or connected parts of a system. A physical event will impact and inflict substantial losses on many firms in a region or sector simultaneously, with various spillovers to other parties. This may necessitate widespread rescue or relief efforts to lessen the burden, as was the case during the recent COVID-19 pandemic. Furthermore, climate risk may befall 'systemic' or 'critical' firms in the real economy, again calling for government intervention to fend off the distress in the relevant firm. As shown below, relief to economic actors ('rescue' or 'bailout')[11] in the case of losses incurred due to climate change is a real possibility. These rescues may take different forms, such as financial assistance, mitigation of adverse effects, or helping firms that become unviable due to climate change to relocate. These interventions may be *ex-post* efficient in the sense that they avoid broader harm. Or, they may be politically motivated in the sense that bailouts cost more than their benefits but are still conducted due to rent-seeking.

In any case, such efforts to provide relief to firms distressed under climate risk will create two distortions. First, this may create the well-known problem of moral hazard. Moral hazard occurs when a party does not protect itself against a certain risk, knowing that if the risk materializes, another party will bear the consequences. Firms anticipating government relief in the case of distress may underinvest in their risk management processes and practices, preventing socially optimal outcomes. Second and relatedly, there will be deadweight losses associated with such a strategy. In the case of under-adaptation, the likely scenario involves governments helping and compensating ailing economic actors with

[9] IPCC (2023), p 8; see also Burke and Emerick (2016) (limited adaptation to recent temperature and precipitation trends in US agriculture 'implies substantial losses under future climate change in the absence of countervailing investments').

[10] See Goldstein et al. (2019), p 18 ('In reviewing more than 1600 corporate adaptation strategies, we find significant blind spots in companies' assessments of climate change impacts and in their development of strategies for managing them'); Li (2025), p 752 (examining reported adaptation strategies of publicly traded companies across the globe against climate risks and finding that 'the average rate of adaptation across all firms and different types of climate exposures is only 23 percent'); Laidlaw et al. (2023) (examining and demonstrating the low uptake of physical risk adaptation plans, risk assessments and scenario analyses in large companies around the world).

[11] Bailout, in a traditional sense, is used to indicate the government rescue of firms in a liquidity or solvency crisis. See Casey and Posner (2016), p 481 ('[a] bailout occurs when the government makes payments (including loans, loan guarantees, cash, and other types of consideration) to a liquidity-constrained private agent in order to enable that agent to pay its creditors and counterparties, when the agent is not entitled to those payments under a statutory scheme'). For a broader definition of bailout, see ibid., p 480 ('[a] bailout is, essentially, a transfer of money or other resources from the government to a private agent (or sometimes to another government)').

assets, infrastructure, and revenue that are lost but would have been saved in the case of adaptation. There are also related opportunity costs of government spending. A better strategy involves active investment in resilience building and adaptation by companies against climate risk, even if this might still involve some government help. This ultimately requires that companies sufficiently identify and address climate risks.

Overall, this article makes three contributions and arguments. First, given the lack of adequate adaptation, climate risk may result in widespread government relief efforts for many firms or targeted interventions in firms deemed 'too important to fail', as witnessed during the COVID-19 crisis. Second, even if such efforts may prove efficient *ex post*, they do not present an ideal strategy against the risks that businesses face as a result of climate change. They rather pave the way for deadweight losses and moral hazard when firms do not sufficiently identify and address climate risk, and society faces welfare losses as a result. Third, this requires creating a framework where economic actors are pushed to adapt to climate change and build resilience.

Climate change adaptation efforts will not be fully successful unless governments provide the necessary discipline for firms to internalize climate risk and also provide the necessary information and means to build resilience for some firms where this otherwise remains too cost-prohibitive (such as in the case of small and medium-sized firms). Therefore, the article further provides policy implications and options for creating a better framework that sets *ex-ante* right incentives and measures for *ex-post* socially optimal outcomes. I primarily argue for system-wide and/or firm-specific stress testing for climate impacts, which should be complemented by proactive adaptation measures. I also demonstrate that corporate actors may not have sufficient incentives to act on foreseeable risks within the common corporate governance framework, strengthening the case for external discipline.

In some cases, however, climate risk may be too unknown to foresee and prepare for; adaptation may not be possible or be too costly; or *ex-ante* measures may not work as intended. In those cases, government rescue efforts will play a residual role in mitigating adverse effects when climate impacts materialize. Here, there is a need for a check to ensure that these efforts are efficient, in other words, they should be implemented to avoid broader harm rather than being politically motivated, and that they remain proportionate. Additionally, fairness questions should be addressed. Certain measures, such as the creation of an *ex-ante* rescue fund, to which certain economic actors contribute partially, would also help alleviate the burden on government spending and reduce moral hazard.

A further note is that, while focusing on climate risk as a source of distress for economic actors, the discussion in this article is relevant for all sorts of risks that can affect economic actors and place them in distressed situations. Therefore, the policy framework I provide is relevant for the overall risk management processes of firms and aims at preventing unfairness, deadweight losses and moral hazard in the real economy associated with government intervention. Climate risk is particularly justified as a focus due to its profound importance for global society and the acute need to accelerate climate change adaptation.

The article is structured as follows. Section 2 discusses how climate impacts may bring firms into distress and, given the nature of the risk, how this may necessitate corporate rescue programs initiated by governments. It also notes that this strategy does not prevent deadweight losses and may even create moral hazard. Section 3 sketches the contours and content of a risk management framework where firms are pushed and guided to identify and address the climate risks they face. This framework includes disclosure, bail-in and stress-testing. It also discusses the residual role of bailouts and, therefore, the need to ensure that they are fair, proportionate and efficient. Section 4 examines the role of corporate actors such as institutional investors and directors in ensuring that their companies build resilience to climate change, and arrives at the conclusion that these parties may not have the necessary incentives, bolstering the need for risk management regulation. Section 5 concludes.

2 Climate Risk and Corporate Rescues

Having shown that climate change adaptation presents a momentous task, it is now apt to investigate how climate risk may necessitate widespread corporate rescue (or relief) efforts or targeted interventions in 'systemic' or 'critical' firms, and, therefore, how the incentives for parties to adapt to climate change may be distorted, creating deadweight losses.

2.1 Climate Risk as a Systemic Risk in the Real Economy

Climate risk poses a systemic risk to the real economy. Systemic risk denotes the potential for a threat or hazard to propagate disruptions or losses to multiple or connected parts of a system.[12] In this fashion, the physical impacts of climate change will affect a whole set of economic actors or assets in a certain area (or simultaneously in multiple areas), with substantial spillovers. These include, among others, extreme heat, rising sea levels, floods, droughts, wildfires, and storms, all occurring with an increasing rate of intensity and frequency.[13] These impacts will have direct or indirect effects on revenue streams, operating costs, and assets by affecting the factors of production. For example, exposure to extreme heat can put assets under stress or cause lower productivity;[14] storms, floods or droughts can damage infrastructure and disrupt supply chains.[15] Indirect effects as a result of physical events, such as decreased customer demand, may also further weaken balance sheets.[16] Indeed, in a recent survey, the operational impact of climate-related disasters (e.g., damage to facilities and workforce disruption), scarcity/cost of resources (e.g., food,

[12] Poledna et al. (2020).

[13] See, e.g., Mora et al. (2018).

[14] See, e.g., Patterson et al. (2023).

[15] See, e.g., Pankratz and Schiller (2024). Cross-border impacts are increasingly important in this regard. See, e.g., Carter et al. (2021); Wenz and Willner (2022), pp 290-316.

[16] See, e.g., Batten (2018), p 5.

water, energy) and increased insurance costs and lack of insurance availability were the top issues impacting businesses.[17]

Climate change can create new systemic shocks (i.e., physical events) or increase the frequency and severity of existing systemic shocks. This can occur when a certain climate change-related event affects most firms in a region or sector, or when events are correlated across geographies. It is already well documented that climate events directly or indirectly affect firms' earnings and equity valuations,[18] and therefore, certain shocks can be impactful enough to put firms in a region or across regions in a distressed situation.[19]

Firms may be able to absorb certain losses related to the materialization of physical risks. They may also be insured against such losses, which still transmit shocks to insurers and to the general financial system. Reality may be different, however, for the uninsured, which is expected to be the case with climate change-induced events,[20] and certain losses (such as decreased customer demand) may be hard to insure.[21]

Climate-related adverse impacts on several economic participants in a region(s) or sector(s), and even their simultaneous failure, present, to a large extent, problems of a catastrophic magnitude, calling for government intervention. In such a case, it is highly likely that governments will apply system-wide measures to help ailing firms and businesses (via compensation, grants, loans, moratoriums, in the form of impromptu bailouts and bail-ins instead of mass bankruptcies, depending on whether problems relate to liquidity and solvency) or will intervene to protect firms against adverse effects (e.g., by fixing supply chain issues or lowering borrowing costs through interventions in financial markets such as commercial paper markets and bond-buying programs[22]). Restructuring processes which aim at increasing the profit-making capability and reducing the debt level of distressed firms are not proper responses (or not a 'first line of defense') to such widespread impacts that can affect many businesses simultaneously. This is because they cannot remedy the inability of firms to generate revenue, as in the case of a climate impact, when it will take some time for firms and economies at the micro and macro level to recover from the impact (i.e., damaged assets and infrastructure are replaced and repaired;

[17] Deloitte (2021), p 6. See also Goldstein et al. (2019), p 22 (detailing examples of climate impacts and their financial implications, as well as some adaptation measures and their costs).

[18] See, e.g., Bressan et al. (2024); Pankratz et al. (2023); Custodio et al. (2022); Bertolotti et al. (2019); Hugon and Law (2019).

[19] See also Sarra (2020), p 286 ('physical risks create solvency risks to businesses').

[20] As Condon puts it, '[i]n a world of non-linear climate responses, the price of insurance may dramatically skyrocket from one year to the next, and certain assets may become uninsurable altogether'. See Condon (2022), p 84 (citing Shankleman (2017)). See also IAIS (2018), p 14 ('The insurance "protection gap" for weather related losses remains significant, with roughly 70% of losses uninsured … resulting in significant burden on households, businesses, and governments').

[21] Batten et al. (2016), p 10 ('For example, a survey of firms conducted by the Federal Reserve Bank of New York (2014) after Superstorm Sandy (2012) found that almost a third of the affected firms had no insurance, and only a few had business disruption or flood insurance. Losses also came from sources which are harder to insure: 59% of firms reported losses from decreased customer demand, in contrast to 29% reporting damage to or loss of assets, which is easier to insure').

[22] See, e.g., Phillips (2020) (discussing the FED's interventions during the COVID-19 crisis).

consumer demand is back to the same level, etc.). In addition, asset sales, which are usually part of restructuring measures, may not be available as firms' assets may be affected by climate impacts. Furthermore, judicial sources may be strained when there is an influx of many distressed firms.[23] Firms may also no longer be economically viable, in the sense that the relevant impact and likely repetitions render it impossible to continue economic activity in a region. In that case, government interventions (via similar measures) would involve facilitating and helping ailing economic actors with setting up a similar or the same economic activity in another place.

Overall, climate change may create situations similar to those during the COVID-19 pandemic, when measures were adopted to help firms financially and to prevent the collapse of otherwise economically viable businesses that had to close shop (i.e., those that suffered a sudden loss of revenue while having ongoing financial and operational liabilities).[24] The situation is also similar to the 'too many to fail' phenomenon in the financial system, where a regulator finds it *ex post* optimal to bail out banks when the number of failures is large, in contrast to a situation where only a few banks fail and could be absorbed by surviving banks, thus preventing the loss of continuation values.[25]

A salient example is the flooding in 2021 due to extreme rainfall in Germany, the Netherlands and Belgium, which cost many lives and destroyed assets and infrastructure.[26] In Germany, especially in the Ahr Valley, thousands of firms of different sizes were affected, with losses estimated to be over billions.[27] Such firms are normally obligated to declare bankruptcy when they cannot pay their debts as they fall due or if they are balance-sheet insolvent within a short period (three and six weeks, respectively).[28] After the flooding, the German government temporarily lifted the obligation for these firms to declare bankruptcy, as they were not able to continue their business for a considerable time until some degree of normalcy returned.[29] The goal was to help these (otherwise financially sound) firms rebuild through the

[23] For a discussion of structural limits of restructuring laws, see Eidenmüller (2023), pp 10–11. See also nn. 80-83 below and accompanying text (discussing, in the context of systemic firms, the shape state aid can take depending on the liquidity or solvency problem), and nn. 84–90 and accompanying text (discussing, in the context of systemic firms, whether state aid would occur inside or outside insolvency proceedings (liquidation or restructuring)).

[24] For an assessment of the emergency regimes put in place by governments around the world, see van Zwieten et al. (2021); Conti-Brown and Skeel (2024).

[25] See Acharya and Yorulmazer (2007) (providing a model on the 'too many to fail'). These bailout incentives from the regulator also create moral hazard in that banks create conditions for it via herding behavior. See also Brown and Dinç (2011).

[26] See, e.g., Eddy (2021); Koks et al. (2022).

[27] See, e.g., Frankfurter Allgemeine Zeitung (2021).

[28] See §15a *Insolvenzordnung* (InsO), https://www.gesetze-im-internet.de/inso/__15a.html (accessed 12 Feb 2025).

[29] See *Gesetz zur Errichtung eines Sondervermögens 'Aufbauhilfe 2021' und zur vorübergehenden Aussetzung der Insolvenzantragspflicht wegen Starkregenfällen und Hochwassern im Juli 2021 sowie zur Änderung weiterer Gesetze (Aufbauhilfegesetz 2021 – AufbhG 2021)*, https://dip.bundestag.de/vorgang/gesetz-zur-errichtung-eines-sonderverm%C3%B6gens-aufbauhilfe-2021-und-zur-vor%C3%BCbergehenden/281195 (accessed 12 Feb 2025).

financial aid package (involving compensation for the loss of assets and income, rebuilding assistance, etc.) provided by the German government rather than allowing them to be liquidated.[30] This situation is also very similar to what happened after the extreme flooding in Germany in 2013.[31]

Another climate-related example is the recent low river levels across different regions of the world, attributed to climate change-related drought.[32] For instance, the low water levels of the Rhine River – a backbone of the German economy –[33] caused significant disruptions in the summer of 2022 by making it more difficult to transport goods, including materials for energy production, and to meet the needs of facilities on the banks of the river.[34] As well as creating significant supply chain problems, such events cause firms to reduce or shut down production because they are unable to ship produced goods at reasonable prices and their storages are full; they cannot use water for different needs, e.g., cooling; their energy needs cannot be satisfied if they rely on hydropower produced by the river; or the river is used to transport raw materials, such as coal, to energy plants that produce the energy used in the adjacent areas. To be sure, firms can adapt to such circumstances, for example, by chartering more ships suitable for low water, using other methods of transportation, or moving their production elsewhere. But firms' ability to adapt will be limited, especially when suffering under bounded rationality, and not every firm will be able to build resilience due to resource constraints of the firm or the general (alternative) infrastructure. If enough firms (are likely to) suffer, this may attract government intervention to mitigate adverse effects.[35] For example, the German government's response to the recent low water levels of the Rhine River included giving priority to the transportation of materials and equipment essential for energy production via the country's rail networks, as otherwise businesses and municipalities reliant on such materials would obviously have been significantly impacted.[36]

Another example is Taiwan's worst drought, which occurred in 2021 and was caused by abnormal climate patterns. This had significant implications for its semiconductor industry, an increasingly indispensable node for the global supply chains, especially for automakers, smartphone producers, etc.[37] Chipmaking is a highly water-intensive process, and the declining water levels in Taiwan's reservoirs created

[30] Frankfurter Allgemeine Zeitung (2021).

[31] See *Gesetz zur Errichtung eines Sondervermögens 'Aufbauhilfe' und zur Änderung weiterer Gesetze (Aufbauhilfegesetz)*, https://dip.bundestag.de/vorgang/gesetz-zur-errichtung-eines-sonderverm%C3%B6gens-aufbauhilfe-und-zur-%C3%A4nderung-weiterer/54235 (accessed 12 Feb 2025).

[32] Hodgson and Bernard (2022) (detailing how recent droughts and related record low river levels across the world affected economies and dependent businesses); Wilkes et al. (2022) (the same).

[33] See, e.g., Ademmer et al. (2023) (making use of historical data on water levels in the Rhine River to analyze the impact of weather-related supply shocks on economic activity in Germany and showing that low water levels lead to severe disruptions in inland water transportation and cause a significant and economically meaningful decrease in economic activity).

[34] Miller and Vladkov (2022); Wilkes et al. (2022).

[35] This also leads to moral hazard, creating incentives for each firm not to invest in resilience even if they could; see, in detail, nn. 48-52 below and accompanying text.

[36] Reuters (2022).

[37] Guo (2021); Wu et al. (2021); The New York Times (2021).

an emergency for semiconductor companies.[38] Given the importance of these companies for the economy and geopolitics,[39] Taiwan reportedly prioritized their water use over municipal and agricultural use to avoid production cutbacks.[40]

Generally, the reasons why governments are highly likely to intervene when climate risks materialize as a systemic shock are twofold. First, the rescue of affected parties may be efficient as the costs of not rescuing them may exceed the costs of rescue.[41] This may particularly be the case where shocks can propagate to other parties (including the financial system) and create macroeconomic effects.[42] Increasing evidence shows how microshocks can turn into macroeconomic effects in today's economies, indicating the ample existence of interconnectedness.[43] Especially relevant in the context of climate change is a study showing that suppliers affected by natural disasters impose substantial losses on their customers, especially when they produce specific inputs. These output losses translate into significant market value losses, spilling over to other suppliers.[44] Second, government rescue may be politically motivated; in other words, various forms of political influence may shape the relevant decision-making, including passive forms (i.e., constituents are an important part of decision-makers' calculus) and active forms (personal connections, lobbying, campaign contributions, etc.).[45] Relatedly, politicians have incentives to

[38] Guo (2021) ('Chip fabrication is water-intensive, relying on a large, steady and ultrapure water supply, used to rinse particles and chemicals from chip surfaces').

[39] Ibid. (noting that 'Taiwan, a vital link in the semiconductor supply chain, owned the largest share (21.4%) of the global market for semiconductor-wafer fabrication by the end of 2020 – followed by South Korea (20.4%), Japan (15.8%) and China (15.3%)' and 'Taiwanese chipmakers are at risk of becoming weak points in the global semiconductor supply chain, as their most-water-intensive fabrication processes are concentrated on a water-stressed and drought-prone island').

[40] Ibid.; The New York Times (2021); Wu et al. (2021).

[41] See, e.g., Elenev et al. (2022) (showing that the US government's intervention in corporate credit markets during the COVID-19 crisis prevented a much deeper crisis by reducing corporate bankruptcies by about half and short-circuiting the doom loop between corporate and financial sector fragility). This is, however, only *ex-post* efficiency; as this paper argues, relief measures in response to climate impacts are not *ex-ante* efficient as long as they cause deadweight losses and moral hazard.

[42] In Section 2.2, under (i), I examine similar contagion effects that are, however, related to one 'systemic' firm.

[43] See, e.g., Acemoglu et al. (2012), p 1978 ('… microeconomic shocks may propagate throughout the economy, affect the output of other sectors, and generate sizable aggregate effects'); Atalay (2017) ('… industry-specific shocks are substantially more important than previously thought, accounting for at least half of aggregate volatility'); Baqaee and Farhi (2019); Aobdia et al. (2014) ('Comparing central industries to noncentral ones, we find that the stock returns and accounting performance of central industries better predict the performance of industries linked to them … highlight[ing] how industries' positions within the economy affect the transfer of information and economic shocks'); Di Giovanni et al. (2014) ('aggregate fluctuations can arise from idiosyncratic shocks due to input-output linkages across the economy').

[44] Barrot and Sauvagnat (2016). See also Carvalho et al. (2021).

[45] See, e.g., Faccio et al. (2006) ('Politically connected firms are significantly more likely to be bailed out than similar nonconnected firms'); Husted and Nickerson (2014) (finding that 'an incumbent president is more likely to grant disaster declarations when facing reelection, particularly in states with a larger number of electoral votes and in states with a governor from the same political party as the president'); Duchin and Sosyura (2012) ('[u]sing hand-collected data on firm applications for capital under the Troubled Asset Relief Program (TARP), we find that politically connected firms are more likely to be funded, controlling for other characteristics').

prioritize and remove pressure from national champions or domestic companies that are locomotives of national economies and of geopolitical importance.[46]

Whether efficient or politically motivated, relief provided to ailing firms, either in the form of financial aid or by mitigating the adverse effects, does not prevent deadweight losses and may ultimately lead to moral hazard. An approach to climate change that solely relies on government intervention to compensate for and mitigate the effects of climate impact will not avoid welfare losses suffered as a result of damaged or lost assets, investment and revenue, and will create an additional burden by increasing government spending. It is definitely a better approach to incentivize and push firms to improve their risk management, and to guide and help them to adapt and build resilience (even if this involves, again, substantial government spending), for example, by providing advanced adaptation-related information.[47]

Relatedly, if firms, municipalities, and other affected parties can expect the government to provide relief in the case of physical impacts, they may decide to underinvest in resilience. This means that firms will not identify and/or address the physical impacts even though they would be in a position to do so at a justifiable cost. Firms may not identify the physical impacts (new or more frequent and severe) to which they will be subject as a result of climate change. Even if they identify those impacts, they may fail to address them by eliminating their vulnerability, for example, by reducing their exposure or increasing their resilience to certain shocks. Similarly, a recent study suggests that the fact that the costs of defending threatened homes against climate change-related wildfires lie with governments, creates moral hazard among homeowners and municipalities, which can decide how and where to build homes.[48] Furthermore, extant literature studies how government responses to floods, such as subsidized flood insurance and *ex-post* rebuilding assistance, encourage rebuilding in high-risk areas after losses.[49] This is akin to what is known as The Good Samaritan's Dilemma, where a benevolent individual's or institution's assistance in transferring money to people in need may dilute their incentives to improve their situation.[50]

When governments' incentives to extend relief to firms are a function of loss-absorbing capacity in the economy and, relatedly, of the number of firm failures, moral hazard will depend on herding behavior in the sense that relevant firms simultaneously fail to identify and address climate risks. Where enough firms adapt and will not become distressed due to climate change, the failure of other firms will not

[46] See nn. 37-40 above and accompanying text (discussing the drought-distressed semiconductor companies and their importance for the Taiwanese economy). These companies may also be systemic firms. See nn. 57-71 below.

[47] Currently, access to reliable and verifiable hazard information and the capacity to analyze it remain elusive for all but the largest businesses and financial players, even if there are incentives to acquire such information. See generally, Condon (2023).

[48] Baylis and Boomhower (2019).

[49] See, e.g., Deryugina (2017); Boustan et al. (2012); Kousky et al. (2006). See also Frank et al. (2021) (studying federal disaster policies in the US and finding that, rather than investing in resilience, they mostly provide relief to affected parties, which is prone to moral hazard).

[50] See Buchanan (1975), pp 71–85. See also Deryugina and Kirwan (2018) (finding that bailout expectations are qualitatively and quantitatively important for whether and how recipients take protective action).

trigger government intervention. Thus, while each firm has an incentive to underinvest in resilience, this may change if a sufficient number of relevant firms invest in resilience for whatever reason.

The issue of moral hazard also depends on the ability of parties vulnerable to the risks of climate change to identify and address those risks. If they are unable to do so, moral hazard will not arise, even if they are later rescued or given relief. It is irrelevant if parties' incentives to identify and address climate risks are diluted if they are incapable of doing so in any case. There are two reasons why this may be the case. Some firms, especially small and medium-sized ones, may lack the capacity and means to enhance their risk management practices concerning climate change. In addition, there is some inherent 'uncertainty' regarding climate risks, which stems from two elements: climate modelling and net-zero pathways. The former indicates that while certain impacts of climate change can be identified, observed and measured, there is inherent uncertainty regarding the physical effects in climate models.[51] More specifically, there are 'unknown unknowns' and, in addition, uncertainty about the likelihood and timing of certain known risks materializing.[52] The latter refers to the uncertainty in reaching net-zero goals, for example, as to when and how. A faster and more extensive net-zero transition implies that the physical impacts on the planetary ecosystem will be more muted. In contrast, a slow transition may lead to exceeding certain tipping points and increased suffering from climate-related events.

2.2 Systemic Risk Meets Systemic Firm

Another possible scenario is when a climate impact hits a systemic firm. A systemic firm is considered 'too important to fail' or critical, indicating that its failure could inflict substantial losses on the economy.[53] And such losses would presumably justify a state rescue of the firm, a *bailout*.

Climate risks, as systemic risks, can also affect systemic firms. The more climate change-related events befall the world, the more likely it is that a systemic firm will be affected by the impacts. However, such firms have incentives to underinvest in resilience. Their 'systemic' nature forces the state to bail them out when distressed. This, in turn, creates moral hazard, encouraging them to take excessive risks.

Systemic firms are generally considered in the context of the financial system. The term 'systemically important financial institution' became common parlance after the global financial crisis of 2007–08. It refers to financial institutions that are 'too big to fail'; in other words, their failure could inflict substantial damage upon

[51] See, e.g., Bolton et al. (2020), pp 27–28 and Annex 1; Condon (2023), pp 15–20.

[52] If these risks become known and occur within a short timeframe when firms can no longer invest in meaningful resilience measures, then even if they receive government relief, this will not create any moral hazard.

[53] See also Eidenmüller and Valbuena (2021) (arguing that a firm is critical/systemic when its continuation (failure) results in significant positive (negative) externalities for society); Levitin (2011), p 438 (claiming that 'systemic risk is the risk that individual firms' failures will result in a socially unacceptable impact on the broader economy').

the economy, necessitating the rescue of the firm.[54] Taxpayers provide an implied insurance policy for these firms.[55]

To the extent that banks can rely on government rescue when they become distressed, they may manage their exposure to climate risk sub-optimally. For example, banks that are overly exposed to assets that suffer under climate-related events will face declines in asset value, which can lead to runs and threaten their solvency. To prevent contagion, governments will be prepared to bail out such financial institutions. This can create moral hazard, which may, in turn, create an adaptation gap in the real economy. When bank loans do not appropriately price the risk due to an implicit guarantee, debtor businesses lack the incentives to address their exposure to physical risk that is not reflected in default risk. Similarly, insurance companies may become stressed and close to failure if they have to bear disproportionately high risks associated with assets affected by physical impacts. If this failure or distress, in turn, spills over into financial stability and the real economy, the bailout of such firms will come into question,[56] which again creates moral hazard with its associated effects.

Apart from systemic financial institutions, systemic firms can also exist in the real economy. This, however, does not attract the attention it deserves. Defining 'systemic' or 'critical' firms in the real economy *ex ante* is quite challenging. Policymakers therefore have substantial discretion in recognizing firms as such and in assisting ailing firms.[57] The following categories should largely capture firms that can be reasonably deemed critical/systemic:

(i) **Firms whose failure could create contagion:**
Some firms may be too important to fail due to their interconnectedness; in other words, their failure could create a chain reaction and contagion, adversely affecting other firms and their solvency. This could, in turn, justify rescuing such firms because of these 'network' or 'domino' effects.
An illustration familiar from financial crises is 'counterparty contagion', which involves 'obligor contagion' and 'supplier/buyer contagion'.[58] In the former case, the failure of a firm that owes large sums to other firms (e.g., its suppliers) could affect the solvency of those firms, which in turn creates spillovers within their own 'network'.[59] In the latter case, a firm's failure creates a loss of business (either as a supplier or buyer) which can be critical for other firms in the supply chain and thus threaten their solvency as well.[60] An interesting example is

[54] See, e.g., Stern and Feldman (2004).

[55] See, e.g., Acharya et al. (2016).

[56] Batten et al. (2016), p 8.

[57] This is one of the reasons why the tendency to bail out firms changes depending on political preferences. See, e.g., Faccio et al. (2006).

[58] See Levitin (2011), pp 455–58.

[59] Ibid., p 456.

[60] Ibid. See also Casey and Posner (2016), p 523 (noting that '[i]f … a firm with a huge number of employees and suppliers collapses, the resulting macroeconomic shock – loss of employment and spending – could have contagious effects').

how, during the global financial crisis of 2008, other automobile manufacturers, such as Ford, supported the bailout of a competitor, General Motors (GM), due to potential contagious effects resulting from GM's failure.[61] The failure of a significant buyer (GM) could have jeopardized the solvency of car parts suppliers, which would then also have significantly affected other buyers, such as Ford.[62] The contagion of certain firms' failure will depend on their interconnectedness with other firms in the economy,[63] as well as on the ability of other firms in the network to absorb the losses (due to sufficient capital, liquidity, other buffers, etc.).[64] This, in turn, will affect the calculus of policymakers regarding the rescue of such firms.

(ii) **Firms that perform vital functions for society:**

Some firms perform vital functions for society, making their failure disastrous. These firms often provide public services such as health care, national security, transport, and utilities. The failure of these firms can propagate a shock across various segments of the economy.[65] An illustrative example is provided by Baqaee and Farhi: 'Both Walmart and electricity production have a similar share of roughly 4% of US GDP [but] it seems natural to expect that a large negative shock to electricity production would be much more damaging than a similar shock to Walmart.'[66] Indeed, utility companies have frequently been the subject of government bailouts.[67] Transport is another example of an essential service, as it plays a major role in the movement of goods and persons. Relatedly, an argu-

[61] See Enriques and Romano (2022), p 81 (citing the statement of Alan Mulally, the then CEO of Ford Motor Company at a congressional hearing in the US on saving the automobile industry, see Examining the State of the Domestic Automobile Industry--Part I: Hearing before the Committee on Banking, Housing, and Urban Affairs, United States Senate, on Examining the State of the U.S. Domestic Automotive Industry and Its Overall Impact on the Nation's Economy, the Automotive Workers, and the Companies Involved in the Supply Chain and Their Employees, 110th Cong. 85 (2008), https://www.congress.gov/110/chrg/CHRG-110shrg50418/CHRG-110shrg50418.pdf (accessed 12 Feb 2025).

[62] Ibid. See also Goolsbee and Krueger (2015), p 4 ('we agreed with others in the administration that it was essential to rescue General Motors to prevent an uncontrolled bankruptcy and the failure of countless suppliers, with potentially systemic effects that could sink the entire auto industry').

[63] This can correlate with their size. See Levitin (2011), p 456. A more sophisticated method for understanding to what degree a firm is interconnected is to measure its 'centrality'. This can be done in two ways: (i) degree centrality, which examines the number of connections that a node within a network has with other nodes; and (ii) eigenvector centrality, which considers the degree to which a node is connected with nodes that have more connections. See generally Goyal (2012); Carvalho (2014).

[64] Baqaee and Farhi (2019), p 1156; Levitin (2011), p 456.

[65] In a way, these firms are also 'interconnected' as they provide a vital function for the economy/society.

[66] Baqaee and Farhi (2019), p 1156.

[67] Recently, for example, the German utility company Uniper, was bailed out (through debt and equity) by the German government due to difficulties arising from supply shortfalls from Russia, given its 'system-critical role for Germany's energy supply'. See Uniper Press Release, 'Agreement on stabilization measures reached – Uniper safeguarded as a system-critical energy supplier' (22 July 2022), https://www.uniper.energy/news/agreement-on-stabilization-measures-reached--uniper-safeguarded-as-a-system-critical-energy-supplier (accessed 12 Feb 2025). See also Chazan (2022) (citing officials who noted that energy companies were 'too big to fail' and their failure could trigger cascading effects similar to the collapse of Lehman Brothers). Uniper was later fully nationalized. See Storbeck et al. (2022).

ment for bailing out airlines during the COVID-19 pandemic was their role in jumpstarting economic growth.[68]

(iii) **Firms that are major employers due to geographical or social circumstances:**

The job-saving argument has long been a cornerstone of company bailouts.[69] Indeed, some firms are major employers in their respective communities, and their failure could trigger significant layoffs that may be difficult to remediate, at least in the short term, leading to larger macroeconomic problems.[70] Some firms can even be considered 'monopsonies' in their role as employers, meaning that a particular firm is the sole employer for a specific combination of skills, needs, times and positions.[71]

These three categories are only intended to be indicative of systemic/critical firms, but they do reflect how policymakers perceive such firms. For example, under EU state aid rules, the bailout of failing firms is deemed incompatible with the internal market and is therefore prohibited.[72] However, there are exceptions.[73] According to the guidelines of the European Commission ('Commission'), which decides on the legality of state aid, state aid may be permissible when 'the failure of the beneficiary would be likely to involve serious social hardship or severe market failure'.[74] This may particularly be the case when (a) there are difficulties in creating new employment, (b) there is a risk of disruption to an essential service that is difficult to replicate or a risk of interruption in the continuity of the provision of a service of general economic interest, or (c) the exit of an undertaking with an important systemic role in a specific region or sector would have potential negative consequences (e.g., as a supplier of an important input).[75]

An example of a systemic firm distressed due to climate change is PG&E, one of the largest utility providers in the US, operating in California. It entered bankruptcy

[68] See Phillips (2020) (discussing the financial aid provided by the CARES Act to airlines and businesses critical to maintaining national security); Sorkin (2021) (discussing the need for and the benefits and costs of airline bailout in the US). See also Tomer and Kane (2020) (stating that '[i]n the months to come, even after the virus is under control, a broken aviation industry could still make it impossible to return to economic normalcy').

[69] See Couwenberg and Lubben (2019), pp 58–70 (giving several examples of government bailouts of companies to save jobs).

[70] This was also one of the justifications presented regarding the Chrysler and GM bailouts at the peak of the last global financial crisis. See Press Release, White House Office of the Press Secretary, Fact Sheet: Financing Assistance to Facilitate the Restructuring of Auto Manufacturers to Attain Financial Viability (19 December 2008), https://georgewbush-whitehouse.archives.gov/news/releases/2008/12/20081219-6.html (accessed 12 Feb 2025) ('[t]he direct costs of American automakers failing and laying off their workers in the near term would result in a more than one-percent reduction in real GDP growth and about 1.1 million workers losing their jobs, including workers from auto suppliers and dealers').

[71] On the labor market monopsony, see Ashenfelter (2010); Naidu and Posner (2022).

[72] Treaty on the Functioning of the European Union, OJ C 326, Arts. 107-109.

[73] Ibid., Art. 107(3).

[74] Communication from the Commission — Guidelines on State aid for rescuing and restructuring non-financial undertakings in difficulty, OJ C 249 (2014), para. 44.

[75] Ibid.

proceedings because, basically, its infrastructure was insufficiently resilient to climate change-induced heat stress.[76] Substantial liability for blazing fires caused by its poorly maintained equipment and resulting damage to human life and property culminated in an estimated $30 billion in liabilities and led the firm to seek bankruptcy protection.[77] PG&E's bankruptcy has been called the first climate change bankruptcy, and it is unlikely to be the last.[78] Going forward, it is increasingly probable that mass tort actions for acute events associated with climate change, particularly wildfires and massive flooding, will precipitate a debtor company's insolvency.[79]

As mentioned above, when critical/systemic firms face financial distress due to a climate change-related event, state financial aid will be forthcoming as these firms' failure could inflict significant harm on the broader economy, justifying the rescue measure.[80] There are primarily two possibilities. First, firms may actually be economically viable and financially sound but temporarily suffer from liquidity problems, similar to the operating cost distress faced by firms during the COVID-19 pandemic. For example, an infrastructure collapse can disrupt business operations and cause cash-flow problems. As a rule, these firms should be able to obtain a bank loan secured by their viable assets (such as business disruption loans).[81] But if the climate-related problem is extensive, banks themselves can become stressed. In such cases, the state can assume a role similar to that of Bagehot's lender of last resort and provide emergency liquidity support to financial and non-financial firms.[82] However, climate-related distress can lead to greater problems than temporary cash-flow issues. This is the second, more problematic scenario, which we have already seen in the case of PG&E. Climate change-related events can cause a significant drop in asset values or an increase in liabilities, bringing these firms to the brink of insolvency. This is especially likely if they are highly leveraged.[83]

[76] See Penn (2019).

[77] Ibid.

[78] See also MacWilliams et al. (2019), p 6; Gold (2019).

[79] Sarra (2020), p 329.

[80] See also Armour and Gordon (2014), p 57 ('[i]f the [systemic] harm is caused by the bankruptcy of the firm, as with financial firms, [governmental] mobilization will consist of actions designed to avoid bankruptcy from occurring: bail-outs').

[81] See in this regard, Brown et al. (2021).

[82] See Bagehot (1873), p 51 (advocating for central banks to assume the role of lender of last resort for banks in periods of distress). See also Levitin (2011), pp 495 ff. (discussing FED's section 13(3) powers to lend to non-financial firms); Conti-Brown and Skeel (2024) (advocating the use of the FED's discount window facility as the best government response to a macroeconomic crisis).

[83] On the leverage ratio of corporations, see Demertzis et al. (2021), p 6; Berg et al. (2021). See also Abraham et al. (2020); Financial Stability Board (2022). Current leverage levels are relatively high but non-financial firms will not be as leveraged as financial firms; therefore, a much bigger shock in asset values or liabilities would be required to impact them significantly. For example, while a 5% drop in asset values can render a financial firm like Merrill Lynch insolvent (see Levitin (2011), p 457), it would take a 50% to 75% asset value drop to make most non-financial firms insolvent given their current debt to equity ratios. See also ibid., p 456 ('counterparty contagion is a particular concern in highly leveraged industries, like finance, where even small losses can leave a firm insolvent') and p 461 ('Although non-financial firms are less likely to be as heavily leveraged as financial firms, they are often more vulnerable to supplier contagion because their suppliers cannot be resourced as easily as finance suppliers can be').

State aid to systemic firms can occur either inside or outside of bankruptcy; in both cases, however, it may be crucial to the firm's viability as a going concern. The government can bail out such firms without initiating insolvency proceedings, which would otherwise be inevitable. This is largely because parties in bankruptcy may not fully capture the negative externalities that a critical/systemic firm's failure would cause, and therefore may decide to opt for liquidation, which destroys social value.[84] Or such firms can enter insolvency proceedings for 'reorganization',[85] which would take place under the shadow of implicit or explicit government assistance.[86] For example, the California Legislature created a wildfire fund partially capitalized by ratepayers, from which investor-owned utilities can draw to cover damage caused by future wildfires.[87] Conditional upon a successful restructuring, PG&E was allowed to participate in this fund.[88] This was deemed critical by investors for PG&E's financial stability moving forward.[89] Overall, the fund aims at

> improving the financial health of the big investor-owned utilities … and preventing further bankruptcies as climate change makes fires more frequent and destructive. The state is concerned that without its intervention, investors and creditors will shun the companies, potentially starving them of financing.[90]

[84] Eidenmüller and Valbuena (2021), pp 522 and 536. In the case of liquidation, sales can occur on a piecemeal or going-concern basis. In the latter case, the most positive outcome would be the sale of assets at their fundamental value to an industry insider that would not cease the operations. However, this may not be possible if the industry players are cash-constrained, especially if they are affected by the same shock, or it may only be possible if the government also bears some of the costs. See van Zwieten et al. (2021), pp 211–13. Furthermore, forced sales can lead to depressed asset prices (e.g., land) and create spillovers, adversely affecting otherwise solvent firms. See Miller and Stiglitz (1999).

[85] Most jurisdictions around the world have introduced procedures that enable distressed companies to maintain their business and restructure their debts, rather than be subjected to a forced sale, for example, Chapter 11 in the US; in relation to the EU, see Directive (EU) 2019/1023 of the European Parliament and of the Council of 20 June 2019 on preventive restructuring frameworks, on discharge of debt and disqualifications, and on measures to increase the efficiency of procedures concerning restructuring, insolvency and discharge of debt, and amending Directive (EU) 2017/1132 (Directive on restructuring and insolvency) OJ L 172, 26.6.2019, pp 18–55.

[86] For financially distressed firms that are believed to have going-concern value, creditors or other investors may also provide interim or exit financing in a restructuring process. However, in cases where the current and future climate change-related drops in asset values or increases in liabilities are difficult to estimate and price, this may not be available. See Sarra (2020), p 325.

[87] The California government did not directly inject capital into the utility company, but, through legislation, allowed future losses to be borne by ratepayers (like taxpayers in a bailout), which then gave incentives to investors to restructure the company. Another legislative change regarding the burden of proof as to when the utility company could pass the costs onto ratepayers also provided a more favorable liability regime for PG&E. For a chronicle of PG&E bankruptcy and related government intervention, see Ellias and Triantis (2021), pp 530-45.

[88] Penn (2020).

[89] Ibid. ('[i]nvestors considered PG&E's ability to participate in the wildfire fund critical to the company's financial stability').

[90] Penn and Eavis (2019).

Whether critical/systemic firms should be bailed out inside or outside of bankruptcy is an intricate question[91] whose definitive solution is not relevant to the fact that these firms ultimately rely on government aid for their financial stability.

Government rescue of 'critical/systemic' firms in the event of climate change-related impacts raises the same issues as the widespread rescue of ailing firms under climate stress. First, as with any bailout, the question of whether it is efficient or fair arises. Second, even though the bailout may be *ex-post* efficient rather than a reflection of rent-seeking behavior, it will not prevent deadweight losses and may create moral hazard.

The rescue of critical/systemic firms may prevent spillovers to other parties, but will not avoid the loss of assets, infrastructure and revenue due to climate impacts and the associated government spending needed to rescue such firms. Here, too, a better strategy involves building resilience to climate change within critical/systemic firms so that a bailout remains only a residual option. This minimizes issues related to bailouts and prevents deadweight losses and possibly moral hazard.

A high probability of rescue for systemic/critical firms can distort management's incentives to address climate risks, creating moral hazard. This again means that these firms may underinvest in resilience to climate change, either by failing to identify risks in a satisfactory way at all, or by not addressing the identified risks that may affect the firm's operations. This is similar to excessive risk-taking by 'too big to fail' financial institutions. By underinvesting in resilience, firms fail to adequately hedge against risk, which has effects similar to those of excessive risk-taking. For example, in the case of a 'systemic' company subject to liability risk associated with increasing wildfires, moral hazard may manifest itself in neglecting to monitor how changing weather patterns (e.g., increasing heat waves) could affect its equipment or in not renewing or maintaining the equipment, even if the company somehow anticipates certain events and impacts, or in having poor wildfire safety practices. Similarly, these firms may not insure themselves against climate change-related risks, even if they remain insurable. Again, the moral hazard argument depends on the extent to which firms can build resilience if they do not anticipate government relief. In the case of critical/systemic firms, which can reasonably be assumed to be large and have sufficient means and capacity to identify and address climate risks, only the inherent uncertainty surrounding climate risk may prevent them from building resilience.

3 Risk Management Against Climate Risk

As argued above, a strategy involving widespread or targeted government relief efforts for ailing firms affected by climate impacts may not yield social welfare-improving outcomes, as it is associated with deadweight losses and moral hazard. Bailouts also raise efficiency and fairness questions. An *ex-post* strategy does not

[91] See also Ayotte and Skeel Jr. (2010), p 491; Couwenberg and Lubben (2019), pp 55 and 74 (arguing for a bankruptcy supported by state aid instead of full-blown bailouts or *ad-hoc* solutions); Levitin (2011), p 483 ('[t]he generic choice between bankruptcy and bailouts is illusory').

address the underlying problem but rather the symptoms. What is needed is an *ex-ante* strategy whereby firms identify and address climate risks; in other words, build resilience to climate change. Such a strategy also promises socially optimal levels of climate change adaptation. Firms need relevant information, discipline, and, if necessary, fiscal assistance, especially in the case of small and medium-sized enterprises. This may be achieved in various ways. Below, I consider the roles of climate risk disclosures, bail-in, and stress testing, and conclude that stress testing, coupled with proactive adaptation policies in accordance with the vulnerabilities revealed by such tests, offers a better solution. Despite these efforts, however, the option of providing relief or rescuing certain firms may be inevitable, which calls for a different set of actions to ensure efficiency, proportionality, and fairness.

3.1 Climate Risk Disclosures

The first tool is climate risk disclosures, which are commonplace now and are intended to overcome information asymmetry for investors.[92] They also have an indirect effect in this context. Under a well-enforced disclosure regime, firms must engage in extensive due diligence to disclose these risks, as misrepresentation and omission can expose them to significant liability. To disclose these risks, firms need to identify them, addressing at least the first part of the problem. In addition, such disclosures require firms to describe their resilience to the identified risks, which may, in turn, nudge them to improve their resilience.[93] However, these disclosures mainly apply to large firms, as their scope does not cover, or only covers in a limited way, small and medium-sized enterprises.[94] Therefore, their effects will be limited. This strategy also leaves it to firms to investigate and reveal their vulnerability to climate change, which means that they need to use private and public information on climate risk. If the latter is lacking,[95] they will rely on burgeoning private sector initiatives that collect and disseminate information related to climate change impacts for adaptation decisions. However, these initiatives are facing increasing scrutiny

[92] See generally Steuer and Tröger (2022).

[93] See Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting OJ L 322, 16.12.2022, Art. 19a, 2(a)(i) and (g) [hereinafter 'Corporate Sustainability Reporting Directive'] and Commission Delegated Regulation (EU) 2023/2772 of 31 July 2023 supplementing Directive 2013/34/EU of the European Parliament and of the Council as regards sustainability reporting standards C/2023/5303, OJ L 2023/2772, 22.12.2023, p 76. See also The Securities and Exchange Commission, The Enhancement and Standardization of Climate-Related Disclosures for Investors, 17 CFR 210, 229, 232, 239, and 249, https://www.sec.gov/files/rules/final/2024/33-11275.pdf (accessed 12 Feb 2025).

[94] The Corporate Sustainability Reporting Directive applies to publicly traded small and medium-sized undertakings (except micro undertakings). However, they are allowed to opt into a lighter disclosure regime, *supra* n. 93, Art. 19a, 1 and 6. The SEC rules, if implemented, will only apply to 'reporting companies' which include publicly held companies and private companies with more than 2000 shareholders of record.

[95] On the initiatives to increase the public institution's capacity to generate and assess climate change-related information, see nn. 112–115 below.

regarding the limitations, transparency and accountability of their products and services.[96]

Furthermore, enforcement may prove a thorny issue. Private enforcement relies on shareholders, who may have muted incentives in the sense that, when undisclosed risks materialize but are compensated by the state, they lack the incentives to bring a securities lawsuit, as damages will be largely compensated. In this case, public enforcement plays a more important role. Still, a lingering question is how securities regulators are to ascertain the physical risks to which firms are exposed and therefore whether these risks have been adequately disclosed.[97] After a risk materializes, they may argue that the firm failed to disclose a material risk it should have been aware of. This *ex-post* enforcement serves the policy goals this article touts, provided it has *ex-ante* effects in that corporate insiders, anticipating liability, will have incentives to identify and disclose the risks.

3.2 Bail-in

An option to provide market discipline for firms to consider climate risk is bail-in, which has been extensively utilized in the financial system after the global financial crisis of 2007-08. Bail-in ensures that certain creditors also bear the costs of a firm's failure (through write-downs or conversion to equity), which should, in turn, incentivize them to monitor and engage with the firm in order to reduce excessive risk-taking.[98] In our context, bail-in can be applied to systemic firms in the real economy by requiring them to hold bail-inable debt – debt that will be written down or converted to equity when the firm is distressed and about to fail. This should, in turn, induce relevant creditors to push these firms to invest in resilience (i.e., hedge against climate risk) or to impose a higher cost of capital on firms that fail to do so. This also addresses moral hazard by *ex ante* penalizing firms for their lack of investment in climate change adaptation, even if they receive *ex-post* relief.

However, the use of bail-in in this context faces the following difficulties. First, governments would need to *ex ante* classify certain firms as critical/systemic – a difficult exercise. Furthermore, policymakers may also need to determine when the bail-in kicks in (i.e., when creditors must accept haircuts) in the case of a climate event and distress. Yet, if there is too much uncertainty about physical risk, policymakers cannot reasonably undertake this exercise. A potential solution is to adopt a general bail-in, which, however, may be too costly. Furthermore, it should be determined at what point of distress certain debts will be bailed in, i.e., whether in insolvency or while the firm is still solvent. The latter would require certain financial ratios to assess the required level of distress, as well as an authority to monitor this exercise. In addition, in the event of a common shock that also affects the bail-inable debtholders (as may well be the case with climate change), such bail-in can create

[96] See Condon (2023), pp 30-45 (examining emerging concerns with the climate services industry).

[97] This may necessitate relying on private climate service providers. See, e.g., ibid., p 8.

[98] See, e.g., Avgouleas and Goodhart (2015).

more adverse effects, threatening their solvency as well, and potentially triggering a larger crisis.[99]

3.3 Stress Testing and Adaptation Plans

An arguably more useful measure is stress testing. It is now a traditional tool in financial regulation for identifying and understanding the sources of fragility in the financial system and addressing them via engagement. Stress testing can be an important method for building resilience to climate change in the real economy, too.[100] It could be used in two ways: event-based or firm-based. The first approach would involve a scenario analysis related to the potential effects of climate change in a specific region or sector. The second would also include a scenario analysis related to climate-related events, but apply only to firms that are deemed to be systemic in the real economy. Scenarios would draw attention to key events, especially tail risks, and investigate how resilient the system, sector or firm is to potential disruptions.[101] This would require a granular and comprehensive understanding of climate hazards, exposure (through owned assets or supply chains), and vulnerability. The results would expose adaptation gaps and lead to engagement with the relevant firm, sector, or region to close these gaps, i.e., developing an adaptation plan or taking necessary resilience measures, if possible (so-called corrective measures).[102] Of course, authorities that are tasked with stress testing and adaptation engagement must weigh the relevant costs and benefits of various potential strategies before mandating their implementation. Some adaptation measures may also require substantial financial assistance for firms that are otherwise unable to undertake the relevant efforts (e.g., small and medium-sized firms).[103] However, in this way, this expense is better spent than on rescuing firms that failed to adapt to climate change, and prevents deadweight losses. Additionally, these firms may lack the means to identify and monitor the climate risks they face.

If firms have the capacity and means to both identify and address climate risks, this approach also prevents moral hazard when firms divert their investments to

[99] See also Levitin (2011), p 513.

[100] See also Van Loo (2022) (showing that 'stress tests are used more widely than is commonly assumed, reaching well beyond financial regulation' and arguing for improved design and wider deployment); Kovvali and Macey (2023).

[101] See BlackRock (2019), p 7 ('Scenarios draw attention to key factors that will drive future developments. This, in turn, can help in assessing how resilient an organization is against potential disruptions. Does it have the ability to adapt to the changes …? Does it have plans in place to mitigate the risks?').

[102] While I argue for a centralized stress test analysis for physical risk exposure, some have argued for standardized scenarios for firms' transition risk analysis. See Armour et al. (2021), pp 1135–38.

[103] Economically viable firms may also borrow from banks to adapt. When this is available, firms do not need to depend on government assistance. However, some firms may no longer be viable (e.g., adaptation is not possible). In that case, government assistance will be needed to help economic actors relocate based on distributional justice. Firms may also be financially constrained (e.g., they have already incurred debts and cannot borrow more, i.e., debt overhang).

projects other than resilience building in anticipation of government rescue.[104] In other words, proactive adaptation policies that build upon stress testing are needed to address moral hazard. To be sure, some market mechanisms, such as insurance where exposure to climate risk is priced, may provide a certain discipline and signal to economic actors that they should adapt and increase resilience. However, the role of insurance will ultimately and inevitably be limited.[105] For example, insurers cannot cover correlated risks, such as climate risks, without charging prices that are too high.[106] Furthermore, moral hazard discourages players from seeking insurance unless compelled. Municipalities and businesses must therefore be informed about climate hazards *and* required to assess and address their vulnerabilities, or be pushed to internalize the costs of non-adaptation (such as by mandating insurance for those at high risk) based on a relevant cost-benefit analysis. How exactly firms address the relevant risks may be left to their discretion, provided that vulnerability is mitigated.

In some cases, it may also be more efficient for the government to take the relevant adaptation measure that increases the resilience of multiple businesses and municipalities (rather than having each party incur separate costs).[107] The government can then recoup the costs through taxes on the beneficiaries (which solves the moral hazard problem). Furthermore, where one adaptation measure helps protect various economic actors from climate impacts, the government may need to implement this measure because collective action problems may prevent firms from making the relevant investment, as benefits are shared while costs are borne by only one party.[108] Again, government intervention here is *ex-ante* efficient compared to rescue measures, which can only be *ex-post* efficient.

Although theoretically sound, there are challenges associated with stress tests. Again, in the relevant form of stress testing, regulators must identify systemic/critical firms in the real economy *ex ante*, which, as elaborated above, is not an easy task.[109] More importantly, designing a credible stress test for climate-related physical risks may be difficult given the uncertainties surrounding the effects of climate

[104] It may be possible, however, to still defer to these firms' own risk assessment when they are judged to have access to superior capacity to gauge climate risk compared to governments. This may especially be the case for the largest multinational firms.

[105] This is due to several reasons, such as the relatively short-term horizon of the CAT models insurers use in their risk evaluation, the uninsurability of certain impacts and events, the limited availability of risk-sharing options, etc. See also Condon (2023), p 52.

[106] See, e.g., Kousky and Cooke (2012).

[107] For example, in a case where a river that is important for many businesses for various reasons is threatened by increasing drought and low water levels does not allow transportation, it may be more efficient for the government to undertake to deepen the river rather than for firms to adapt to the new reality by separately incurring various costs (such as using more expensive ships designed for low water levels, changing supply chains, etc.). Of course, the efficiency argument assumes that the government is well-functioning.

[108] In the above example, if a company undertakes the deepening of the river (assuming it can do so without government approval), the benefits will accrue to various firms using the river for business purposes, while the costs will be incurred by one company.

[109] See Dungey et al. (2022) (investigating the systemic importance of US non-financial corporations and analyzing the firm-specific characteristics that identify systemically important non-financial firms).

change and the relevant transmission mechanisms in the real economy.[110] This may result in situations where firms take measures based on highly speculative results, which may turn out to be unnecessary and therefore create a situation where it would have been better to spend resources on remedying actual losses *ex post*.

Therefore, the success of this policy ultimately hinges on the ability to generate verifiable and reliable climate risk-related information, and it is therefore crucial to build up the capacity 'to assess direct physical risks to assets on a local level – today and under different future climate scenarios … [and] also estimate knock-on effects, such as the impact on energy demand, labor productivity and economic activity.'[111] This is certainly easier said than done and is currently implemented to varying degrees in different jurisdictions.

In the US, government initiatives have been underway to improve access to climate-related data to facilitate exposure evaluation and adaptation decisions, but predominantly for the functions of financial regulators.[112] In the EU, the recent adaptation plan involves measures to increase (publicly available) sources on climate impacts and adaptation through initiatives such as the Risk Data Hub and the Climate-ADAPT platform.[113] Under this adaptation plan, a European Climate Risk Assessment has been published to assess current and future climate change impacts and risks relating to the environment, economy and wider society in Europe.[114] Furthermore, with the passage of the Climate Change Act 2008 ('CCA'), the UK has developed a framework for producing 'Climate Change Risk Assessments' and 'National Adaptation Programmes'. In addition, the CCA allows the government to request certain organizations to produce reports on the current and future predicted effects of climate change on their operations, as well as their proposals for adapting to climate change (known as 'Adaptation Reporting Power'). Notably, using this power, the government has asked 'essential service providers' (such as energy and transport suppliers) to report on their preparedness for climate change risks.[115] As stated above, this article generally proposes implementing this power pursuant to 'stress testing' the economy or systemic firms.

[110] For the data challenges associated with hazards, exposure, and vulnerability, see Caldecott et al. (2021). See also Batten et al. (2016), pp 19 ff. ('designing a credible system-wide stress test for global climate-related physical risks remains a challenge given the uncertainties about the effects of climate change on weather events across the world and the transmission of weather-related disasters through the financial system'); Bolton et al. (2020), Chapter 3.

[111] See BlackRock (2019), p 2.

[112] Condon (2023), pp 45–56 (discussing the developments in the US, such as the Climate Data and Analytics Hub recently launched by the US Department of Treasury to assist with climate risk assessment and proposing a 'National Climate Service'). Recently, a report from the President's Council of Advisors on Science and Technology (PCAST) provided extensive recommendations to prepare the US economy for climate risks. See PCAST (2023).

[113] See Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Forging a Climate-resilient Europe – The New EU Strategy on Adaptation to Climate Change, COM/2021/82 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN.

[114] See European Environment Agency (2024). Member States also have their own adaptation plans.

[115] See generally https://www.gov.uk/government/publications/climate-change-adaptation-policy-information/climate-change-adaptation-policy-information (accessed 12 Feb 2025).

3.4 Enhancing the Framework for Government Relief

There is a well-known paradox: 'The government wants both to commit not to make bailouts and to be able to make bailouts if they are necessary'.[116] Even if certain steps are taken to induce firms to identify and address climate-related risks, these may not be workable, forcing governments to retain the option of sectoral, regional or firm-level relief. Furthermore, the inherent uncertainty regarding climate risks means that complete resilience may not be achievable, necessitating *ex-post* interventions.

In that case, we need a framework to ensure that any government relief program is fair, proportionate and efficient. As hinted above, policymakers generally enjoy discretion in deciding which firms are to be relieved or rescued and under what conditions. Untrammeled discretion can undermine the function of government rescue as a last resort and increase moral hazard if governments are not strict in their policy. In particular, politically strong firms can lobby for state aid without any actual justification. Or policymakers can make bailout decisions to cater to their constituencies even if those decisions are not efficient. Firms may be tempted to manipulate the system by making themselves appear 'too important to fail' or at least appear to do so by threatening mass layoffs, etc. In principle, bailouts should be rare; therefore, they should not be handed out easily so as to prevent firms from regularly expecting them, creating conditions for their occurrence and developing accordingly socially undesirable incentives.[117]

In the EU, state aid rules are meant to ensure that firms do not gain unfair advantages through government assistance. This framework also safeguards the notion that bailouts – a form of state aid – are not unjustified and remain proportionate.[118] However, as long as the relevant aid only compensates for damage suffered due to a climate impact, it will be exempt from the requirements for notification and Commission approval.[119] Nevertheless, some high-level rules still govern this exemption.[120] Furthermore, in emergency situations, the Commission is known to adopt

[116] Casey and Posner (2016), p 536.

[117] See also ibid., p 530; Levitin (2011), p 499 (distinguishing between Type I (false positives – too many firms will be deemed critical) and Type II (false negatives – too few will be deemed critical) errors in bailouts).

[118] See also Eidenmüller (2023), p 15 (arguing that *ad-hoc* bailouts remain strikingly underregulated and proposing the introduction of 'Principles on Ad Hoc Bailouts of Critical Firms'); Eidenmüller and Valbuena (2021), pp 523–535 (discussing certain principles that ought to govern bailouts).

[119] Treaty on the Functioning of the European Union, *supra* n. 72, Art. 107(2). See also Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty, Section 8 (also known as the General Block Exemption Regulation, which, in turn, derives from the authority conferred by the Council of the European Union on the Commission, see Council Regulation (EU) 2015/1588 of 13 July 2015 on the application of Articles 107 and 108 of the Treaty on the Functioning of the European Union to certain categories of horizontal State aid).

[120] Ibid.

new guidelines.[121] While they still uphold the notions of the state aid framework in the EU, the rapid decision-making involved in such situations may result in hasty Commission decisions that are later found, by the court, to be incompatible with state aid rules.[122]

Rescue measures are generally controversial, although there may be good reasons for them, and governments can recover, and even profit from, their investments in ailing firms.[123] Given that the relief provided to these firms means that taxpayers shoulder the associated losses, questions of fairness abound. This public backlash makes it generally difficult to implement bailout decisions, even when they are efficient. These concerns are generally alleviated if bailouts remain proportionate (providing no more assistance than necessary to alleviate distress) and if corporate insiders do not profit from the bailout (this is usually the case when managers lose their job and shareholders are wiped out, but they retain the previous (distributed) profits resulting from excessive risk-taking). Furthermore, if firms comply with a robust risk management framework, this should mean that rescue efforts are not a result of any corporate wrongdoing or negligence, but rather stem from the unpredictability of climate risks.

However, to alleviate the burden on taxpayers and on governments that otherwise incur substantial debts themselves (which, in the worst-case scenario, trigger the 'doom loop'), a useful approach is to require firms to pay *ex ante* for the state relief they may receive *ex post*. More concretely, this will involve creating an *ex-ante* rescue fund to which firms contribute and from which they can draw when they suffer from climate-related events. This may be especially useful when there is a high likelihood of *ex-post* relief in the event of distress (as in the case of systemic firms or when exposure and vulnerability to a climate risk may affect many firms simultaneously). This is similar to a deposit insurance scheme, where banks (and, by extension, depositors) pay a premium *ex ante* for a guarantee in the event of *ex-post* distress or to a resolution fund formed by *ex-ante* contributions to assist *ex-post* distressed financial institutions.[124] Unless corporations can pass on the costs related to contributions to the resolution fund to their customers, this could translate into greater shareholder liability than would be the case under the classic limited liability of shareholders. Even if there is no pricing regulation (which exists, for example, for

[121] See, e.g., Communication from the Commission Temporary Framework for State aid measures to support the economy in the current COVID-19 outbreak, 2020/C 91 I/01 (which was amended, for the first time, on 3 April 2020 (OJ 2020 C 112 I, p 1) and, for a second time, on 8 May 2020 (OJ 2020 C 164, p 3) (setting out additional temporary State aid measures relating to the COVID-19 pandemic that it considers compatible under Article 107(3)(b) TFEU, which can be approved very rapidly upon notification by the Member State concerned).

[122] For example, recently, the General Court found the German government's relief package for Lufthansa during the COVID-19 pandemic to be incompatible with the Guidelines the Commission provided (see ibid.), although it was notified to and approved by the Commission. See Court of Justice of the European Union, Press Release No 75/23 (Luxembourg, 10 May 2023), https://curia.europa.eu/jcms/upload/docs/application/pdf/2023-05/cp230075en.pdf (accessed 12 Feb 2025).

[123] Levitin (2011), p 496 (indicating some recent bailouts and stating that '[i]n most cases, the government broke even or made substantial profits on loans and other investments; and the bailed-out firm or industry recovered'). See also Weisman (2014); Speed and Georgiadis (2022). Cf. Lucas (2019).

[124] Financial Stability Board (2014), p 12.

firms in the utility sector), competition in the relevant market may make it difficult to increase prices. Therefore, these costs will reduce profits, thereby affecting the residual claims in the firm for shareholders (in a sense, making them liable for these costs). On the other hand, when costs are passed on to customers and consumers, such policies may become inflationary, creating credibility problems and requiring political mastery to convince voters of their necessity.

This solution has also been adopted for utility firms in California. These firms are critical, and are subject to climate-related risks (heatwaves), which, when materializing, can bring these firms into distress. Accordingly, the California Legislature has set up a rescue fund to which relevant firms pay a certain contribution before becoming distressed and from which they can draw after they have become distressed.[125] Obviously, there may be a question regarding the sufficiency of the resources available under the rescue fund – a question which has also arisen over previous years in the context of rescue funds for financial institutions. Nevertheless, such a set-up has two benefits. First, it shifts the burden back (though partly) from taxpayers to firms (and potentially their customers). Relatedly, it may reduce or eliminate moral hazard if firms' contributions are tied to their risk weighting (i.e., firms that are riskier and more likely to require financial assistance contribute more). This will be possible as a result of stress testing, which can help pinpoint firms' vulnerabilities or risk-weighting. As firms come to bear the financial consequences for their risk management, this will also incentivize their investors (shareholders and creditors alike) to monitor them. However, the difficulty of determining which firms should contribute to such funds remains. There is a risk of both under-inclusiveness and over-inclusiveness, as well as the possibility that firms may strategically avoid inclusion when it is determined on the basis of certain objective criteria (i.e., when the marginal cost of avoiding the threshold is lower than the marginal cost of contributing to the fund).

4 Climate Risk and Corporate Governance

This last section discusses whether and how corporate governance can contribute to aligning the incentives of corporate actors (i.e., shareholders and directors) with the social interest in climate change adaptation. I do not view either institutional investors or directors as strong monitors with the appropriate and sufficient incentives to build resilience and adapt to climate change in investee companies, which, in turn, strengthens the case for external regulatory discipline.

4.1 Monitoring by Institutional Investors as Shareholders

Institutional investor stewardship has a long history of being viewed as a remedy for corporate ills. In particular, the fact that, as diversified shareholders, institutional investors prioritize portfolio returns over the value of individual investees

[125] See nn. 88–90 above.

creates incentives to internalize inter-firm spillovers.[126] Indeed, one might posit that because these investors prioritize their portfolio returns, they may be particularly averse to the failure of systemic/critical firms, lest this spills over to other investee firms.[127] In other words, in a probability-weighted scenario, the wider losses in the economy that these investors incur due to the failure of systemic/critical firms may be larger than the firm-level gains brought by excessive risk-taking. This will, in turn, incentivize them to monitor and engage with these firms to hedge against failure, in this article's context, against climate risks. Interestingly, for example, the UK 2020 Stewardship Code for institutional investors requires its signatories to identify and respond to systemic risks, which are defined as 'those that may lead to the collapse of an industry, financial market or economy and include but are not limited to climate change; and the failure of a business or group of businesses.'[128] Indeed, this provision seems to encourage institutional investors to engage with the risk that the failure of investee companies (for example, due to climate change) harms the wider economy.

However, this overlooks a crucial point: that governments can be reasonably expected to rescue critical/systemic firms. If this is the case, even if investors are focused on maximizing portfolio value, they may not care about downside losses because the government will rescue the critical/systemic firm, preventing ripple effects across the economy. This point holds even if current shareholders are totally wiped out in a bailout: what matters to them is that there are no spillovers to the wider economy associated with the collapse of a systemic/critical firm, which is prevented by a government rescue.[129] Therefore, a strategy relying on portfolio value-maximizing investors to prevent externalities from the failure of systemic/critical firms would not work.[130] This is consistent with the evidence that greater shareholder power in banks was correlated with poorer performance during the financial crisis.[131] A counter-effect may arise from the reputational impact of a scenario in which a systemic firm fails and institutional investors, as shareholders, are identified as ineffective monitors. This may increase regulatory and societal scrutiny of institutional investors, as occurred after the global financial crisis of 2008. To avoid such a situation, these investors may have incentives to engage with the management

[126] See, e.g., Hansen and Lott Jr. (1996).

[127] Cf. Armour and Gordon (2014).

[128] See Financial Reporting Council (2020), p 11. The Code is now under review and will be revised. The proposed Code under consultation retains the principle that signatories must identify and respond to systemic risk, but removes the reference to climate change and the failure of a business or group of businesses as sources of systemic risk. This should not be an issue, as these are inherently systemic risks and signatories would be expected to identify them as such and engage with them. The consultation and proposed Code are available at https://www.frc.org.uk/consultations/stewardship-code-consultation/ (accessed 12 Feb 2025).

[129] Institutional investors, however, internalize the costs of bailouts indirectly. States' financing of bailouts may come from increased tax or borrowing via sovereign debt, which may negatively affect those investors to a certain extent.

[130] In the context of systemically important financial institutions, some scholars argued for opting out of limited shareholder liability. See, e.g., Conti-Brown (2012); Schwarcz (2014); Romano et al. (2020).

[131] See, e.g., Ferreira et al. (2021).

regarding (climate) resilience. However, as the repeated failures of systemic firms demonstrate, such incentives appear to be weak.

In any case, a central posit is that climate change poses a systematic risk for institutional investors, with climate impacts affecting various asset classes and many regions and sectors where substantial investments are made. This should at least incentivize them to focus on adaptation in large investee businesses to mitigate any adverse financial impacts or exit investments that are under substantial climate risk, if possible. However, since governments are likely to provide relief to firms and the economy affected by climate impacts, such incentives will be reduced to the extent that financial losses are thereby prevented. Thus, institutional investors may be subject to the same moral hazard problem.

4.2 Monitoring by Directors

Directors of a company are primarily responsible for overseeing company management and supervising business risks. Therefore, they are the natural corporate actors responsible for ensuring that their companies adapt to climate change-related impacts and build resilience, if possible. Various incentive mechanisms exist for directors, ranging from personal consequences and civil liability, to criminal liability.

The failure of a firm may lead to personal consequences for directors (e.g., job loss and reputational damage), especially during a government rescue of large or systemic companies.[132] This can give them certain incentives to monitor excessive risk-taking or to hedge against risks that could otherwise lead the company into distress.[133] Yet, it is often corporate management that is under the spotlight when firms fail and receive government assistance. Directors, not being in the driver's seat, may avoid the stigma associated with failure. Furthermore, there may be a significant time gap between decision-making, the end of tenure, and the results of those decisions. Even though climate change has already had effects, its impacts will primarily materialize in the long term. The strategic decisions that companies make today (e.g., where to allocate capital, how to arrange supply chains, where to build assets, etc.) may affect their resilience to climate change down the road; but by then, directors may have left office and retired.[134] This problem helps to avoid bearing reputational or other consequences (such as job loss) that make them accountable for their decisions and blurs the allocation of responsibility for the firm's distress or failure

[132] See, e.g., Friedman and Kraus (2011) ('It would not be logical for any self-interested bank executive to run a bank into the ground because of his or her belief that it would then be bailed out if she would then be fired (and, if compensated with equities, wiped out)'). When a firm fails otherwise due to bankruptcy, corporate management faces similar consequences. See, e.g., Eckbo et al. (2016).

[133] See, e.g., Schwarcz (2017), p 768 ('[t]he idea that [too big to fail] causes systemically important firms to engage in morally hazardous behaviour is … antithetical to managerial incentives').

[134] On the average tenure of directors, see, e.g., Tonello (2020) (noting that 'average tenure for seated directors is 9.7 years in the larger companies of the S&P 500 index and only slightly lower (9.5 years) among the broader Russell 3000 index. By way of comparison, the average tenure of directors at the largest companies in the United Kingdom's FTSE index is 4.1 years').

due to climate impacts.[135] Granted, the directors who took office later may identify certain problems with the previous strategy, but once certain decisions are made, it may be very difficult to change course for various reasons, such as path dependencies, high costs, and capital constraints.

It does not help either that directors are granted stock-based compensation, which has become increasingly common to enhance the monitoring incentives of the board of directors.[136] Resilience is a long-term investment for firms, whereas stock-based compensation shortens the time horizon to the date when the stock is expected to be liquidated (even when the stock is restricted).[137] To be sure, long-term risks will be reflected in the current stock price; however, this is only true to the extent that investors can reasonably price in those long-term impacts. Under information asymmetry, investors are unaware that managers sacrifice long-term value for short-term value in their own interest and thus cannot price in the long-term value loss. This is particularly relevant regarding climate risks. Corporate management will have more information about the risks the company is facing (with regard to asset location, supply chains, vulnerabilities etc.). This means that investors cannot fully price in exposure to long-term climate impacts, thus allowing managers to allocate resources to investments that boost short-term value for their own interests but sacrifice long-term value due to a lack of resilience.[138] Relatedly, another problem arises with stock options where corporate managers benefit from the upside if the stock price improves but do not bear the downside when the stock price goes down. This introduces a bias in that managers undervalue investments that protect against value loss, but do not generate additional value.[139] This is also true for investments aimed at adapting and increasing resilience to climate change. Furthermore, substantial investment in resilience may reveal that the company is subject to significant climate risks, which can reduce the stock price and is thus not in the interest of managers.[140] Stock-compensated directors have the same incentives as those managers and may therefore fail in their monitoring efforts.[141]

To be sure, mandated disclosure of climate-related risks may, to some extent, address information asymmetry. However, this requires strong private and public

[135] This is a similar problem to the case of the DuPont pollution scandal, where company management that made a series of decisions resulting in significant environmental (and human and livestock) harm were long gone by the time the damage became fully evident. See Shapira and Zingales (2023).

[136] See, e.g., FW Cook (2024), p 8.

[137] See Armour et al. (2020), pp 21–25 (discussing the shortened management horizon due to the liquidation of stock awards and resulting underinvestment in compliance).

[138] This can be done in two ways; (i) firms may allocate capital to other projects rather than improving resilience; or (ii) firms can choose projects that offer more short-term value and less resilience over those that provide less short-term value and more resilience.

[139] Armour et al. (2020), pp 25-26 ('… the manager is indifferent to the benefits to shareholders of activities that reduce the loss suffered to the firm in bad states (such as investment in compliance, or more generally, insurance against low-probability, high-impact events)').

[140] Ibid., pp 26–31 (discussing this in the context of investments in compliance).

[141] Ibid., pp 37–38 ('… unless [directors'] time horizons are substantially longer than those of the managers, they are unlikely to function effectively in reducing managerial agency costs in the form of the time-horizon problem'). For directors, stock options remain rare, and therefore the problem of upside bias is less of an issue. See FW Cook (2024), p 10.

enforcement, which is likely to be lacking. In addition, strict enforcement requires, on the part of enforcers, a better knowledge of the climate risks that firms face and are aware of or should have been aware of. This means that building public capacity regarding climate hazards, exposure and the vulnerability of economic actors can strengthen corporate incentives by making it more difficult for corporate insiders to benefit from information asymmetry. Last but not least, as long as investors and firms can expect some relief in the event of climate impacts, for example, as part of a large relief package, financial losses will be alleviated and thus any impact on the stock value will be muted.[142] This means that moral hazard may prevent any positive effect that market pricing may have on managerial/directorial incentives to build resilience.

One might consider introducing targets regarding resilience and adaptation goals in the compensation of executives and directors, in line with the currently popular ESG-based remuneration. However, in many respects, this is a fraught exercise. First of all, for such targets to be effective, they need to be specific. However, corporate management and directors have incentives to set generic targets that are easy to achieve. Shareholders may push for more specific targets through say-on-pay, but they may suffer under information asymmetry (i.e., corporate management has better information on vulnerabilities than shareholders) and moral hazard (i.e., shareholders may be reluctant to compensate managers and directors for resilience when they expect potential losses to be absorbed by the government, as argued above). Secondly, compliance with such targets is not easily verifiable and may result in performance-insensitive pay. Thirdly, in a scenario where resilience enhances firm value (by preventing decreases in revenue, asset damage, etc.), corporate management is already compensated through financial targets. Therefore, adding a specific resilience-related target may lead to double compensation.

So, directors have questionable non-financial and financial incentives to address climate impacts in their companies. What about the potential civil and criminal liability for directors? In terms of civil liability, violations of the duty of care and the duty of loyalty are relevant.[143] However, in both cases, liability is very weak.[144] First, regarding the duty of care, the decisions made by directors will be protected by the business judgment rule and will therefore receive the utmost deference in most jurisdictions.[145] Furthermore, such liabilities can be exculpated and are usually

[142] However, the situation may be different in the rescue of a systemic firm. In such cases, shareholders may be wiped out (including shareholdings held by directors), or their holdings may be significantly diluted when the government invests equity (again, diluting holdings by directors).

[143] For a comparative study of climate change and directors' duties, see Climate Governance Initiative and Commonwealth Climate and Law Initiative (2022).

[144] Some argued in favor of expanding directors' liability in cases where a firm's behavior imposes negative externalities on others. See, e.g., Armour and Gordon (2014) (in the context of systemically important financial institutions); Kovvali (2021) (discussing a focused liability regime that will hold the directors and officers of corporations running essential businesses liable if they fail to prepare for crises).

[145] The business judgment rule means that courts will not second-guess the board's business decisions, even if those decisions harm company value, absent evidence of gross negligence or bad faith. The relevant contours of the test vary depending on the jurisdiction. See generally, Armour et al. (2017), pp

insured.[146] With respect to the duty of loyalty, oversight duties and failure to act in good faith are pertinent. A complete failure to address climate risks specific to the company that the directors knew or should have known about may constitute an infringement of the good faith requirement and thus the duty of loyalty.[147] In Europe, however, private litigation concerning the duty of loyalty is not common.[148] In Delaware, where enforcement is the strongest, *Caremark* and its progeny have gained increased relevance.[149] Known as the *Caremark* duties, the board is responsible for putting in place an information and oversight reporting system that allows the board and management to receive accurate and sufficient information regarding the company's compliance with the law.[150] This may help hold the board accountable when corporations face significant liability for non-compliance. While relying on the *Caremark* duties has proven to be very difficult (requiring as much as 'bad faith'), recent judgments have shown that these duties may have wider applicability.[151] However, it is an open question whether they will apply when companies face substantial liabilities due to non-adaptation.[152] Granted, climate risk is a business risk subject to oversight, but it is not entirely clear yet whether *Caremark* extends to cases where business risks have been ignored, rather than to cases involving non-compliance with the law.[153]

The question of criminal liability also arises in cases of egregious conduct that causes harm to life and property. Theoretically, directors may be criminally liable

Footnote 145 (continued)

69–71. For Delaware law, which insulates managers the most (coupled with liability waivers and insurance), see *Aronson v. Lewis*, 473 A.2d 805, 812 (Del. 1984); *Van Gorkom*, 488 A.2d, at 872. Recently, in a closely watched case, the England High Court rejected ClientEarth's and other shareholders' claims against Shell's directors for failing to address climate risk (albeit in the form of transition risk rather than physical risk) on grounds similar to the business judgment rule. The ruling is available at https://www.judiciary.uk/wp-content/uploads/2023/07/ClientEarth-v-Shell-judgment-240723.pdf (accessed 12 Feb 2025).

146 See, e.g., Del. Code Ann. tit. 8, § 102(b)(7) (2021).

147 Climate Governance Initiative and Commonwealth Climate and Law Initiative (2022).

148 Gelter (2012) (examining why shareholder derivative suits remain rare in Europe).

149 Although the original *Caremark* decision formulated monitoring obligations under directors' duty of care, subsequent case law has characterized them as part of their duty of loyalty. See *Stone v. Ritter*, 911 A.2d 362, 362 (Del. 2006). This also means that breaches of these obligations cannot be exculpated.

150 *In re Caremark Int'l Inc. Derivative Litig.*, 698 A.2d 959 (Del. Ch. 1996). The design of the compliance oversight system is left to the board's business judgment. *Id.*, at 970.

151 See, e.g., Shapira (2021).

152 The PG&E Fire Victim Trust – a fund responsible for compensating survivors of the recent wildfires in California – sued PG&E directors for breaching their fiduciary duty by failing to put in place critical safety measures despite being aware of the dangers posed by the company's deficient measures and infrastructure. PG&E assigned its claims against the former board members and officers to the Fire Victim Trust. However, the case has been resolved through a settlement which is to be funded entirely with proceeds from D&O insurance. See Solis (2022). It should be noted that, as PG&E was incorporated in California, Delaware law was not applicable.

153 Williams (2021), pp 1892-93 and 1903-08. In two cases arising from the global financial crisis of 2007-08, claims of this sort (i.e., failure of the board to properly oversee business risk) failed. See *In re Citigroup Inc. S'holder Derivative Litig.*, 964 A.2d 106, 131 (Del. Ch. 2009); *In re Goldman Sachs Grp., Inc. S'holder Litig.*, No. CIV.A.5215, 2011 WL 4826104 (Del. Ch. Oct. 12, 2011). *Cf. Marchand v. Barnhill,* 212 A.3d 805 (Del. 2019). See also Shapira (2022); Bainbridge (2021-22).

if their decisions not to build resilience to climate risks ('inaction') or to disregard them ('action') are classified as criminal acts. Yet, this liability is subject to onerous requirements of criminal liability, and the low probability of meeting these requirements (in terms of both the chain of events required for the liability and the conditions for the liability) results in a minimal deterrent effect.[154]

5 Conclusion

The ever-looming threat of climate change subjects firms around the world to substantial risks. Acute weather events and long-term shifts in climate are placing economic actors in distress. Significant adaptation gaps exist, creating a pressing need to enhance resilience in the economy. This article has argued that governments are highly likely to extend widespread relief to ailing firms and make targeted interventions in critical firms in the real economy when they suffer climate impacts. While this may be efficient or driven by political motives, it is, in any case, not an ideal strategy and should rather play a residual role.

To prevent deadweight losses and moral hazard, an *ex-ante* policy aimed at building the resilience of economic actors is needed. This involves regulating the risk management practices of firms and providing some kind of discipline for firms to reduce their vulnerability to climate impacts. This article has discussed various ways of achieving this. These options range from climate risk disclosure and bail-ins to stress testing and adaptation plans; in other words, from enlisting nudges and market pressure to using regulatory sticks. Stress testing followed by engagement with relevant firms for adaptation provides a reasonable option for reducing the adaptation gap. This approach addresses the lack of information and adaptation capacity for some firms, while reducing the moral hazard for others. In any case, it avoids deadweight losses by reducing vulnerabilities to climate impacts. This discussion of external discipline is further strengthened by the questionable incentives of corporate actors, such as institutional investors and directors, to monitor resilience-building efforts in their companies.

Nevertheless, building complete resilience to climate change may not be achievable. Adaptation measures can be too costly. Some risks may be too unknown or speculative to prepare for, and there may be imperfect implementation of regulatory or market discipline. All this means that there is a residual chance that government rescue of firms will be necessary. This indicates the need to ensure that bailouts are fair and efficient. This can be achieved through rules and principles governing *ad-hoc* bailouts and mechanisms that shift the financial burden back to firms, such as rescue funds capitalized by *ex-ante* contributions from relevant firms.

[154] See generally Coffee Jr. (2020). See also Garrett (2015) (documenting that '… far more often than not, when the largest corporations settle federal criminal cases, no individuals are charged'). PG&E, for example, was criminally prosecuted many times for its alleged role in causing blazing fires that cost lives and property; however, so far, there has been no substantial liability, even in cases where it pleaded guilty. See, e.g., Penn (2021). An internet search reveals no criminal proceedings against its top management and directors.

Climate change mitigation rightly attracts significant attention from market players, regulators, and scholars. However, there is an acute need to prepare for impacts that are inevitable and those that will become more likely as mitigation efforts lag. This article contributes to addressing this question in a socially optimal fashion.

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