CLIMATE CHANGE RISK: CHALLENGE FOR CORPORATE GOVERNANCE

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Abstract

The major research question of this paper is to analyze climate change risk as a challenge to corporate governance. Climate action failure was the environmental risk most frequently listed in the top ten country risks. It also becomes a major reason that many companies are taking their own initiatives on climate change action which poses an imminent challenge for corporate governance as boards of directors track and assess such initiatives by their own companies. Boards can play a key role in guiding their organizations into the next new normal in the wake of global pandemic, economic disruptions, and ongoing climate change problems. This paper identifies and studies the corporate governance risks and opportunities related to global climate change risk and provides recommendations to boards of directors. The major sections of this paper are global climate change risks, corporate climate change pledges, climate-related financial disclosures, major topics in the Global Climate Change report, whether companies are ready to manage major climate change risks and opportunities, climate-related investment benchmarks, and conclusions. Future research could investigate this climate change risk challenge with case studies or empirical studies.

Keywords: Climate Change, Risk, Corporate Governance

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1. INTRODUCTION

In three days of confirmation hearings with the U.S. Senate for a lifetime judgeship, U.S. Supreme Court nominee, Amy Coney Barret, declined to give her opinions about the cause of climate change, saying that she hadn't studied scientific data enough to offer an informed opinion and that climate change was a contentious matter of public debate. She was schooled by 17-year-old Swedish enviro-prodigy, Greta Thunberg, who likened the judge's restraint to lacking a view on gravity and other topics in science: "To be fair, I don't have any views on climate change, either. Just like I do not have any views on gravity, the fact that the earth is round, photosynthesis, nor evolution. But understanding and knowing their existence really makes life in the 21st century so much easier" (RT News, 2020).

Laurence Fink, CEO of BlackRock, with $7.4 trillion of assets under management, 70 offices in 30 countries, and clients in over 100 countries, wrote in his January 2020 annual letter to all major global public company CEOs that BlackRock would make investment decisions with environmental sustainability as a core goal and that BlackRock would begin to exit certain investments that present a high sustainability-related risk, such as those in coal producers. His intent was to encourage every company, not just energy firms, to rethink their carbon footprints. He wrote: "Awareness is rapidly changing, and I believe we are on the edge of a fundamental reshaping of finance. The evidence on climate risk is compelling investors to reassess core

assumptions about modern finance. As I have written in past letters, a company cannot achieve long-term profits without embracing purpose and considering the needs of a broad range of stakeholders. Ultimately, the purpose is the engine of long-term profitability. We believe that when a company is not effectively addressing a material issue, its directors should be held accountable" (Fink, 2020).

Michael Mann, one of the world's most eminent climate experts, agreed with Fink's emphasis on climate change risk and commented: "If we are going to avert ever more catastrophic climate change impacts, we need to limit warming below a degree and a half Celsius, a little less than three degrees Fahrenheit. Outsourcing environmental and energy policy to the polluters and dismantling protections would make that essentially impossible. It is a political statement because it speaks to the need to enact policies to deal with climate change, but it is also a scientific statement. The 1990s were the warmest decade in at least the last millennium" (Hertsgaard, 2020).

In October 2018, scientists with the United Nations' Intergovernmental Panel on Climate Change published a study, *Global Warming of 1.5 Degrees* (IPCC, 2018), which found humanity had to cut heat-trapping emissions roughly by half by 2030 to avoid catastrophic climate breakdown. Michael Mann summarized: "With the U.S. not making the dramatic reductions that were necessary to keep us on that path, now the incline is steeper. It's no longer 5% reductions a year for the next ten years; it's more like seven and a half per cent" (Hertsgaard, 2020, p. 3). As a comparison, 7% is how much global carbon emissions are projected to fall in 2020, due to the COVID-19 economic lockdowns that shrank driving, flying, and other carbon-intensive activities. However, there is no vaccine for climate change (Hertsgaard, 2020).

In face of this urgency, Mann broadly supports implementing a Green New Deal, which he defines as a vast governmental effort that deploys both regulations, such as no more coal-fired electric plants, and market mechanisms, such as carbon pricing to transition away from fossil fuels as rapidly as possible and tax credits for renewable energy projects. Five years ago, nearly 200 countries signed the Paris climate accord, a collective global response to tackle the climate crisis. Since it was signed, the five hottest years on record have been recorded, along with a cascade of disasters, from strengthening hurricanes and floods to significant growing wildfires (Hertsgaard, 2020). U.S. President elect, Joe Biden, has appointed a climate policy task force, which has already released a number of proposals, including moving all electric power plants off fossil fuels by 2035, increasing energy efficiency by upgrading 4 million buildings and 2 million homes over four years, installing 500 million solar panels in the next five years, and shifting major cities toward zero-transmission public transportation options (Harvey, 2020).

The urgent importance of governance for climate challenges has also drawn attention of scholars around the world. Cogan (2006) highlighted that "climate change is now a governance issue" and "climate change risk is now part of the director's job" (p. 3). Climate governance practices were assumed to have a significant role in corporate and investment planning. Using a sample of 98 firms in three industries across 10 countries, Galbreath (2010) examined the relationship between governance practices and climate-related risks. The findings were somewhat contradictory regarding board independence. Both firms with separate roles for CEO and board chair and firms with higher inside versus outside director ratio achieved better governance on climate change. Ben-Amar and McIlkenny (2015) documented a positive association between board effectiveness and the firm's decision to provide climate change disclosures, and the quality of such disclosures. In their subsequent study, voluntary climate change disclosure was found to increase with board gender diversity (Ben-Amar, Chang, & McIlkenny, 2017).

Liao, Luo, and Tang (2015) revealed that more independent directors and the existence of a board-level environmental committee led to a higher tendency to disclose greenhouse gas (GHG) information. Ko and Tai (2020) conducted an exploratory case study to investigate the climate change risk management of the transport industry in Hong Kong. They found that a higher level of board involvement and key elements of governance structure, such as accountability and transparency, played a significant role in effective climate-related risk management. Aguilera, Aragón-Correa, Marano, and Tashman (2021) reviewed the literature on corporate governance of environmental sustainability and recognized the fragmented nature of current research. They urged future research to employ a more integrated approach and study how different corporate governance actors may interact to shape environmental outcomes.

The major research question of this paper is to analyze climate change risk as a challenge to corporate governance. Our study speaks to the growing literature connecting corporate governance and climate changes and makes three main contributions. First, we provide the updated trend and phenomenon in the global climate change landscape, aiming to advance understanding of this emerging area and foster the integration of climate-related elements into corporate decision-making. Second, this paper offers an insight into the development of climate-related financial reporting and identifies areas for companies to implement the recommendations of Task Force on Climate-Related Financial Disclosures (TCFD). Third, drawing upon the CDP Global Climate Change report (CDP, 2019), we synthesize and assess the key strategic issues, risks and opportunities presented by climate changes. Such an effort is important to prepare companies and their boards for climate change adaptation and mitigation.

The structure of this paper is as follows. Section 2 presents the major global climate change risks. Section 3 discusses corporate climate change pledges. Section 4 discusses climate-related financial disclosures. Section 5 reviews the major topics in the Global Climate Change report. Section 6 investigates whether companies are ready to manage the major risks and opportunities related to climate change. Section 7 provides climate-related investment benchmarks. Section 8 summarizes and concludes the paper.

2. GLOBAL CLIMATE CHANGE RISKS

The rapid and widespread outbreak of COVID-19 has given the world an opportunity to test the hypothesis of whether and how an economic shutdown might affect climate outcomes. Initial data suggests that 2020 annual emissions could decrease by as much as 7% globally, due to the downward shift in energy demand worldwide. The resulting short-term cooling effect could last until 2025, even as economies reopen and travel restrictions are lifted. There may be shifts in the workforce that are more climate-friendly, such as working at home, maintaining online meetings, and doing less business travel. However, any gains in GHG emissions may be obviated by a return to business as usual and the fractured geopolitical environment in which alignment toward common goals has proven more elusive (Franco, 2020).

Without the support of the business community, real action on climate change may be a non-starter. The good news is that commitment to the environment is stronger today than it was in past years, and it may be possible to make climate change beneficial to business (Aguilera et al., 2021; Ko & Tai, 2020). Every year, the World Economic Forum conducts its Global Risks Report, polling thousands of the world's business leaders. Among other queries, the survey asks these leaders to identify the top risks for doing business in their countries over the next decade. The risks questions received 12,012 responses from 127 countries in the 2020 report (World Economic Forum, 2020).

The survey uses five categories of risk: economic, environmental, geopolitical, societal, and technological. The results showed that all five environmental risks included in the survey rose in the rankings and were among the top ten rising global concerns for businesses around the world. For the first time in the 15-year history of this survey, the five environmental concerns were the top five long-term risks by likelihood in order: extreme weather, climate action failure, natural disasters, biodiversity loss, and human-made environmental disasters. All five environmental risks were also in the top ten long-term risks by impact: 1) climate action failure, 3) biodiversity loss, 4) extreme weather, 7) natural disasters, and 9) human-made environmental disasters. Since the past five years have been the warmest on record, such environmental challenges demand collective action, but fractures within the global community appear to only be widening. While there is the need for more ambitious climate action, the United Nations warned that countries have veered off course when it comes to meeting their commitments under the Paris Agreement on climate change. The good news is that the window for action is still open, if not for much longer, as Michael Mann observed (World Economic Forum, 2020).

From the Global Risk Report, a sample of major countries by global regions showed that the top three risks came from the societal category (infectious diseases with the COVID-19 pandemic), the related economic category (fiscal crisis and asset bubbles), and the technological category (cyberattacks). This sample represented North America (the United States and Canada), Europe (Germany, France, the United Kingdom, and Sweden), East Asia and the Pacific (China, India, and Australia), Eurasia (Russia and Kazakhstan), South America (Brazil and Argentina), Africa (Nigeria and South Africa), and the Middle East (Saudi Arabia and Iran).

If the world can overcome these top social and economic risks of COVID-19, it will have not only succeeded in combatting a global pandemic but there will be the data and support necessary to continue the global transition to a green economy. Policy shifts will be a key challenge, such as public finance constraints, electoral incentives, and populist discourse risk reinforcing the flawed belief that there must be a trade-off between economic growth and climate action. COVID-19 is exposing how, when, and where the world can fast-forward to a new nature economy without losing sight of the related societal and technological challenges. The Global Risk Report showed that the world's business community is increasingly concerned with the future of the planet, even during a time in which boosting production and creating jobs is a priority (Franco, 2020).

Table 1 shows the five environmental risks used in the Global Risk Report and where in the top ten country risks these five environmental risks were ranked by this sample of major countries. Climate action failure was the environmental risk most frequently listed (six times) in the top ten country risks although both extreme weather and human-made environmental disasters were listed four times. Climate action failure is a major reason many companies are taking their own initiatives on climate change action which is a challenge for corporate governance as boards of directors track and assess such initiatives by their own companies.

Table 1. Regional environmental risk rankings: Environmental risks in the top 10 country risks

	Extreme weather	*Climate action failure*	*Natural disasters*	*Bio- diversity loss*	*Human-made environmental disasters*	
North America						
The United States			4			
Canada		6	10		9	
Europe						
Germany		9		10		
France		5			10	
The United Kingdom	3	5				
Sweden		8				
East Asia & Pacific						
China	8		4		5	
India				7		
Australia	5					
Eurasia						
Russia						
Kazakhstan						
South America						
Brazil						
Argentina						
Africa						
Nigeria						
South Africa		10				
Middle East						
Saudi Arabia	9				10	
Iran						
Average top 10 risk ranking	6.3	7.2	6	8.5	8.5	

3. CORPORATE CLIMATE CHANGE PLEDGES

Consistent with the World Economic Forum's Global Risk Report findings, global companies are making climate change pledges and targets. For example, the Business Roundtable (BR), a major trade association that includes the CEOs of some of the largest and most influential U.S. companies with more than 15 million employees and more than $7.5 trillion in annual revenues, is endorsing a market-based mechanism as part of a plan to sharply curb GHG emissions that cause climate change. The BR warned of the threats that climate change posed to the United States and said that although significant progress had been made to reduce GHG emissions, the uncertainty caused by the patchwork of state and federal efforts was hurting companies. The BR supports a goal of reducing net U.S. GHG emissions by at least 80% from 2005 levels to 2050 (Business Roundtable, n.d.).

Concerning a market-based mechanism, the BR called for putting a price on carbon with a carbon tax and/or cap-and-trade schemes, to reduce GHG emissions, since a clear price signal is the most important consideration for encouraging innovation, driving efficiency, and ensuring sustained environmental and economic effectiveness. Any revenues that come from such a market-based system should be used to support economic growth, reduce societal impact, and aid people and companies that are most negatively affected. Also, it should be linked with a doubling of federal funding for research, development, and demonstration of GHG reduction technologies (Colman, 2020).

Several high-profile BR non-financial companies, such as Amazon, Apple, Facebook, Google, Microsoft, and Walmart, have pledged to be carbon neutral by 2030 (Mandel, 2020). Another number of high-profile BR banks, such as JPMorgan Chase, Morgan Stanley, Citigroup, and Bank of America, have agreed to tally GHG emissions by companies or clients in their lending portfolios. For example, JPMorgan Chase and Morgan Stanley are urging their clients to reduce their global net emissions to zero by 2050, a key target in the Paris Climate Agreement. Also, 55 global banks, insurance companies, and financial firms, such as HSBC Holdings Plc, Societe Generale SA, BNP Paribas SA, ING Group NV, Credit Agricole SA, and MetLife Inc., have committed to setting climate goals specific to mortgages, bonds, and other asset classes in their portfolios to align with the Paris Climate Agreement (Chen, 2020). According to Eccles and Klimenko (2019), about half of the S&P companies addressed environmental, social and corporate governance (ESG) topics in their quarterly conference calls with investors and analysts and the percentage of shareholder resolutions focused on environmental and social issues has grown from 33% in the 2006–2010 period to over 50% by 2017, with climate change and other environmental issues as leading topics.

4. CLIMATE-RELATED FINANCIAL DISCLOSURES

How can one tell if a company will stay committed to its climate goals? Partnering with other companies and nonprofits shows a willingness to be held accountable. In July 2020, a group of corporations, including Microsoft, Nike, Unilever, Starbucks, Danone, and Mercedes-Benz launched an initiative, Transform to Net Zero, to share resources and strategies for achieving their climate targets. Also, many companies have joined the Science Based Targets (SBTs) initiative, a collaboration among the United Nations Global Compact, the World Resources Institute, the Worldwide Fund for Nature, the CDP, and the We Mean Business Coalition. This collaboration works to

define best practices and offer guidance to companies looking to align their targets with the latest science on climate change. Currently, 992 companies are part of this group (Mandel, 2020). These companies span over 60 countries and nearly 50 sectors[1]. The top 5 countries are: France, Germany, Japan, the USA, and the UK. Recent joiners include major global household names such as Facebook, Amazon and Ford. Boards of directors could check to see if their companies are participating in such coalitions and check progress toward climate change and reduction of climate risk for their companies.

At the request of the G20 Finance Ministers and Central Bank Governors, the Financial Stability Board established the industry-led Task Force on Climate-related Financial Disclosures in 2015. Based on the 2015 Paris Agreement on Climate Change, the European Union has agreed to ambitious targets for 2030, regarding GHG emission reductions, renewable energy, energy efficiency, and emissions targets for cars and vans. As a significant commitment to the Paris Agreement, the European Commission (EC) published new guidelines to improve how firms report climate-related information in 2019. Benefits for reporting companies include: increased awareness and understanding of climate-related risks and opportunities; a more diverse investor base and a potentially lower cost of capital; more constructive dialogue with stakeholders (particularly investors and shareholders); and an enhanced corporate reputation and maintenance of social license to operate (European Commission, 2019). The Commission recommends that companies read the 2019 Guidelines alongside the relevant national legislation and its *Non-Binding Guidelines on Non-Financial Reporting.* The 2019 Guidelines, like the 2017 Guidelines, are non-binding, and companies may report climate-related information differently provided the legal requirements are met. While the guidelines paved the way to modernize the policy framework for environmental activities, companies and financial institutions have a critical role to play in the transition to a low-carbon and climate-resilient economy. For example, weather-related disasters caused a record 283 billion euros in economic damages in 2017 (European Commission, 2019).

Based upon research of the Fortune Global 500 companies, the TCFD has helped increase the focus on corporate climate action from many different stakeholders by measuring and reporting climate change risk. This research also found that commitments to carbon neutrality frequently complimented SBTs and 100% renewable power goals. The Fortune Global 500 companies have over $8 trillion in revenues and 18 million employees. 42% of the European headquartered companies and 25% of U.S. headquartered companies are acting or are publicly committed to climate action. One quarter of these companies have made a public commitment that they are, or will be, carbon neutral by 2030, using 100% renewable power or meeting an SBT emission reduction target. Since the Paris Agreement in 2015, four times as many companies have taken climate change action (from 31 companies to 114). This research suggests that if the growth continues in a similar way, by 2030, 79% of the Fortune Global 500 could be carbon neutral or be using 100% renewable power or have an SBT for internal emissions reductions (Natural Capital Partners, 2019).

CDP is a not-for-profit international organization, based in the United Kingdom. It supports companies and cities to disclose their environmental impacts and aims to make environmental reporting and risk management a business norm. In recognition of both the TCFD and the EC focus on climate-related information, CDP committed to align its information requests with the TCFD's recommendations and the EC's guidelines to support the generation of decision-useful climate information. In the CDP Global Climate Change report, 6,937 companies participated and were identified by region and industry (CDP, 2019). The largest region responders were Europe (1,813 companies), the United States of America (1,784 companies), China (750 companies), and India (710 companies). Of the 14 industries, the largest ones were manufacturing (2,312 companies), services (1,193 companies), materials (760 companies) and food, beverage & agriculture (689 companies).

There were seven key findings from the CDP Global Climate Change report (CDP, 2019; Sorkin, 2019):

- Companies are identifying significant risks but need to expand their analysis.
- The biggest companies (the world's 500 largest companies by market capitalization) report major financial implications.
- The opportunities are bigger than the risks.
- Differences are striking across countries and regions.
- The finance sector is seeing more implications than the real economy.
- The wins far outweigh the costs of management.
- Companies and investors need to learn lessons from the power sector.

Concerning this last key finding, the major lesson learned from the power sector is that it has the only companies who reported both higher costs to manage risks and to realize opportunities than just the implications of the risks and opportunities. The risks being reported were a mixture of physical risks (damage to assets because of climate impacts or lack of water resources in the future), as well as the transition risks associated with the low-carbon transition (these included market and technology risks and were not overly focused on the pricing of GHG emissions alone). Since the assets in this sector are long-lived and require significant capital investments, these companies had to undergo business model changes to align with structural shifts in the energy system overall from fossil fuel to non-carbon energy sources. Companies that did not integrate low-carbon transition risks into their strategies early will be facing higher risks than what were initially planned. Also, the CDP report found:

- The largest 500 global corporations potentially face roughly $1 trillion in costs related to climate change in the decades ahead unless they take proactive steps to prepare.

[1] Here is the link to access the full list of companies which joined the Science Based Targets initiative: https://sciencebasedtargets.org/companies-taking-action

• These world's largest companies estimated that at least $250 billion of assets may need to be written off or retired as the planet heats up.

Many of these companies estimate that such financial risks could emerge in the next five years.

5. MAJOR TOPICS IN THE GLOBAL CLIMATE CHANGE REPORT

The CDP Global Climate Change report stated that the demand for climate-related information is growing. Understanding that inadequate information can lead to the mispricing of assets and a misallocation of capital, more and more financial decision-makers are demanding information on the business risks and opportunities associated with climate change. The CDP report summarized its findings by four major topics: governance, strategy, risk management, and metrics and targets (CDP, 2019).

5.1. Governance

One cannot manage what one does not measure, and where responsibility for climate change sits within a company can be an indicator of just how seriously a company is taking this issue. CDP has seen a positive correlation between board-level oversight and management responsibility for addressing climate risks and opportunities and a company's commitment to action. 73% of companies reporting to CDP confirmed that they have board-level oversight of climate-related risks. Despite being the second largest proportion of the reporting sample, the U.S. company average was just below the 60% global average of board-level oversight.

5.2. Strategy

With climate change impacts already hitting companies across the globe, an increasing focus is being placed on both actual and potential climate-related risks and opportunities. Faced with growing scrutiny, companies need to show their stakeholders that they are integrating these potential changes into their business strategies and focusing on the long-term. Faced with growing climate risks, 72% of these companies said they now integrate climate risk into their business strategy. European companies led the pack while U.S. companies fell below this global average at 65%.

5.3. Risk management

Using scenario analysis is a key focus for risk management in the TCFD's recommendations. Approximately half of the companies (3,397) reporting to CDP were asked to report on their scenario use. 1,436 (42%) of these companies said they were using scenario analysis and another 1,138 (34%) anticipate doing so in the next two years. The major types of scenario analyses are a publicly available physical scenario, a publicly available transition scenario, or an internally developed scenario using such publicly available data.

The most common physical risks are:

• the increased severity of extreme weather risks;

• changes to precipitation and weather patterns;

• rising mean temperatures.

The most common transition risks are:

• increased pricing of GMG emissions;

• mandates on and regulation of existing products and services;

• enhanced emissions-reporting obligations;

• changing customer behavior.

Most companies (513) only used transition scenarios, compared to only 127 companies using physical scenarios. This was surprising given the high number of physical risks that companies identified in their risk analysis. Once a company has identified its risk, it is also vital that it examines just how it will manage these climate-related impacts on its business. Of the entire 6,937 companies reporting to CDP, 3,783 (54.5%) said that their processes for identifying, assessing, and managing climate-related issues were integrated into multi-disciplinary risk management processes. This is an important step in escalating climate-related issues from a siloed, or isolated department, issue to a company-wide issue. Importantly, it means raising climate change as an issue for legal, risk, and financial departments.

Data users need to understand which risk types are considered in climate-related risk assessments. Since not all risk types are relevant for each organization, it is important to regularly assess risk types to determine if they may pose a substantive risk to the business. The following types of risk ascertain how thoroughly companies are examining multiple risk types in the comprehensiveness of their risk management (presented in order of magnitude):

• current regulation (90%),
• emerging regulation (75%),
• legal (73%),
• reputation (72%),
• market (69%),
• acute physical (61%),
• technology (58%),
• chronic physical (52%).

Understanding a company's time frame for risk analyses provides insight into the thoroughness of its assessment procedures. Companies that frequently assess risk and examine risks far into the future should be better equipped to handle longer-term uncertainties and liabilities. 26% of all the reporting companies monitor risk every six months and 20% monitor risk annually with a majority looking from 3 to over 6 years into the future.

5.4. Metrics and targets

To meet growing investor and lender demands, a company also needs to disclose its metrics and targets for assessing and managing its climate-related risks and opportunities, including calculating its emissions and reporting progress against its climate targets. The CDP report used scope 1, 2, and 3 emissions in analyzing the carbon footprint of companies. Scope 1 emissions are direct emissions produced by the burning of fuels by the emitter. Scope 2 emissions are indirect emissions generated by the electricity consumed and purchased by the emitter. Scope 3 emissions are indirect

emissions produced by the emitter activity but owned and controlled by a different emitter from the one who reports on the emissions (www.acciona.com).

The CDP report analyzed the scope 1 emissions for the 6,937 companies who reported to CDP. The three largest industry sectors that had scope 1 emissions were:

- 146 power companies accounted for over 2.8 billion metric tons;
- 583 materials companies accounted for 2 billion metric tons;
- 111 fossil fuel companies accounted for 1.1 billion metric tons.

The next largest sectors were manufacturing and transportation services which emitted 900 million and 800 million metric tons of scope 1 emissions, respectively. All the other sectors emitted less than 200 million metric tons, and the mineral extraction sector only emitted 100 million metric tons. 3,610 companies (52%) reported that they have an absolute and/or intensity emission target in place. Absolute reduction refers to the total quantity of GHG emissions whereas intensity compares the amount of emissions to a unit of economic output, like revenues or number of employees. Only 2,407 (67%) of these companies disclosed enough data for their emission reduction targets. More of these companies just set intensity, rather than absolute, targets. Only 1,349 companies (19%) set multiple targets across all three scopes (CDP, 2019).

6. MAJOR CLIMATE CHANGE RISKS AND OPPORTUNITIES: ARE COMPANIES READY FOR CLIMATE CHANGE?

Climate change has created both risks and opportunities for businesses. Many firms disclosed direct impacts from climate change. For example, the fossil fuel and mineral extraction industries had relatively straightforward calculations of potential costs from an increase in taxes designed to curb emissions of carbon dioxide, a major GHG that contributes to global warming. Accordingly, such costs are one of the most common climate-related risks that companies now disclose. More challenging for fossil fuel, mineral extraction and other industries are stranded assets threats. For example, Total, a French energy company, warned that ambitious efforts by nations to limit global warming and restrict fossil fuel use could render some of its oil and gas reserves unburnable or stranded. BASF, a German chemical company, said it has a significant corporate carbon footprint that could scare off environmentally conscious shareholders unless it takes steps to act on climate change.

It is trickier to take scientific reports about rising temperatures and weather extremes and predict what those broad trends might mean for specific companies in specific locations. For example, Hitachi, a Japanese manufacturer, said that increased rainfall and flooding in Southeast Asia had the potential to knock out suppliers and it was taking defensive measures as a result. Banco Santander, a large Brazilian bank, said increasingly severe droughts in the region might hurt the ability of borrowers to repay loans. Alphabet, Google's parent company, noted that rising temperatures could increase the cost of cooling its energy-hungry data centers. Pacific Gas and Electric (PG&E), California's largest electric utility, said that the rise in wildfire risk in the American West, partly driven by global warming, could create significant financial risks and costs if it were held liable for the fires. In the CDP report, PG&E estimated the potential impact from wildfires at $2.5 billion. However, demonstrating the difficulties of such climate change disclosures, PG&E filed for bankruptcy protection in 2019, saying it now faced up to $30 billion in fire liabilities shortly after its power lines sparked what became California's deadliest wildfires (Plumer, 2019).

On the positive side, the CDP report found that many companies see moneymaking potential in climate change. 225 of the world's 500 largest companies highlighted $2.1 trillion of possible opportunities from climate change with the majority expected to materialize within the next five years. These estimated $2.1 trillion benefits exceeded the potential risks of $970 billion by $1.13 billion resulting in a positive benefit/cost outcome. Such financial figures were linked to increased revenue through demand for low carbon products and services and a better competitive position to reflect shifting consumer preferences. Opportunities were linked to direct operations, concentrated around reduced operating costs through efficiency gains and cost reductions, and a better competitive position to reflect shifting consumer preferences.

So, are companies ready for climate change? The Global Climate Change report analyzed this important question, using the report sections: the risks of climate change, the opportunities related to climate change, and industries under the microscope, as follows (CDP, 2019).

6.1. The risks of climate change

This report section listed the top ten financial impact drivers by company counts:

- increased operating costs, e.g., higher compliance costs and increased insurance premiums: 1,729 companies;
- reduced revenue from decreased production capacity, e.g., transport difficulties and supply chain interruptions: 1,359 companies;
- increased operating costs, e.g., inadequate water supply for hydroelectric plants or to cool nuclear and fossil fuel plants: 773 companies;
- reduced revenue from decreased demand for goods/services: 656 companies;
- reduced demand for goods/services due to shift in consumer preferences: 584 companies;
- increased capital costs, e.g., damage to facilities: 508 companies;
- increased production costs due to changing input prices, e.g., energy and water, and due to changing output requirements, e.g., waste treatment: 438 companies;
- increased costs and/or reduced demand for products and services resulting from fines and judgments: 325 companies;
- costs to adopt/deploy new practices and processes: 279 companies.

There were four categories reported by company counts for financial implications of these major risks:

• identified being exposed to substantive risks: 3,659 companies;
• identified risk driver type: 3,507 companies;
• disclosed financial impact drivers: 3,465 companies;
• provided potential financial impact figures: 2,185 companies.

From the largest 500 global corporations, 215 companies reported a significant, total potential impact to their businesses of over $970 billion. They disclosed that potential financial impacts of transition risks outweighed physical risks by a ratio of 60 to 40. The top four drivers of potential risk impacts were:

• increased operating costs, due to higher compliance costs, increased insurance premiums, etc., at $179 billion;
• the write-off of assets or their early retirements because of potential damages to them being in high-risk locations at $170 billion;
• reduced demand for goods and services due to a shift in consumer preferences at $102 billion;
• changes in policy leading to write-offs, asset impairment, and early retirement of existing assets at $73 billion.

Although just below the 279 companies' cutoff for the top ten financial impact drivers, the CDP report discussed the issue of stranded assets. 168 companies identified the potential write-offs, asset impairment, and early retirement of existing assets, due to policy changes. Another 134 companies identified the potential for write-offs and early retirement of existing assets due to physical risks of property and assets in high-risk locations. Only eight fossil fuel companies disclosed potential financial impact drivers associated with stranded assets, but the aggregated potential financial impact amounts were over $11 billion. The likelihood of these impacts varied quite substantially from unlikely to virtually certain. Also, the world's 500 largest companies reported $252 billion of potential losses from stranded assets.

6.2. The opportunities related to climate change

This report section listed the top five opportunities, affecting both the customer and direct operational parts of the supply chain, by counts:

• products and services: 4,300 opportunities;
• resource efficiency: 2,000 opportunities;
• energy source: 1,500 opportunities;
• markets: 1,000 opportunities;
• resilience: 500 opportunities.

Concerning financial implications of these substantive opportunities, the same four risk categories were used and reported by company counts:

• identified being exposed to substantive opportunities: 3,543 companies;
• identified opportunity driver type: 3,382 companies;
• disclosed financial impact drivers: 3,361 companies;
• provided potential financial impact figures: 1,958 companies.

From the largest 500 global corporations, 225 companies reported significant potential opportunities for their businesses of $2.1 trillion, which exceeded the potential risks of $970 billion by $1.13 billion. Thus, there was a positive benefit/cost outcome. The top four drivers of potential opportunity impacts were:

• increased revenue through demand for low emissions products and services at $970 billion;
• better competitive position to reflect shifting consumer preferences at $487 billion;
• increased revenue through new solutions for adapting to needs at $236 billion;
• increased capital availability as more investors favor low-emissions producers at $198 billion.

Just over half of the reporting companies identified potential climate-related opportunities that could have a substantive or strategic impact on their business. 35% said that they did not foresee such opportunities while 10% noted that they had identified opportunities but are unable to realize them. European headquartered companies identified the highest number of opportunities while U.S. headquartered companies had roughly the same number of companies report opportunities as those who did not. For the industry sectors, companies in the financial services, fossil fuels, and power industries reported higher average rates than the overall average while companies in the apparel, mineral extraction, food, beverages and agriculture, manufacturing, services, and transportation all reported lower than average opportunities. Dlugolecki and Loster (2003) explained why climate change is relevant to the financial services industry and studied the climate-related opportunities for different segments within the industry, including commercial banking, insurance, asset management, project finance, and professional services. The variation across other industries reflects the evolving trends to address climate change, including decarbonization, energy efficiency development, and product solutions supporting "*Innovating to Zero*" (Koch, 2020).

Concerning potential financial impacts from climate change, every major region had more opportunities than risks. In the two largest regions, Europe reported $1.297 trillion of opportunities versus $641 billion of risks for a favorable benefit/cost outcome of $656 billion and the United States reported $453 billion of opportunities versus $110 billion of risks for a favorable benefit/cost outcome of $343 billion. All the global industries had positive benefit/cost predictions from climate change, except infrastructure and transportation which had small relative, negative results of $30 billion and $20 billion, respectively. The five largest global industries all had positive results over $100 billion as follows:

• financial services at $700 billion;
• manufacturing at $300 billion;
• services at $150 billion;
• fossil fuels at $116 billion;
• food, beverage & agriculture at $110 billion.

6.3. Industries under the microscope

In analyzing potential financial impacts, the CDP report discussed six industry sectors which were like the previous ones with the largest favorable benefit/cost outcomes: financial services, manufacturing, fossil fuels, infrastructure, materials,

and power. For example, half of the fossil fuel industry companies in the largest 500 global companies provided financial figures for the risks and opportunities they identified[2]. They reported a positive benefit/cost outcome of $116 billion which CDP found surprising. These companies identified opportunities from their low-carbon transition in terms of new products and services they could bring to the market, ranging from renewables, hydrogen, and biofuels to carbon capture and storage and natural gas.

At the same time, most of the risks they reported were linked to increasing policy, particularly GHG pricing. They did not report many significant risks as a result of this transition to low carbon, which they viewed as an opportunity, even though it could result in reduced demand for their products from market changes or consumer preferences, such as the switch towards electric vehicles, increasing reputational risks, as well as potential shifts in their costs of capital. While energy transition may take decades to complete, energy markets are impacted on a much shorter time scale, due to increasing uncertainties, changing risk preferences of fossil fuel investors, and changes in the economy of energy markets (Grove & Clouse, 2020).

Investors, stakeholders, and boards of directors should be investigating such climate challenge risks for companies in all these industries. For example, there may be increasing operating costs, such as higher compliance costs or increased insurance premiums, due to physical impacts of climate change and increasing water scarcity and reputational risks. However, there may also be climate opportunities, particularly focused on consumers, linked to increased revenue through demand for low carbon products, services and a better competitive position to reflect shifting consumer preferences. Also, there may be opportunities linked to operations focused on reduced operating costs with efficiency gains (Grove & Clouse, 2020).

7. CLIMATE-RELATED INVESTMENT BENCHMARKS

An October 2020 McKinsey & Company report addressed the importance of corporate governance in these times of the coronavirus pandemic, resulting in economic impacts, and climate change. Even before the spread of the coronavirus, investors and other stakeholders were calling on senior management and corporate boards to focus on ESG concerns. They were prompting companies to pay more attention to the impact of their actions on the environment. In the wake of the global pandemic, economic disruptions, and ongoing climate change problems, boards of directors play a key role in guiding their organizations into the next new normal. This may well be the moment when boards and leadership teams prove their value or show their flaws. About 70% of all activist and institutional investors' demands over the past decade have focused on governance (Birshan, Goerg, Moore, & Parekh, 2020).

KKR is a leading global investment firm that manages $235 billion of multiple alternative asset classes, including private equity, credit, and real assets. It has offices in 20 cities across four continents and 753,000 people employed worldwide by its portfolio companies. In an October 2020 interview, Henry Kravis, co-founder, co-chairman, and co-CEO, said that whenever KKR investigates a possible company acquisition, it analyzes ESG issues to make sure the company is well positioned, especially on climate change, regulatory, and government issues (Kravis, 2020).

Similarly, the McKinsey report concluded that shareholders and stakeholders continue to make it clear that the impact of any business on the environment and society matters to them. To head off such concerns, senior management and boards of directors should regularly review their portfolios of business activities and map their impact on major global initiatives. For example, a growing number of companies benchmark themselves against the UN's Sustainable Development Goals (Birshan et al., 2020).

Other benchmarks could use the Task Force on Climate-Related Financial Disclosures or metrics from the Sustainability Accounting Standards Board. If shareholders and stakeholders have common benchmarks with which to measure companies, they can put pressure on boards of directors and senior management to clean up their acts. Then attention will be paid to key environmental issues that were once called "externalities" because they sat outside traditional economic models and accounting frameworks (Tett, 2020).

The growing number of companies that have pledged carbon zero or neutral goals could benchmark themselves against the CDP Global Climate Change report findings. This report included 6,937 companies that disclosed the risks and opportunities that climate change could create for their businesses. Concerning the key governance topic of board-level oversight of climate change, the global average was 60%. Also, there was a positive correlation between board-level oversight and management responsibility for addressing climate risks and opportunities and a company's commitment to action. 73% of companies reporting to CDP confirmed that they have board-level oversight of climate-related risks. Concerning the key strategy topic of integrating climate risk into business strategy, the global average was 72%. Similar results were found for the key topic of metrics and targets, primarily for scope 1 emissions.

8. CONCLUSION

Climate change has risen to be the defining crisis of our time. As United Nations Secretary-General António Guterres pointed out at 2019 Climate Action Summit, "the climate emergency is a race we are losing, but it is a race we can win" (Guterres, 2019). Moody's has estimated the potential economic damage from the rising temperatures caused by carbon emissions at seven times the costs of dealing with the coronavirus outbreak. Emphasizing a long-term focus, it is high time to start flattening the curve on an impending climate

[2] Currently there is no mandatory framework for reporting climate-related risks and opportunities. However, with growing pressure from investors, continued social attention globally, policy focus from regulators, and emerging support for TCFD reporting, it is largely expected that majority of the companies will provide consistent and meaningful disclosure about climate-related risks and opportunities and their responses.

emergency with a bonus of quadrupling the returns within a decade. The World Bank has calculated that a $1.8 trillion investment by 2030 concentrated in five categories: 1) weather warning systems, 2) infrastructure, 3) dry-land farming, 4) mangrove protection, and 5) water management would yield $7.1 trillion in benefits (Chakhoyan, 2020). Faith Birol, the executive director at International Energy Agency (IEA), is confident in society's ability to transition to cleaner energy and has outlined five key trends for optimism:

1. Solar is leading renewables to new heights.
2. Today's crisis means interest rates will stay lower for longer.
3. More governments are throwing their weight behind clean energy.
4. Companies are stepping up.
5. Innovation is gathering steam.

Our paper studies the recent development in climate change and analyzes the climate change risks as a challenge to corporate governance. First, according to 2020 Global Risks Report conducted by the World Economic Forum, issues related to global warming, such as extreme weather and biodiversity loss, were ranked as the top five risks for doing business over the coming decade. This was the first time one category has occupied all the top slots since the report was launched in 2006. Consistent with these report findings, global companies are making climate change pledges and targets.

Second, our findings suggest that more specific disclosures of climate change risks and opportunities will help meet information needs of investors and stakeholders. There were monumental efforts to improve how firms report climate-related information worldwide, including TCFD established in 2015 and the reporting guidelines published by the European Commission in 2019.

Third, in its 2019 Global Climate Change report, CDP provided a high-level analysis of the 6,937 companies that responded to the climate change questionnaire. These companies acknowledged that the demand for decision-useful climate information is growing. The report summarized the findings by 14 major industries and four major topics: governance, strategy, risk management, and metrics and targets, and uncovered the market needs and trends in response to climate change.

Fourth, for the challenge of strengthening corporate governance, we recommend boards of directors utilize the trends identified in the CDP report and assess whether their companies are really stepping up to address climate change. Are they treating climate change as a major risk and/or opportunity, like the discussions in the CDP report? For example, several major oil companies have announced plans to turn themselves into lower-carbon energy businesses and advance offshore wind, hydrogen, and carbon capture. Several of the world's giant tech companies are also investing in renewables and areas like energy storage and fuel cells (Birol, 2020).

In addition, companies are encouraged to develop more wisdom in dealing with the risks and opportunities of climate change to benefit their investors and other interested parties (Grove & Lockhart, 2019). In developing such wisdom, Jamie Dimon, JPMorgan Chase CEO, observed: "It is long-term thinking, real policy with real facts and analysis, not guessing and not looking year-over-year. The year-over-year stuff has just become a waste of time and caused us to make really dumb decisions" (Smith, 2020).

Our paper is limited to the fundamental development of climate change risk and related corporate governance challenges. Future research could explore the impact of different corporate governance dimensions on environmental strategies and disclosures. Another avenue is to use case studies and board interviews to investigate the adoption and implementation of governance practices to address climate change risk.

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