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Risks

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Abstract

This study proposes a novel managerial framework for strategic management in response to climate change that is based strongly on a risk-management perspective. We first argue that climate change has unique characteristics that pose unprecedented challenges to firms and managers. Our managerial framework then focuses on how firms can improve performance and reduce future volatility of financial returns by (1) identifying the risks associated with climate change, (2) assessing the climate risk impacts on the strategic objectives of the firm, (3) integrating the risk assessment findings into strategic decision making, and (4) implementing measures to mitigate the risks and exploit new opportunities. Each component of this Climate Risk Planning framework is accompanied by a detailed discussion of the relevant theoretical foundations and is illustrated with examples and suitable strategic decision-making tools.

Introduction

On November 30, 2015, the largest gathering of heads of state ever to attend a United Nations meeting convened in Paris.¹ The reason for this unique summit of leaders was the desire to finalize a global accord to combat the problem of climate change within the United Nations Framework Convention on Climate Change (UNFCCC). In a groundbreaking display of unity, 195 countries accepted the final climate agreement, paving the way for concerted international efforts to reduce the emissions of greenhouse gases.² The commitments made by political leaders are based on broad scientific consensus that anthropogenic greenhouse gas emissions are altering our planet's climate in unprecedented ways and are leading to rapid changes in long-standing climate patterns around the world,³ and global average temperature is increasing at a faster rate than had been anticipated by many climate researchers.⁴ As a result, climate change is widely expected to have a fundamental, global impact on our economic, political, and social systems, and a growing number of business and government leaders are openly acknowledging that it will become one of the most significant “grand challenges” human civilization will face in the coming decades.⁵ This development has especially profound ramifications for firms as they are the major organizational forms of economic activities in our society and face unique challenges from climate change due to the variety of concurrent risks and stakeholder pressures it creates.⁶

Not surprisingly, a growing number of leaders from the private and public sectors, from civil society and the military are acknowledging the potentially dramatic threat to our current economic and political systems presented by climate change. As Anthony Zinni, former head of the US Central Command asserted: “We will pay for this one way or another. We will pay to reduce greenhouse gas emissions today, and we’ll have to take an economic hit of some kind. Or we will pay the price later in military terms. And that will involve human lives.”⁷ The US military,

an organization that is particularly skilled in the sophisticated assessment of risks, recently ordered all of its commanders to incorporate climate change into all aspects of their decision-making to increase “climate resilience” of the armed forces.⁸ Specifically, in a report prepared by the Department of Defense for the US Congress, the military stressed that “Global climate change will aggravate problems such as poverty, social tensions, environmental degradation, ineffectual leadership and weak political institutions that threaten stability in a number of countries.”⁹ It further emphasized that “the ability of the United States and other countries to cope with the risks and implications of climate change requires monitoring, analysis and integration of those risks into existing overall risk management measures, as appropriate for each combatant command.”¹⁰

Similar arguments were made at the aforementioned historic UN climate conference in Paris in 2015, which one of the authors of this paper attended to conduct field research. Several world leaders, including UN Secretary General Ban-Ki Moon, US President Barack Obama and German Chancellor Angela Merkel emphasized the risks climate change poses to all aspects of our society and economic future. Although many of the speeches focused on macro-level risks to countries and the global economy, many of the same risks are even more relevant for companies and their operations. While 93% of publicly traded firms in the US (corresponding to \$33.8 trillion in market value) are confronted with direct or indirect risks from climate change, only 12% of those companies have divulged those risks publicly.¹¹ Moreover, climate change is of particular concern for investors, as the CEO of SASB stated, “Climate risk is real and embedded across a portfolio, and as such, investors cannot diversify away from climate risk by divesting.”¹² Similarly, only 28% of S&P Global 100 companies had conducted an evaluation of the impact of climate change on their business and only 18% confirmed implementing specialized climate risk assessments.¹³ Despite the fact that only a small percentage of firms that face climate risks

currently engage in sophisticated climate risk analyses, there is a growing demand—among investors and managers—for formalized and systematic approaches that can help conceptualize firms’ strategic responses to climate risks. As Brian Cahill, a managing director at Moody’s credit rating agency put it: “there is a real hunger for knowledge” regarding climate change-induced risks in the business community.¹⁴

However, despite the increasingly salient effects of global climate change on companies and the growing demand among managers and investors for knowledge on how to prepare for it, strategic management scholars have largely neglected how firms and managers can respond optimally to climate change-induced risks and how climate change will affect current business models, firm strategy and performance.¹⁵ Only a small number of recent articles explicitly discuss climate change,¹⁶ illustrating the lack of attention by business scholars to this important issue, particularly from a risk management perspective. Moreover, prior work largely has not elevated the unique characteristics of climate change that are the result of fundamental and unpredictable changes in the natural environment on a scale humanity has not experienced before.¹⁷ Climate change presents an unprecedented combination of interdependent risks to firms, introduces high levels of uncertainty along a variety of concurrent dimensions into the decision making process of firms, and involves varied impacts that occur both immediately and over a much longer time horizon than managers typically consider.

In our paper, we address this underexplored area of research by first delineating the unique nature of climate change and the unprecedented challenges it will present to firms. Our managerial “Climate Risk Planning” framework provides a conceptualization for how firms can assess climate risks and respond to them, thereby developing a modified strategic approach that is centered on integrating risk management. The framework is therefore firmly anchored in a risk management

perspective and captures the entire process for a company's strategic response to climate change (see Figure 1).

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While many consulting firms such as McKinsey & Co. have published advice to businesses on how to confront climate risk, including calling on businesses to create a “comprehensive risk-management strategy,” our framework explores *how* exactly this strategy can be implemented in various types of industries.¹⁸ Climate risk-management cannot consist merely of insufficient adaptation measures that are implemented after “normal” businesses decisions are made. Specific implementation measures regarding climate risk-management must be fully integrated into business decisions from the start. Indeed, while many corporations discuss climate change as an abstract, unknown future problem, many do not incorporate climate risk into their management practices yet.

At the center of this Climate Risk Planning framework lies the identification and strategic assessment of climate risks, followed by the integration of risk analysis results into a firm's strategy decision making. The final step of the framework includes the implementation of strategic measures carefully selected based on the risk analysis and integration activities, to mitigate the climate risks the firm faces and to take advantage of new strategic opportunities. We argue that these efforts will result in improved firm performance and reduced volatility of financial returns. At each step of our framework, there is potential for firms to outperform their competitors (or conversely fail to do so), starting with the degree to which a firm identifies and analyzes its exposure to climate risks. Thus, our framework for firms' strategic responses to climate change depicts each element of how firms can address climate risks and explicates the variation in impacts of climate change on firm performance.

The Unique Strategic Challenge of Global Climate Change

“Climate change is unlike any other environmental problem, really unlike any other public policy problem. It’s almost uniquely global, uniquely long-term, uniquely irreversible, and uniquely uncertain – certainly unique in the combination of all four.”¹⁹ This succinct assessment motivates our argument that climate change poses a unique challenge not only to our society but also to firms and managers, and their strategic decision making. Our proposed framework—while drawing on existing managerial theories—encompasses a novel conceptualization of strategic management that is adapted for a world shaped by climate change. In the following, we delineate the two main reasons for why climate change requires a distinctive approach to strategic management: (1) climate change—through its systemic nature—raises the complexity and interdependency of risks companies face in an unparalleled manner and on a scale not experienced by human societies before, and (2) climate change increases the levels of uncertainty in firms’ business environment in an unprecedented way. Moreover, these two issues are compounded by the fact that the impacts of climate change on firms occur with varied time horizons (e.g., climate risks manifest themselves both in the short-term and over decades-long periods).

The complexity and interdependency of climate risks

First, climate change-induced risks have the potential to affect virtually every aspect of a firm’s business environment concurrently, which stands in contrast to other risks—often more narrow in scope—that companies usually face. As a report on climate change-related risks by PricewaterhouseCoopers explains: “What is changing is the complexity of the risks, their interdependence with other risks and the wide-reaching, contagious impact they have (e.g. global price rises) ... Often overlooked, climate change adds to complexity. It amplifies or alters existing risks, for example raw material availability (e.g. water, energy) or transport disruption due to

extreme weather events ... So climate change is a ‘risk multiplier.’”²⁰ Consequently, firms will have to incorporate the additional complexity of risks they will face because of climate change into their strategic decision making. The systemic nature of climate change and the interdependent risks it presents are presented in Figure 2 and captured in our strategic climate change risk matrix depicted in Table 1.

--- Please see Figure 2 and Table 1 ---

We classify these interdependent climate change risks into three different categories that act on two levels: the global level and the firm level. The first risk category encompasses the direct physical effects of climate change on the natural environment of firms (field I in Table 1). Examples of direct/physical risks on a global level include among others a rise in sea levels and temperatures, increased flooding and droughts, more frequent extreme weather events (e.g., heat waves, tropical storms, torrential rainfall, etc.), and higher humidity in the atmosphere.²¹ These risks translate directly to the firm level by, for instance, posing potential threats to firms’ physical assets and existing production processes. For example, in 2016, Coca-Cola was forced to halt their production of canned drinks in Namibia in response to the severe drought in southern Africa,²² and more recently American Airlines was forced to ground planes in Arizona due to extremely high ground temperatures.²³ The effects of climate change on the natural environment then create and magnify risks in our economic, political, and social systems, thereby becoming the root cause for the two other main risk categories we identify: (1) value chain risks (field II in Table 1) and (2) external stakeholder risks (field III in Table 1). For example, increased frequency of droughts may increase pressure from community stakeholders, especially for firms that use substantial amounts of fresh water. Similarly, climate change impacts might raise the likelihood of regulation, such as

carbon taxes and more unpredictable weather and frequent storms increase the disruption of supply chains.

While we have classified these risks into three categories to emphasize that they act upon multiple aspects of a firm, it is also important to note that in many cases, the risks in different sub-categories are related and interdependent. As a result, climate change acts as a “risk multiplier” as noted above, significantly exacerbating a variety of different risks. For example, product market pressures can be a motivating factor influencing investor activism and regulatory changes can affect energy and other input prices. The interdependencies are cross-cutting and multi-layered such that there is a complex system of risks associated with climate change that have the potential to affect all aspects of a firm’s operations and strategy.

The uncertainty caused by climate change

The second reason that climate change is a unique strategic challenge is that it introduces very high levels of additional uncertainty into the strategic decision making of firms.²⁴ There are three types of perceived uncertainty about a firm’s environment faced by managers: state uncertainty (unpredictability about the relevant conditions in their firm’s competitive environment), effect uncertainty (the inability to predict the impact that environmental changes will have on their firm), and response uncertainty (lack of knowledge about the available responses or their impact).²⁵ Importantly, climate change acts as a multiplier by increasing all three types of uncertainty and reinforcing interactions between them.

The additional uncertainty will also make the assessment of climate risks more difficult, because the world’s climate is a complicated system and trying to predict the exact locations and timing of climate change-induced effects, therefore, proves challenging.²⁶ This is one reason why climate scientists often provide a range of potential scenarios that model different possible

consequences of climate change.²⁷ Because climate change affects the entire planet, the magnitude of uncertainty faced by any given firm—which will depend on the industry and geographic location—could significantly alter the decision criteria the firm has to consider when developing its strategies.

For instance, as the frequency of severe floods is expected to grow in many parts of the world, selecting the right location for key assets (such as production plants, logistics hubs, etc.) will become much more critical. This task will be particularly complicated by the heightened uncertainty about where and how often these floods might take place and will require more sophisticated planning for contingencies. A recent example can be found in the devastating flood that occurred in the state of Louisiana in the US in August 2016 due to unusually high levels of rainfall.²⁸ An estimated 6,000 firms were impacted by the flood, resulting in up to US\$5 billion in economic damages for the private sector.²⁹ Many of the affected firms were not adequately prepared (e.g., numerous businesses did not have flood insurance) due to the historic rarity of such floods in the area.³⁰ However, although the flood was characterized as a 1-in-500-year event by the US National Oceanic and Atmospheric Administration, it was the eighth extreme weather event in the US that received this classification in a 12-month period.³¹

Similarly, severe droughts can lead to the shortage of water for firms that depend on it. For companies that rely on a steady supply of water for their operations (e.g., for electricity generation, crop cultivation, industrial production), the expected rise of severe and prolonged droughts as a result of climate change will raise uncertainty and pose additional challenges. The recent multi-year drought in California that started in 2011 provides a powerful instance of the adverse effects firms in a variety of industries can suffer from droughts, particularly with respect to their future strategic planning. The strategic challenges firms can face include the reduced availability of

resources for manufacturing processes, higher costs of production factors, uncertainty about the availability of factor market inputs, a forced drop in output, and less reliable and more costly energy (e.g., the Californian drought imposed additional costs of \$1.4 billion on electricity consumers from 2011 to 2014 due to a reduction in hydropower generation).³² The future uncertainty about the persistence, magnitude, and recurrence of such droughts due to climate change exacerbates such strategic challenges for firms.

The increase in frequency and severity, and the underlying increase in uncertainty, are not limited to floods and droughts but apply to all climate-related events, including severe storms, winter storms, wildfires, and cyclones.³³ While there are forecasts of the increasing frequency of such events across the board, the impacts will be location- and company-specific. As a recent report on climate change by BlackRock, a prominent investment firm, points out, “The physical effects of climate change are hard to model, and their impact is likely disparate across geographies.”³⁴ (BlackRock has begun evaluating firms based on their climate change planning, a necessary step towards ensuring that companies in their portfolio have at least considered climate risk-management.)³⁵ The issue of higher uncertainty due to climate change is particularly relevant in an increasingly global economy, where a larger share of firms rely on international supply chains. Within this economic system, small, localized supply disruptions can reverberate throughout global supply chains and negatively impact industry output around the world negatively.

The uncertainty associated with climate change is not limited to the physical impacts of climate change. Firms are facing increasing uncertainty about the other risk factors included in Table 1, including regulations, technology, consumer preferences, and stakeholder action. While these examples are far from all-encompassing, they illustrate that the uncertainty resulting from

climate change has the potential to fundamentally alter current business practices and strategic firm behavior, a development for which many firms are ill-prepared. Moreover, while it can be argued that firms have to deal with uncertainty on a daily basis and that there are market mechanisms in place to help them address it, the unprecedented scope and magnitude of uncertainty exceed the more specific and manageable uncertainties that strategic decision makers are accustomed to addressing.

Finally, the challenges to strategic management posed by the systemic risk and unprecedented levels of uncertainty climate change introduces are further compounded by the varied time horizons of climate change impacts on firms, occurring both in the short-term and in the long-term. While some impacts, such as increased droughts, temperatures, frequencies of storms, carbon regulations, and some stakeholder action have already started to manifest themselves, others, such as large scale consumer preference shifts and limited access to raw materials, maybe years or even decades in the future. These varied time horizons, combined with uncertainty of climate risk impacts, lead to challenges for strategic decision making, as typical valuation and assessment models (e.g., net present value calculations) not only require assumptions about when impacts will occur, but also substantially discount the distant future, potentially leaving the firm unprepared for the effects of climate change. There are multiple reasons why managerial decision-making sub-optimally discounts long term impacts, including managerial opportunism, stock market short-termism, and a tendency for management to ignore issues where they lack tangible, quantifiable impacts.³⁶

Currently, U.S. firms are not required to disclose information on climate-related risks in any public financial statements or information regarding how they plan to integrate these risks into their management framework. While an increasing number of public companies have chosen to

disclose their exposure to climate risks in the past decade, this information varies widely.³⁷ However, in 2022, the Securities and Exchange Commission proposed a rule that would require public companies to disclose decisions made by a corporation's board and management regarding climate-related risks and their risk-management process.³⁸ Specifically, the rule will require public companies to disclose how they anticipate climate change will impact both specific line items as well as the company's business model. If finalized, these types of disclosures would allow for both public access to comparable information across firms on their climate risk management practices and encourage firms to further consider a Climate Risk Planning framework.

The aforementioned factors make climate change a unique challenge for managers and lead to a lack of action on the part of managers, owing to cognitive biases in corporate decision making.³⁹ In the following section, we present our novel framework for how firms can respond to climate risks systematically to overcome the impact of some of these biases.

Strategic Management in the Age of Climate Change: A Risk-based Framework

Risk management perspective

We derive a Climate Risk Planning framework for strategic management in response to climate change that is organized around the analysis, integration, and mitigation of climate risks. We develop the framework represented in Figure 1 to explain how the impact of climate change on firm performance will depend on the actions taken by firms to systematically incorporate climate change risks into their strategic decision-making process. Rather than consider risk management efforts tangential to their main strategic efforts, firms that pursue successful strategic responses to climate change will analyze climate risks in light of their competitive position and strategic goals, and engrain the risk management approach deeply into their strategic decision making.

Identification of climate change risks

The first step towards eventual integration of the climate change risks described in Table 1 into a firm's strategy is the recognition and identification of these risks. The failure to take measures to comprehensively identify climate risks could adversely affect firms' performance and future strategic direction. Unfortunately, even though many firms face climate risks, most firms do not explicitly identify and quantify them.⁴⁰ Many managers fail to take account of the risks because the risks are so widespread and systemic, and there is uncertainty about impacts and timing.

Firms therefore often ignore these complex and multi-dimensional risks until they experience the direct effects of climate change or are forced to comply with new regulation. Only when faced with such a "triggering mechanism" will firms start devoting managerial attention and resources to determine the urgency and feasibility of addressing the risk.⁴¹ Climate change will increase the number of ecological "surprises" that cause shocks to the economic system.⁴² These shocks in turn draw the attention of managers and stakeholders to the complex reality of future strategic challenges for the firm, potentially leading them to invest in assessing and creating strategies to deal with these challenges.

For example, extreme drought in Malaysia in 2014 led to water rationing (limiting use to every other day) and increased electricity prices. Local glove manufacturers TopGlove Corp and SuperMax Corp, two of the world's largest rubber glove manufacturers, were faced with the choice of reducing production or trucking in water at ten times the usual cost.⁴³ This forced the firms to reassess their risk exposure caused by droughts, evaluate the water sources available at each production facility, and pursue efforts to increase water and electricity efficiency. The same holds for Coca Cola, which was forced to stop drawing ground water for use in its bottling plant that

served most of Southern India in 2003 after dramatic community protests over water use culminated in a court order.⁴⁴ After the significant disruption of production due to community activism, Coca Cola instituted a widespread program to identify and assess water-related risks. As these examples illustrate, responding only retroactively to “trigger events” brought about by climate change can be detrimental for firm performance as it can force firms to implement sub-optimal, reactive measures that disrupt their strategic objectives.

Firms that proactively collect information and monitor their climate change-related risk exposure are better positioned to respond. Firms facing competitive environments that are more dynamic, uncertain, and “hostile” that conduct strategic analyses tend to be more successful.⁴⁵ On the other hand, firms that fail to allocate resources to risk evaluation are ill-prepared for the climate risks that they face, and are more likely to pursue strategies that are vulnerable to disruption by climate-related events.⁴⁶

Our framework proposes that firms proactively conduct a comprehensive identification of climate risk exposure on a regular basis. Using the categorization provided in Table 1, firms can collect the information necessary to identify the types of climate change-related risks to which they are exposed, and quantify both the magnitude and likelihood of these risks. These risks will vary across industries (risks faced by multinational oil companies are dramatically different than packaged food makers and consulting firms) and across firms within an industry (due to differences in location of assets, supply chain configuration, operating processes, stakeholder relations, etc.). Because the risks affect various aspects of a given business, this process of risk identification involves accessing information that is embedded across the company and consists of more than simply aggregating information. The process must be coordinated and interactive, ideally starting a conversation about climate risk across various functions within the firm. The

identification of climate risk exposure should then be viewed as an information gathering process, initially not directly connected to resource allocation or personnel evaluation. At first, the goal must be to begin to overcome the lack of attention, status quo bias, and organizational challenges to generate a comprehensive understanding of the ways in which climate change will affect the firm and use the results of this analysis to assess risk impact in the next step.

One example of a firm successfully identifying its long-term climate risk exposure is AngloGold Ashanti, a South Africa mining company. In 2008, AngloGold commissioned a report to assess parts of its business that could be at direct risk due to climate change, both within the specific context of its mining operations and in the broader communities in which the company operated.⁴⁷ The study found that the company's mines were at risk of increased flooding and, in turn, more landslides, while the mine workers would be prone to higher rates of exhaustion from increased temperatures exacerbated by low ventilation in the mines. The study also found that the company would incur increased energy costs in order to better cool the mine for workers, as well as external costs to prevent infrastructure disintegration from the wetter climate in the local area. Additionally, in other locations outside of South Africa in which AngloGold operates, increased "human distress" as a result of more extreme local climate conditions was cited as a key threat to employees involved in handling the company's supply chain.

Although it is unclear how many of these changes AngloGold actually implemented, identifying the climate risks is an essential first step for any business. AngloGold Ashanti was early in assessing climate-specific risks to its business operation, and, since 2008, many of these physical effects of climate change have borne out. Anglo American, which has a stake in AngloGold Ashanti, cut its dividend in 2022 after intense rains reduced its platinum mining capacity in South Africa.^{48 49} Additionally, the mining industry as a whole has experienced a shift

in demand as businesses and countries shift away from fossil fuels toward renewable energies.⁵⁰ Climate change will cause decreased demand for coal and natural gas and increased demand for cobalt, lithium, and nickel as electric batteries power more automobiles while renewable energy processes such as solar photovoltaics (used in solar panels) will increase demand for raw materials like silicon.⁵¹ The mining industry will therefore transform, and quantifying the impact of these industry- and firm-specific transition risks and opportunities for a business like AngloGold would assist the company to create a long-term climate strategy in its business outlook.

Scentre Group is another example of a business that successfully identified the climate risks it faces. Scentre Group is a shopping center company serving Australia and New Zealand. In 2018, the company assessed its portfolio using data from the Australian Bureau of Meteorology and New Zealand Ministry for the Environment 2018 Climate Change Projections.⁵² The company found that its assets were at particularly high risk of extreme heat, floods, and flash rainfall. The quantification of these risks using available data can be the first step toward making changes to a firm's asset portfolio.

Of course, these risks will look different for different sectors. From utility companies that have to deal with the direct threats of climatic events that threaten the power grid and water supply, to transportation companies that may have to invest in infrastructure more regularly as it degrades, to manufacturing companies that may encounter distribution challenges and even shifting demand for their products.⁵³

Strategic assessment of risk impact

The initial identification of exposure to the risks of climate change subsequently allows firms to evaluate the impact these risks will have on them. This assessment involves a mapping of

risk exposure based on an understanding of the strategic objectives, resources and capabilities of the firm.

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As noted above, companies should consider that exposure to climate change risks can vary across firms and industries; there is no one size fits all solution. Table 2 provides an overview of this variation, juxtaposing the level of vulnerability (high/low) with each type of climate risk. For example, firms in polluting industries and those perceived as environmental laggards in their industry face higher risks of stakeholder and investor activism demanding improved environmental performance and disclosure, while firms in cleaner industries and those perceived as leaders in environmental management will have lower risks from external stakeholders. Service industry firms with little production or distribution infrastructure will face lower risk of climate-related supply chain disruption, while global manufacturing and logistics firms with assets in vulnerable geographic areas and a global infrastructure are highly exposed to these risks. Within a given industry, physical, regulatory, stakeholder, and supply chain risk exposure will depend on the geographic location of a firm's productive assets and supply chain risk will further depend on structure, organization, and ownership across the supply chain. Due to the variation of climate risk impact across firms and industries, firms that want to conduct a thorough assessment of their exposure will have to engage in a substantial information gathering process. Firms that fail to gather comprehensive information on the impact of climate risks on each area of their company will less accurately estimate the strategic vulnerability of their firm to climate change.

The environmental reporting non-profit Carbon Disclosure Project (CDP) issued a report in 2019 that analyzed how international businesses were responding to climate change.⁵⁴ While 3,659 of the businesses included in the report identified being exposed to substantive climate-

related risks, only 2,185 companies provided potential financial impact figures, indicating that more thorough information gathering and financial application analyses were significantly less common.

One example area that will become more costly for businesses and require increased investment is human labor. Specifically, companies that produce goods in already-warm climates may have to adapt to worker productivity issues, with one study estimating that temperature increases could cost the global economy \$2 trillion by 2030, concentrated in hotter climates across Africa and Asia.⁵⁵ A firm may have to conduct an initial evaluation of labor costs based on more local projections of how these climatic events will impact its operations before turning to methods to mitigate the risk. For example, increased temperatures may negatively affect worker health.⁵⁶ This will have different implications for different firms—a firm may find that it must incorporate ventilation or cooling systems and offer more flexible work times for any employees doing manual labor in these climates. Other companies may need to provide employees with filtering masks in areas that are experiencing dust kickup as a result of extreme drought.⁵⁷ However, none of these companies can implement these measures until they conduct full assessments of how the health of their employees will be affected by climate change.

Still other companies may find that their labor costs will increase due to other necessary measures like retraining programs. Civil engineering firms, for example, may need to invest in training to reeducate employees on how to redesign structures to adapt to changing rain patterns, with one civil engineer saying, “Our civil engineers haven’t been trained to deal with climate change in their training. Our urban planners, our city managers, our architects. Nobody’s been taught.”⁵⁸ However, none of these measures can be implemented unless a company first conducts a full evaluation of how climatic events will impact its operation and its finances. Only after

conducting this type of risk evaluation can companies research and incorporate specific measures necessary to act as a bulwark against climate threats.

Another consideration for firms when evaluating risk impact is that the same type of risk can have different impacts on the strategic objectives of different firms as a company's strategic risk exposure depends on several factors, including the resources and capabilities of the firm (including both static and dynamic capabilities), its strategic position within its industry, and the industry structure it faces (See the "Strategic Assessment" box in Figure 1). First, the firm's resources and capabilities determine how effectively the firm can manage the risks. For example, a firm with capabilities to manage access to critical inputs across multiple suppliers with flexible supply schedules would be less impacted by climate change-induced supply shortages from a subset of suppliers than a firm in the same industry that either relies on a few suppliers, relies on suppliers that are co-located, or lacks the capabilities associated with flexible sourcing. Similarly, firms that have already invested in developing resource efficiency programs in their production facilities will experience a lower impact from energy price increases, or price increases from other inputs. In addition to a firm's static resource base, a firm's dynamic capabilities also affect its level of strategic risk exposure because they determine the firm's ability to adjust and respond to climate change risks. A firm that possesses dynamic capabilities that allow it to effectively accommodate changes in customer demand, regulation, operations, or supply changes through innovation of products and processes will be less negatively affected by climate change risks associated with these factors. For example, in the agriculture industry, Bayer has invested in research to develop drought-resistant crops.⁵⁹ In the utility sector, English company Anglian water invested in interconnecting water supply zones to sure up water supply in areas particularly vulnerable to drought.⁶⁰ To be effective, businesses must proactively fund research into these types of

innovations as a first step toward adapting their business models to the broader effects climate change will have on the market.

A third factor for firms to consider is that their strategic risk exposure also depends on the strategic position of the firm within its industry and core markets. For example, firms that depend critically on brand reputation in their product market and possess a highly valuable global brand will be at higher risk of stakeholder attacks targeting their brand reputation when stakeholder risks are high compared to a less brand-intensive firm. Likewise, firms that compete primarily on low prices will face greater exposure to input price increases that could affect them more than their rivals.

Finally, the level of strategic risk exposure is also influenced by the competitive structure of the firm's industry. For example, a firm operating in a highly-concentrated industry with limited rivalry will be better able to pass increases in supplier prices on to their customers, at least in the short term, thus insulating it from input price volatility. Other firms, in highly competitive markets, will not be able to pass on cost increases associated with input prices or any other costs associated with climate change risks.

This law of economics plays out whenever firms face risk exposure. One salient example, unrelated to climate change, of this was the global supply chain issues that surfaced during the COVID-19 pandemic, which caused certain sectors to incur substantial risk. Supply chain shocks that emerged in late 2020 accounted for a significant portion (one-third) of the strains in global production networks.⁶¹ Larger firms were largely able to pass on the costs associated with these production strains to consumers due to consumers' low price sensitivity in the market and less competition.⁶² This, in turn, strongly contributed to inflation for consumer goods.⁶³ The result was that, in 2021, facing rising supply chain risks, large U.S. companies reaped the largest profit

margins since 1950.⁶⁴ On the other hand, in one survey 80% of small business owners in the U.S. reported that the inflation that resulted from supply chain issues was cutting into profits in 2022, likely because these businesses faced higher price sensitivity from consumers.⁶⁵ As climate risks continue to grow and, with them, costs for businesses incurred by everything from supply chain disruptions to production problems to the implementation of climate adaptation measures may continue to drive a wedge between the profit margins of larger firms in less competitive markets and smaller firms in more competitive markets.

Similarly, if there are low barriers to entry in the firm's market, it provides an opportunity for new entrants that are better suited to climate change-affected industry conditions, potentially undermining the firm's strategic position. Thus, industry structure can either insulate the firm from strategic risk or further expose the firm to the underlying risk through the competitive dynamics of the market.

Climate risk integration into strategic decision making

After a thorough strategic assessment of the climate risks facing the firm, our Climate Risk Planning framework proposes that firms subsequently integrate climate change risks into their strategies through the use of a variety of risk management tools. There are relevant tools developed and discussed in the finance and operations management literature that can be leveraged to contribute to the systematic integration of climate change risk into a firm's strategic decision-making. Table 3 provides an overview of the major tools and gives corresponding examples for how each tool can assist in identifying and assessing climate change risks. We have categorized the tools into those that are more suited to addressing one specific risk at a time and tools that can be utilized to integrate information and assessment across all of the risks faced by the firm. These tools can assist the organization in overcoming decision-making biases associated with climate

change-related uncertainty and varied time horizons. In particular, the integrative tools provide the holistic approach necessary for systemic climate risk impacts.

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Most of the project-specific tools, including hedging, value-at-risk, insurance, and real options, are typically applied in finance to evaluate the risk of a specific investment or project. These tools can be useful for evaluating and responding to climate risks as well, and are most powerful when utilized in conjunction with holistic risk assessment to further incorporate risk analysis into the strategic management of the firm. We have also included supply chain configuration as a tool to assess alternative supply chain structures for their exposure to a variety of climate change-related risks. The more integrative tools, including scenario planning and enterprise risk management (ERM), allow managers to assess the value of alternative strategic options under multiple future scenarios of potential climate change effects or trace the impacts of climate change throughout the organization.

ERM systems are particularly effective at helping managers integrate climate change risk into a firm's strategy. Such systems focus managerial attention on strategic uncertainties and guide the development of new strategic initiatives.⁶⁶ For example, Nationwide Insurance implemented an ERM system when risk management shifted from managing financial risks to also encompassing operational risks. The ERM system allowed for the decentralized assessment and integration of risks, allowing those managers who were closer to the risks to engage in quantifying and planning for risk reduction. As a result of adopting this system, Nationwide was able to focus on reducing and transferring risks where they did not have a competitive advantage (i.e. forecasting market variables), and retaining strategic risks where the company had an advantage in terms of

risk assessment and bearing.⁶⁷ Thus, the implementation of the ERM system at Nationwide had a substantial impact on the firm's practices, investments, and activities.

Another example of a successful ERM implementation is Hydro One, a Canadian electric utility company. The implementation of an ERM program at Hydro One brought new risk assessment tools to the company, including the "Delphi Method,"⁶⁸ and facilitated the systematic evaluation of risk trends and tolerances. The ERM system included an integrated process for allocating capital and garnered a favorable reaction from credit rating agencies Moody's and Standard and Poor's, reducing the cost of capital for the company. It has also heightened the managers' and employees' awareness of risk management, ingraining the attitude that risk management is "everyone's responsibility."⁶⁹ For both Hydro One and Nationwide, systematic analysis and integration of risk allowed the companies to reduce or avoid risks that were of low strategic value and make investments to manage recognized multidimensional risks associated with strategic assets and activities.

These tools provide firms with the means to include climate change risks into strategic decision-making regarding resource allocation, investments in product and process R&D, sourcing of raw and intermediate inputs, as well as larger decisions about which markets to enter and how to position their products in the marketplace. In some cases, climate risk assessment also presents new opportunities to the firm. For example, expected increases in consumer demands for more energy efficient products or products with less environmental impact might create markets in which the firm could exploit existing or new capabilities. In other cases, climate risk assessment will highlight the potential for possible disruptions, future cost increases, or demand reductions that should be evaluated as part of the decision-making process. As a result, firms that pursue a

systematic approach to climate risk integration by deploying the appropriate tools are better positioned to mitigate climate risks and subsequently outperform their competitors.

Mitigation of climate change risks

Our Climate Risk Planning framework proposes that, by integrating the relevant climate risk analysis and impact assessment into a firm's strategic decision-making, firms subsequently reduce the vulnerability of their firms by taking advantage of new strategic opportunities. This approach does not imply that firms avoid all investments and activities with climate change-related risks. Instead, by systematically quantifying and evaluating the climate change risks associated with strategic decisions, firms create a portfolio of assets, investments, activities, and decisions that protects firm value and strategic objectives under multiple possible futures and risk realizations. This could include both reducing investments in risky assets and activities and promoting investments in proactive measures to better safeguard against the effects of climate change.

The "right" set of mitigation investments will necessarily vary across firms, based on differences in strategic risk exposure and strategic objectives. We provide specific examples of actions that firms can take to mitigate climate change in each risk category in Table 4. We have classified these mitigation actions into internally and externally-focused actions, depending on whether they primarily target internal actors and processes (such as production processes, energy efficiency, training, using an internal carbon price for investment decisions) or external factors (such as supply chain redundancy, non-market strategy, and relocation of critical assets). For example, energy-intensive firms in price sensitive product markets faced with likely increases in electricity prices due to carbon regulation may elect to pursue more energy efficiency opportunities or seek longer-term energy purchase contracts for renewable energy. Firms that depend on

securing a social license to operate and face exposure to more intense stakeholder or investor activism may seek to develop capabilities around environmental reporting and disclosure and CEO leadership on environmental issues. This can preemptively shape their relationship with stakeholders instead of having the firm react to negative events.

--- Please see Table 4 ---

By pursuing such risk mitigation activities, firms can avoid investments and strategic initiatives that carry an unacceptably high risk (relative to the expected benefits) and proactively identify new investment opportunities that will increase in value as climate change impacts progress. Moreover, firms may also invest in measures that mitigate risks that could potentially compromise the firm's core activities. Not only does this approach allow companies to outmaneuver their competitors that fail to respond adequately to climate change risks, but it will also better prepare them for climate change-induced shifts in their competitive environment.

Performance implications

The integration of climate change-related risk management and resulting investments in mitigating exposure to climate change are expected to provide dual benefits for firm performance. There is substantial literature that addresses the question of whether investments in sustainability (of various types) increase firm performance.⁷⁰ This research focuses on whether environmental (or social) performance is associated with financial performance outcomes. Based on a study of the relationship between a firm's releases of toxic chemicals and Tobin's q as a measure of financial performance, lower pollution is found to be associated with better financial performance.⁷¹ Similarly, among large publicly traded firms, those with lower levels of (legally) emitted toxic chemicals have significantly higher market values, controlling for other factors that enhance firm performance.⁷² While these studies assess the relationship between environmental

management and firm performance more generally, we argue that climate change risk mitigation integrating risk mitigation with strategic management also serve to improve financial performance.

Firms that design their strategies to consider climate change by utilizing a risk management perspective will realize benefits from these strategies. This is consistent with the idea that the relationship between environmental and financial performance depends on the firm's environmental management processes.⁷³ Directing sustainability investments toward the firm's most important areas of climate risks provides the greatest performance benefits, which will vary across firms and industries. Accordingly, recent studies of the performance impact of sustainability investments rely on a more nuanced measure by relating the sustainability investments to those related to "material" issues and others, based on the Sustainability Accounting Standards Board's (SASB) industry-specific guidance on the materiality of various sustainability issues. Findings suggest that while investments targeting issues material to the firm lead to increases in market value, investments that target less material issues do not. In fact, firms that make the most investments in the material issues and also make the least investments in immaterial issues achieve superior performance.⁷⁴ This evidence points directly at the importance of thorough and holistic climate risk assessment, integration, and mitigation. Investments guided by firms' analysis of their strategic risk exposure and mitigation efforts, rather than by less directed sustainability activities, result in performance improvements.

Studies have also examined the impact of risk management practices themselves on firm performance. A study of governance structures that promote risk management integration (such as the presence of a chief risk officer, or "CRO," and adequate channels of reporting to the CRO) demonstrates that banks with stronger risk governance had higher stock returns and returns on equity in the wake of the 2007/8 financial crisis. The study concludes that the benefits of a risk

management system (such as ERM), including a more optimal allocation of capital and a favorable reaction from credit rating agencies, arguably reduce the cost of capital for the company. The same was not true for other (non-risk-related) corporate governance attributes.⁷⁵

Similarly, environmental risk management is associated with lower cost of capital in major U.S. firms.⁷⁶ As managers proactively and strategically manage stakeholder pressures, they enjoy the support of important stakeholders (including customers, regulators, investors, and activists), in turn reducing capital constraints and avoiding costly activist discontent.⁷⁷ Recent evidence further indicates that adopting an ERM system increases firm value,⁷⁸ suggesting that if managers invest in mitigation efforts guided by risk management systems, future financial performance will be higher.

In addition, when managers take a holistic, portfolio approach to strategic decisions, cognizant of the correlation of risks across activities and investments, the firm is less subject to specific climate-related events, making its returns more stable and less volatile. A meta-analysis of the relationship between risk management and volatility of returns found consistent evidence, across multiple studies, that the use of risk management tools (in these studies, most often derivatives and operational risk management practices) reduces risk exposure, volatility of returns and sensitivity of returns to price volatility.⁷⁹ Proactive climate change risk assessment and mitigation will decrease the volatility of returns by reducing exposure to uncertainty, e.g., in the form of input prices, severe weather disruptions, shifts in consumer demand, and activism from external shareholders. Therefore, firms that invest in climate change risk mitigation efforts guided by a risk management approach will have less volatile financial returns over time.

Discussion and Conclusion

Man-made climate change is undoubtedly one of the most significant challenges humanity will face in the coming decades and will have an outsized impact on firms and their strategic decision-making. The unique nature of climate change poses unprecedented risks to firms, which we argue have not yet been adequately captured by existing frameworks in strategic management. Our study proposes a novel conceptualization of strategic management in response to climate change, focused on a risk management perspective. As the effects of climate change become more apparent and fundamentally alter the competitive environment of firms, our Climate Risk Planning framework predicts that firms that do not incorporate the risks posed by climate change into their strategies in a holistic way will be outmaneuvered by their competitors who do.

Figures and Tables

Figure 1

Framework for strategic management in response to global climate change

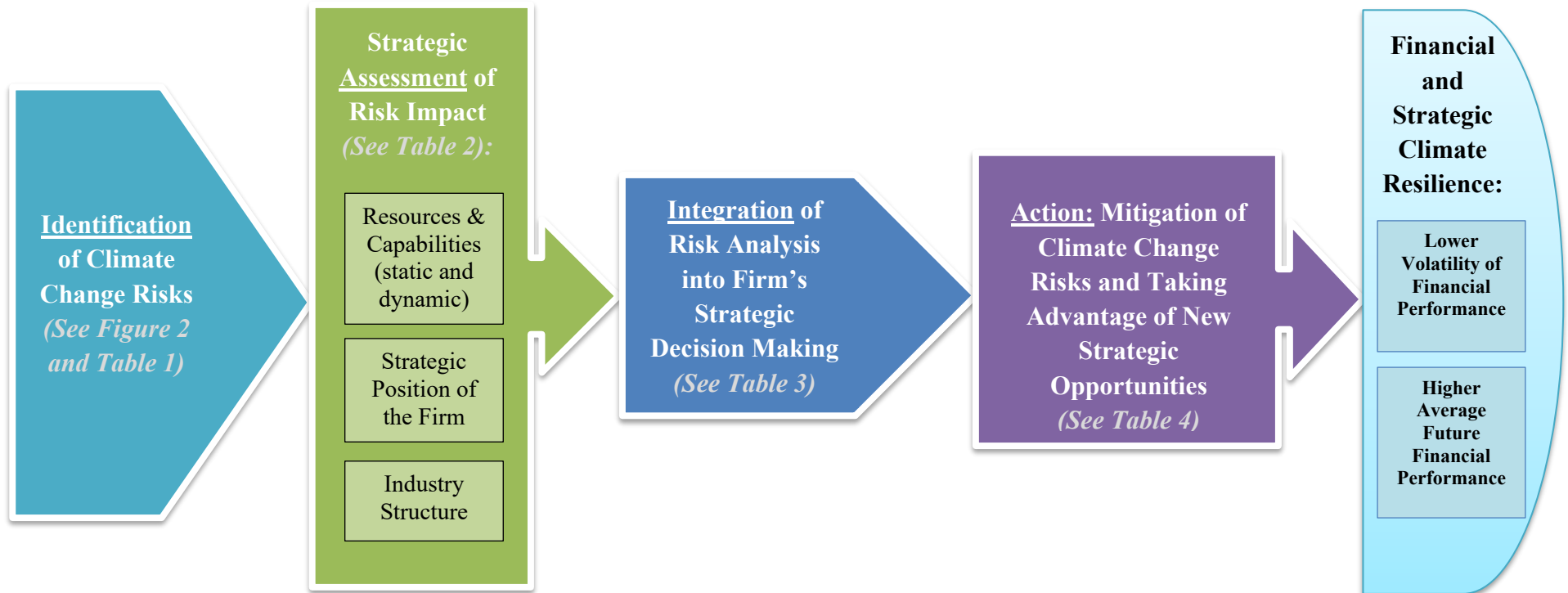


Figure 2

Identification of climate risks

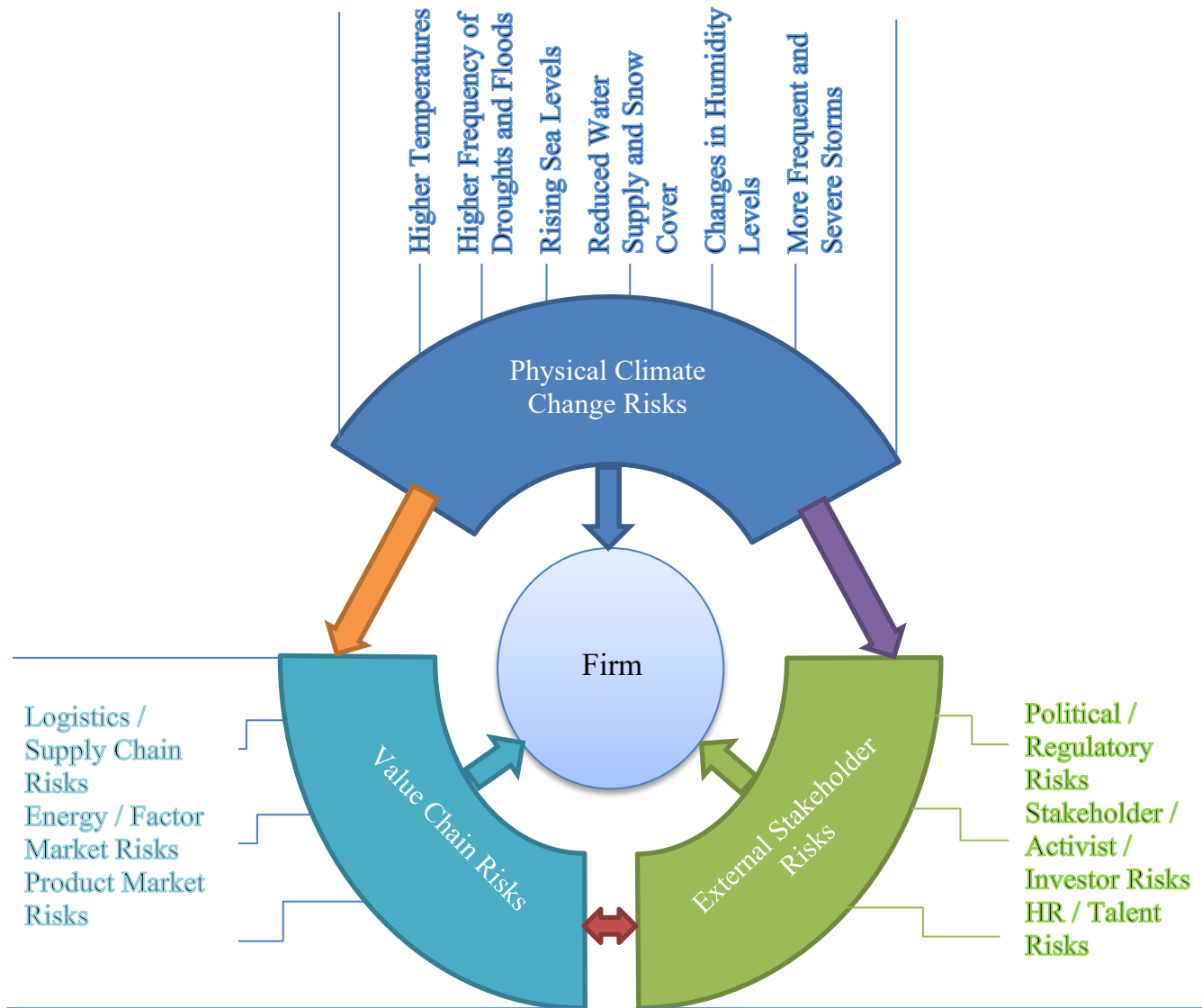


Table 1

Climate change risk-matrix: level of risk vs. different types of risks

Risk Level	Risks from climate change						
	<i>I – Direct/ Physical Risks</i>	<i>II – Value Chain Risks</i>			<i>III – External Stakeholder Risks</i>		
		<i>Logistics/ Supply Chain</i>	<i>Energy/ Factor Market Prices</i>	<i>Product Market</i>	<i>Political/ Regulatory</i>	<i>Stakeholder/ Activist / Investor</i>	<i>Human Resources/ Talent</i>
<i>Global effects</i>	<ul style="list-style-type: none"> Higher temperatures Higher frequency of extreme weather events (e.g. floods, droughts, tropical storms, torrential rainfall etc.) Rising sea levels Reduced water supply and snow cover Increased atmospheric humidity 	<ul style="list-style-type: none"> Global supply chains become more unreliable due to potential supply disruptions Certain geographic areas not viable for transportation or location of assets 	<ul style="list-style-type: none"> Increased energy prices and higher supply volatility Higher and more volatile factor market prices Potential lack of availability of certain resources/ production factors 	<ul style="list-style-type: none"> Shifting customer demands towards low-carbon products Low-carbon innovations from new entrants 	<ul style="list-style-type: none"> Political turmoil and military conflicts over scarce resources (e.g., water) Strict regulations of greenhouse gas emissions (e.g., carbon tax) Unfavorable political environment for polluting industries 	<ul style="list-style-type: none"> Activist movements against firms with large carbon footprints Shift of investor preferences away from highly polluting industries 	<ul style="list-style-type: none"> Climate change strategy as recruiting factor Climate refugee crises Different skillsets and training are demanded on the labor market
<i>Firm-level effects</i>	<ul style="list-style-type: none"> Threat to physical assets (e.g. production plants, supply hubs, corporate buildings) Threat to production processes 	<ul style="list-style-type: none"> Bottlenecks in supply chains More frequent supply disruptions Higher transportation costs More rapidly shifting suppliers 	<ul style="list-style-type: none"> Higher variable costs for energy and raw materials Higher managerial uncertainty for sourcing raw materials and production factors 	<ul style="list-style-type: none"> Pressure to change product portfolio to respond to customer demands Higher competition / lower profitability 	<ul style="list-style-type: none"> Increased political and regulatory uncertainty (higher costs) Potential relocation of assets because of military conflict Higher costs for carbon-intensive operations due to carbon pricing 	<ul style="list-style-type: none"> Higher scrutiny from activists (potentially costly campaigns from activists) Higher costs of capital Reduced availability of capital 	<ul style="list-style-type: none"> Lack of available skilled talent Current skillset of employees outdated Higher costs for employee recruitment, training and retention

Table 2

Strategic risk assessment: impact of risks differs across firms and industries

Risk Impact	Risks from climate change						
	<i>I – Direct/ Physical Risks</i>	<i>II – Value Chain Risks</i>			<i>III – External Stakeholder Risks</i>		
		<i>Logistics/ Supply Chain</i>	<i>Energy/ Factor Market Prices</i>	<i>Product Market</i>	<i>Political/ Regulatory</i>	<i>Stakeholder/ Activist / Investor</i>	<i>Human Resources/ Talent</i>
Low Impact	<ul style="list-style-type: none"> • Critical production and distribution assets located in less vulnerable geographic locations 	<ul style="list-style-type: none"> • Duplicative supply chain in varied geographic areas for key components 	<ul style="list-style-type: none"> • Highly efficient production process, investments in energy efficiency and closed loop manufacturing • Innovative capabilities that can reduce dependence on specific inputs 	<ul style="list-style-type: none"> • Ability to innovate to meet and exceed customer demands • Facing few direct rivals in product market 	<ul style="list-style-type: none"> • Reputation for favorable environmental performance, providing goodwill • Lower environmental impact allowing firm to meet new regulations at lower cost 	<ul style="list-style-type: none"> • Reputation for favorable environmental performance • Goodwill with stakeholders • Industries with lower environmental impact 	<ul style="list-style-type: none"> • Less reliance on human resources, more automation
High Impact	<ul style="list-style-type: none"> • Key assets located in vulnerable geographic areas (e.g., in coastal cities, flood-prone areas) • Manufacturing and logistics companies. • Multinational firms with global assets, heavily reliant on multiple transfers of intermediate goods 	<ul style="list-style-type: none"> • Key suppliers located in vulnerable geographic areas • Complex supply chain • Reliant on unique supplier located in vulnerable area for key component • Customers demanding just-in-time delivery 	<ul style="list-style-type: none"> • Energy intensive relative to rivals and substitutes • Products that depend on inputs that are sourced from geographically concentrated suppliers • Agricultural firms • Food processing firms 	<ul style="list-style-type: none"> • Substitute products with lower environmental impact • Non-essential products • Large incumbents not investing in product R&D 	<ul style="list-style-type: none"> • Firms in polluting and heavily regulated industries • Firms with a large carbon footprint, especially relative to industry rivals 	<ul style="list-style-type: none"> • Firms in industries facing greater stakeholder scrutiny • Prior environmental disaster • Investors with preferences for more sustainable operations 	<ul style="list-style-type: none"> • Highly dependent on human resources • R&D intensive firms

Table 3
Tools for risk integration

Tool	Uses	Brief Description	Example
Tools that can address risks one-by-one			
Data analysis	<ul style="list-style-type: none"> - Identify risks, trends. - Inform calculations with projected probabilities, forecast loss magnitudes. 	Collecting and analyzing data on relevant trends, such as storms, energy prices, regulation, and customer demands. Trends themselves may indicate growing risks. Forecasting techniques can project trends into the future to guide and inform analysis of risk.	Munich RE, one of the largest re-insurance companies in the world, began collecting and analyzing climate and weather data in the mid-1970s. Throughout the 1980s and 1990s, the company was able to use these data to identify trends in the frequency and costliness of weather-related losses in significant detail, and utilize the updated probabilities and magnitude in their risk models. ⁸⁰
Hedging	<ul style="list-style-type: none"> - Manage risk by making investments to reduce the downside risk associated with other investments, activities, or assets. 	Hedging strategies in finance involve engaging financial instruments, such as derivatives and options, to reduce the downside risk of loss associated with a particular investment. For climate change related risks, hedging is based on the same fundamental concept of hedging the risk associated with one investment by making another investment with a different (negatively correlated) risk profile in order to reduce the probability or magnitude of loss in the aggregate. ⁸¹	A highly energy-intensive manufacturing firm concerned about the future volatility of energy prices, due to anticipated but uncertain carbon reduction policies, may seek to secure futures contracts that provide energy at a future date at a specific price. Or uncertainty associated with physical climate risk in different locations may lead a firm to hedge the risk of impacts in one location by also seeking to place operational assets in a second location with a very different risk profile. Or the risk associated with shifts in technological competition might be addressed by making simultaneous investments in a number of technologies (e.g. electric vehicles and internal combustion engines).
Value-at-risk	<ul style="list-style-type: none"> - Quantify monetary exposure to climate change risk for specific projects or facilities. 	Estimating the so-called value-at-risk can be used for climate risk analysis and is widely deployed in the financial industry. The basic idea is to calculate the maximum potential loss at a pre-determined probability for a certain (financial) position during a certain time period. For instance, a manager could calculate the maximum potential losses associated with the destruction of a manufacturing facility due to extreme weather as no more than \$15 million over the next two years at 95% confidence. This type of calculation allows managers to measure the exposure for each of the critical dimensions of their business and get a well-quantified assessment of the potential losses at probability confidence intervals that are acceptable to them. ⁸²	VaR framework can be used to estimate the value at risk from climate change impacts of varying severity in the global economy. Such an estimate concluded that the expected VaR under common climate projections is US\$2.5 trillion, while the 99th percentile climate change VaR is US\$24.2 trillion. ⁸³ Aviva, an insurance and investment firm based in the U.K., commissioned a report from the Economist Intelligence Unit, 2015, which also used VaR to estimate the value at risk from climate change. ⁸⁴ The study concludes that the expected value at risk is \$US4.2 trillion, though like the prior study it emphasizes the significant tail risk that makes the high-end projections much worse than the mean. Aviva uses this methodology to evaluate climate risks in their insurance and investment activities.
Supply chain configuration	<ul style="list-style-type: none"> - Consider different risk profiles of various suppliers in purchase decisions. - Evaluate risk of suppliers from all types of the climate risks, including physical, value chain, and stakeholder risk. - Construct supply chain to optimize on efficiency and resilience. 	While managers often recognize the potential for supply chain disruptions to impact their company, most managers have done very little to reduce the likelihood of disruptions or mitigate their effects. ⁸⁵ Supply chain resilience emphasizes both reducing the risk of disruption and building supply chains that can quickly recover from any disruptions that do occur. After assessing supply chain risks, many firms can create contingency plans, identifying alternative suppliers with whom they contract for back-up supplies in case of a disruption. ⁸⁶ Segmenting supply chains by products or regions prevents disruption in one part of the supply chain from rippling into disruption in the entire supply chain. ⁸⁷	Royal KPN, a Telecommunications firm in the Netherlands, recognizes that the risk due to floods that interrupt their communications network is “huge” (as reported in their response to the CDP survey). To protect themselves from these losses, the company has invested in a “geo-redundant” network to ensure that any operating disruption will be resolved within four hours or less, due to the ability to shift any critical activities to an alternative location. Further, the company installs all critical equipment well above sea level. ⁸⁸

Insurance	<ul style="list-style-type: none"> - Manage risk by securing financial payout in case of loss. 	One type of hedge. Investment up front provides payout under specified future conditions.	Insurance companies have been developing new insurance products to meet the needs of firms facing climate change related risks. Policies can cover losses from weather-related disruptions and damage, input price increases, or consumer backlash from negative PR. Munich RE offers insurance against lower than expected amounts of sunshine, which negatively affect solar electricity generation. ⁸⁹
Real options	<ul style="list-style-type: none"> - Manage risk by making small investments now that increase flexibility for subsequent decision making. 	Unlike derivatives or financial options that a company might invest in to hedge their risk, real options involve investments in “real” or tangible assets. Real options provide value through the flexibility that they offer to the firm—flexibility borne out of either investing in an asset that yields more alternatives for subsequent investments or the flexibility to delay deciding on whether to commit to a specific investment. The real options framework is especially powerful in situations of uncertainty, when the future state of the world is not yet known. The value in each option is driven by the revelation of information over time, so that delayed decisions are more informed. ⁹⁰	Real options theory can be employed to address uncertainty and risk in the supply chain by increasing flexibility. Alternatives described within the real options framework include deferring investments, staging series of smaller investments (where the later can be canceled), exploring with prototype projects, leasing instead of buying property, outsourcing, and expanding commitments after learning of a favorable outcome. ⁹¹
Integrative risk management tools			
Enterprise risk management (ERM)	<ul style="list-style-type: none"> - Unified framework for assessing and incorporating all risks. - Tool for gathering information across the organization about risk exposure and valuation. - Integrates risk valuation with strategic decision making. 	ERM provides an integrated assessment of all material risks facing a company. The first step in an ERM program is identifying the risks to which the company is exposed that will be included in the system. This has expanded over time from financial and currency risk, to operational and strategic risks, ⁹² and can be extended to climate change related risks. The firm then needs to implement a consistent way to measure risk exposure. The firm then aggregates the risks, taking into account correlations across the risks. This system benefits the management of risks by presenting a single framework for assessment and management, potentially informing every aspect of strategic decision making. In addition, an ERM program provides the potential to connect all operations and managers into the same system, so that all operating managers throughout the firm have the ability to assess how the risks associated with each new project impact the risk profile at the firm level.	The A2A Group, an electric utility firm in headquartered in Italy, uses an ERM system to evaluate climate risk and integrate risk management into strategic decision making. Re-gearing the use of this system, the company states, “The purpose is to make the business risk management an integral and systematic part of management.” Their ERM process directly involves managers in risk identification, evaluations, and assessment, and keeps managers informed of the results. “The assessment is done every six months and its results are reported to the Internal Control Committee (part of the Supervisory Board) and to A2A General Managers.” This process shapes the strategic decision making of the firm. “Review of climate change risks and opportunities are an integrated part of A2A’s strategy process, all new projects and investments, the annual business planning process and the financial and extra-financial reporting process.” ⁹³
Scenario planning	<ul style="list-style-type: none"> - Identify potential future risks. - Evaluate future scenarios involving several dimensions of possible climate-related changes. - Assess value of projects or investments under various potential future conditions to assess risk exposure and potential value changes. 	Scenario planning is a general tool used under many different circumstances in which there is significant uncertainty about key aspects of the future operating environment. Scenario planning begins with an informed brainstorming session to conjure up a number of internally consistent possible future scenarios. “Scenario planning seeks not to predict the future but to envisage alternative views of the future in the form of distinct configurations of key environmental variables.” ⁹⁴ For assessing climate change related risk, it could involve developing a range of scenarios associated with different climate related outcomes (e.g., differing frequencies of violent storms, various levels of carbon taxes, alternatives for consumer preferences). Managers evaluate the value of their firm, and the firm’s significant investments and activities, under each of the possible future scenarios.	BG Group, and Oil & Gas company from the United Kingdom, describes using different possible future scenarios for the price of carbon such that “Our shadow carbon price enables us to test the resilience of investments to future climate change policies which could result in costs associated with GHG emissions as well as to a range of scenarios consistent with the 2deg C goal.” ⁹⁵ Swire Pacific, a Real Estate Management firm based in Hong Kong, reported to the Carbon Disclosure Project that they have engaged with Forum for the Future to run scenario planning exercises to evaluate their climate risk exposure. The company incorporates the learning from these workshops, especially regarding issues and events that would significantly affect their business, in their organization risk planning process. ⁹⁶

Table 4

Climate change risk mitigation: firm responses vs. different types of risks

Firm Responses	Risks from climate change						
	<i>I – Direct/ Physical Risks</i>	<i>II – Value Chain Risks</i>			<i>III – External Stakeholder Risks</i>		
		<i>Logistics/ Supply Chain</i>	<i>Energy/ Factor Market Prices</i>	<i>Product Market</i>	<i>Political/ Regulatory</i>	<i>Stakeholder/ Activist / Investor</i>	<i>Human Resources/ Talent</i>
<i>External responses</i>	<ul style="list-style-type: none"> Climate change adaptation (e.g., relocation/ preparation of assets) Contingency planning/ redundancy 	<ul style="list-style-type: none"> Supply chain redundancy Engage potential substitute suppliers Shift supply chains to less vulnerable suppliers/count ries 	<ul style="list-style-type: none"> Hedging against price risks (e.g., for energy, raw materials) Purchase low-carbon energy 	<ul style="list-style-type: none"> Diversification of product portfolio, shift to products with superior environmental impact Develop product solutions for future 	<ul style="list-style-type: none"> Corporate political strategy Respond strategically to regulations (e.g., regulatory compliance) Participate in collective action efforts vis-à-vis government actors (e.g. industry associations) 	<ul style="list-style-type: none"> Respond strategically to stakeholder pressure (e.g., game of private politics) Pre-emptive engagements with stakeholders Partnerships with stakeholder groups 	<ul style="list-style-type: none"> Attract and retaining talent (firm reputation, availability of workers)
<i>Internal responses</i>	<ul style="list-style-type: none"> Organizational restructuring Resilience training programs Develop response to disaster / physical impacts and training to implement 	<ul style="list-style-type: none"> Climate forecasting for vulnerability assessment Contracts with suppliers contain clauses to protect from harm 	<ul style="list-style-type: none"> Increase internal energy and resource efficiency Use of internal carbon price Innovation to reduce energy & resource use Increase self-sufficiency in energy (e.g., solar panels) 	<ul style="list-style-type: none"> Reallocate investment toward products with more value in resource constrained future “Design to sustainability” approach 	<ul style="list-style-type: none"> Regulatory affairs/non-market strategy department Provide leadership on internal practices to gain a “seat at the table” 	<ul style="list-style-type: none"> Rapid response team for external challenges Develop internal capabilities for reporting and management of climate related issues. CEO leadership on central climate issues 	<ul style="list-style-type: none"> Employee climate training programs Global talent sourcing

Endnotes

¹ For more information about this historic meeting, see UNFCCC, “Leaders Day at COP21 UN Climate Change Conference: Over 150 Leaders Back Drive for New Agreement in Paris,” UNFCCC, 2015, <http://newsroom.unfccc.int/unfccc-newsroom/leaders-day/>.

² For more information on the agreement, please see European Commission, “Paris Agreement - European Commission,” 2016, http://ec.europa.eu/clima/policies/international/negotiations/paris/index_en.htm. While the United States at the time of submission of this paper has indicated its intent to withdraw from the agreement due to a new presidential administration, it cannot do so legally until November 2020.

³ IPCC, “Climate Change 2013: The Physical Science Basis” (IPCC, UN, 2013). details the scientific consensus about the impacts and causes of climate change.

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⁶ The multitude of climate change impacts on firms are noted by Hauke Engel, Enkvist Per-Anders, and Kimberly Henderson, “How Companies Can Adapt to Climate Change | McKinsey & Company,” July 2015, <http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/how-companies-can-adapt-to-climate-change>; Kimberly O. Packard and Forest Reinhardt, “What Every Executive Needs to Know about Global Warming,” *Harvard Business Review* 78, no. 4 (2000): 128–35; Peter Romilly, “Business and Climate Change Risk: A Regional Time Series Analysis,” *Journal of International Business Studies* 38, no. 3 (May 2007): 474–80, <https://doi.org/10.1057/palgrave.jibs.8400266>; Gernot Wagner and Martin L. Weitzman, *Climate Shock: The Economic Consequences of a Hotter Planet* (Princeton University Press, 2016).

⁷ New York Times, “Quotation of the Day,” *The New York Times*, August 9, 2009, <http://query.nytimes.com/gst/fullpage.html>.

⁸ Rowan Scarborough, “Pentagon Orders Commanders to Prioritize Climate Change in All Military Actions,” *The Washington Times*, February 7, 2016, <http://www.washingtontimes.com/news/2016/feb/7/pentagon-orders-commanders-to-prioritize-climate-c/>.

⁹ DoD News, “DoD Releases Report on Security Implications of Climate Change,” U.S. Department of Defense, July 29, 2015, 1, <http://www.defense.gov/News/Article/Article/612710/dod-releases-report-on-security-implications-of-climate-change>.

¹⁰ DoD News, 1.

¹¹ These statistics are drawn from the report by Jeff McMahon, “93 Percent Of Public Companies Face Climate Risk; Only 12 Percent Have Disclosed It,” *Forbes*, July 13, 2016, <http://www.forbes.com/sites/jeffmcmahon/2016/07/13/93-percent-of-public-companies-face-climate-risk-only-12-percent-disclose-it/>.

¹² Jean Rogers, “Why Investors Can’t Avoid Climate Risk by Divesting,” *Wall Street Journal*, September 14, 2015, <https://blogs.wsj.com/experts/2015/09/14/why-investors-cant-avoid-climate-risk-by-divesting/>.

¹³ This statistic is from a study from the Center for Energy and Climate Solutions that cited Engel, Per-Anders, and Henderson, “How Companies Can Adapt to Climate Change | McKinsey & Company.”

¹⁴ The demand for knowledge about how to respond to climate change in particular is noted by Climate Group, “Brian Cahill, Moody’s: Businesses Have ‘a Real Hunger for Knowledge’ on How to Assess Climate-Related Risks,” The Climate Group, July 13, 2016, <https://www.theclimategroup.org/news/brian-cahill-moody-s-businesses-have-real-hunger-knowledge-how-assess-climate-related-risks>. Climate Group, “Brian Cahill, Moody’s: Businesses Have ‘a Real Hunger for Knowledge’ on How to Assess Climate-Related Risks.”

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