

Major Saskatchewan Firms And Their Views On Climate Change Impacts On Their Supply  
Chains: A Look At Modelling, Mitigation And Adaptation, And Implications

by

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## Abstract

Climate change is an issue that currently does, and will, impact global supply chains. Saskatchewan relies heavily on global supply chains to ensure necessities are available, and Saskatchewan itself as a resource-based economy has a significant role to play in many supply chains, so long as supply chains are able to adapt and adjust to a changing climate. Climate change and supply chains are not issues lacking attention; the literature shows command of the issue, causes of disruptions, and methods of bettering supply chain resiliency outcomes. However, previous research has focused on specific industries or geographies, often not specifically looking at Saskatchewan. Using qualitative interviews with employees of firms critical to the functioning of Saskatchewan society, I am able to deeper analyze how Saskatchewan firms are preparing for the impacts of climate change on their supply chains, if they are at all. Results from the interviews were similar to what was echoed in the Literature Review; in general, some preparations have been done by some Saskatchewan firms. Other firms have done limited preparations or thinking about the issue of climate change impacts on their supply chains partly due to the difficulties in modelling future impacts, misguided financial incentives, and the ‘wickedness’ of the issue. My findings allow the public and policymakers to gain a greater understanding of Saskatchewan society’s readiness for climate change impacts, specifically those impacts that will bring forth issues in delivering the goods and services required in the modern day.

*Keywords:* supply chain, climate change, Saskatchewan

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## Glossary

<b>TERM</b>	<b>DEFINITION</b>
<b>STAKEHOLDER</b>	A broader perspective on a firm's interested parties; encompasses shareholders, employees, consumers, community members, and suppliers (Banton, 2021).
<b>ADAPTATION</b>	Adapting to life in a changed climate, whether actual or expected future climate (NASA, 2022).
<b>MITIGATION</b>	Reducing climate change – such as reducing emissions. Can include carbon capture and other techniques if they work (NASA, 2022). Often used interchangeably with 'Adaptation'.
<b>FOSSIL FUEL</b>	Non-renewable resources formed from prehistoric plants and animals, gradually buried by layers of rock. Includes oil, coal, and natural gas (U.S. Department of Energy, n.d.).
<b>NATURAL GAS</b>	A fossil gas primarily composed of Methane, used to create electricity and for energy needs (U.S. Energy Information Administration, 2021).
<b>ENERGY TRANSITION OR 'TRANSITION'</b>	Refers to the shift from non-renewable fuels such as oil, coal, and natural gas to more renewable resources such as solar, geothermal, wind, nuclear, etc. (S&P Global, 2020).
<b>EMISSION SCOPE</b>	Refers to how emissions are made and calculated by an organization. Scope 1 encompasses the direct emissions from an organization, like from its vehicles. Scope 2 encompasses emissions from electricity or energy use required for the company to operate. Scope 3 refers to all other emissions involved in the supply chain, from suppliers, and from consumers of products; Scope 3 is difficult to measure (Deloitte, 2022).
<b>(SUPER) WICKED PROBLEM</b>	A problem with innumerable causes, tough to describe, with no right answer. Many different stakeholders, complex and tangled causes, and the problem is difficult to come to grips with (Camillus, 2008). Climate change is often described in greater

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	<p>terms, defined as a 'super-wicked problem', due to the fact that time is of essence, solutions are being sold by those who caused the issue, central authority is weak or non-existent, and policy responses discount the future irrationally (Levin, Cashore, Bernstein, &amp; Auld, 2012).</p>
<b>THREAT MULTIPLIER</b>	<p>Often used in security and intelligence discussions, the term refers to the tendency for climate change to exacerbate problems in regions and make effective governance difficult; climate change, while a problem on its own, creates other issues and can drive conflict (Klare, 2019).</p>
<b>NODE (SUPPLY CHAIN)</b>	<p>Refers to any part of the supply chain when holistically looking at one; warehouse, logistics centre, port, production facility, etc.</p>
<b>GLOBAL MAJORITY COUNTRIES</b>	<p>"The term 'Majority World' is often used to remind the West that these countries outnumber them. Majority World refers to countries where most of the [world] population resides." (Thelwell, 2019)</p>
<b>GLOBAL MINORITY COUNTRIES</b>	<p>"The 'Minority World' are the nations more commonly considered 'developed' where a small percentage of the earth's population lives." (Thelwell, 2019)</p>

## Introduction

Over the last two years, with the COVID-19 Pandemic and numerous climate change driven events, the world has seen how small events can lead to global consequences. Recently, the world has experienced extreme heat in North America, hurricanes that have hit the southern coasts of the USA, locusts in Africa, drought in North America and Asia, floods in North America, Europe, and Asia, as well as wildfires that made people gasp in Oceania and North America. While much attention has been focused on the science behind climate change and the possible societal impacts, less attention has been paid attention to the impact climate change will have on global supply chains in the coming decades, and specifically on what the consequences of those impacts will be on people around the world.

99.9% of scientific studies now conclude that humans are overwhelmingly responsible for the changes in the climate (Ramanujan, 2021), with around 415 parts per million (ppm) of CO<sub>2</sub> in the atmosphere and a warmer climate of around one degree Celsius from early 20<sup>th</sup> Century averages (Roston et al., 2021). While those numbers may sound small, the impacts they bring are not. Climate change brings with it a higher likelihood of more frequent and severe weather storms, such as hurricanes, while also bringing forward an increased likelihood of worse environmental effects, such as longer and more intense heatwaves, and higher sea levels (Er-Kara, Ghadge, & Bititci, 2020). In essence, we are long past the point of debating whether or not climate change is real or if it is caused by human impacts, instead at the point of trying to determine how bad the effects of it can get.

At the current rate, given the various promises that leaders have made, an individual such as me – a 22-year-old from North America – will experience, according to Thiery et al. (2021):

- 2.2x more wildfires,
- 1.7x more river flooding,
- 2.5x the number of crop failures,
- 2.9x the tropical cyclones,
- 7.7x more droughts, and
- 26.1x more heatwaves,

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under climate change than I would without it, given the possibility of 2.4 degrees Celsius of warming; 2.4 degrees Celsius is based off current promises from world leaders and governments. While my future is a little better under 1.5 degrees Celsius of warming, keeping warming to 1.5 degrees Celsius is a monumental task that thus far seems unlikely to happen (Baker, 2021).

While the results of the study differ marginally depending on where one is from, those being born into the world today are even worse off with

- 2.4x more wildfires,
- 1.9x more river flooding,
- 2.7x the number of crop failures,
- 3.4x the tropical cyclones,
- 9.5x more droughts, and
- 36.6x more heatwaves

likely to be experienced under climate change than would be without it, given 2.4 degrees Celsius of warming (Thiery et al., 2021). Even more important to note is what these numbers do not directly tell us: present-day supply chains are not able to withstand the coming consequences of a changing climate, at least not in the modern configuration.

For example, Er-Kara et al. (2020) state some of the challenges businesses may face because of “broad climate change issues” (p. 3). The challenges include (as quoted):

- Supply problems of raw material resources
- Changes in customer behaviour and demand
- Relocation of production
- Changes in the efficiency and effectiveness of processes
- Changes in product quality
- Decrease in labour performance
- Damage or destruction of facilities, infrastructure, and physical assets
- Transportation problems
- Destruction of markets
- Decreased financial performance
- Climate-related mortality and morbidity



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- Changes in regulations
- Damage to the reputation of the company
- Changes in energy consumption
- Extra costs

Andreoni and Miola (2015) put it best:

*The increasing complexity and interconnectivity that characterize the present economic system makes modern society vulnerable to any kind of disturbance generated all over the world. The global supply chain is a paradigmatic example of networks on which disruption propagate rapidly through the system. (p. 16)*

The reason for this paper is that, while many companies purport to be prepared for the 'new normal', it is unclear exactly how Saskatchewan firms have adapted their supply chains or are thinking about mitigating the impacts of a warmer climate.

For many years, corporations have stymied, slowed down, worked against, and lied about climate change, even in the face of studies from in-house scientists that showed the catastrophic impacts that are now coming to fruition (Oreskes & Conway, 2010; Wright & Nyberg, 2017).

Climate change is a wicked problem – an issue that "...has innumerable causes, is tough to describe, and doesn't have a right answer," (Camillus, 2008) – that is, it is a problem that has many causes, consequences, and interdependent factors that make solving or working on it incredibly difficult, especially in our globalized economy. While this paper could focus on the societal level economic and political systems that reduce the likelihood of 'solving' climate change, doing so would require immense resources and a few thousand pages.

Instead, I will be focusing on what major corporations, headquartered in or important to Saskatchewan, are doing to prepare for the likely impacts of climate change, with a specific focus on their supply chains. Within that focus, the paper will look at how these corporations are working towards adjusting their supply or value chains (henceforth 'supply chain'), whether in terms of permanent adaptation or preparing to mitigate against impacts. Furthermore, the paper will explore some of the consequences should adaptation and mitigation not prove to be

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enough, looking at the downstream impacts if the goods and services provided by the firms are disrupted; impacts of some goods and services could lead to destabilized regions of the world and insecurity in many forms. In essence, I will be asking the following questions: How is climate change impacting major Saskatchewan firms' supply chains? What are the methods those companies are using for mitigating climate change and adapting supply chains? What are the possible downstream impacts to society?

In this paper, I will establish that because climate change is a risk to the functioning of supply chains as currently organized in modern society, supply chain professionals and organizations must make deeper considerations of not only their impacts on the environment but their adaptation and mitigation strategies for future climate change. I contribute to the literature on supply chain risk and climate change by establishing how Saskatchewan firms are preparing for a different climate, and the types of impacts their actions could have. Specifically, I will look at whether Saskatchewan firms are adequately prepared for present and future shocks to their supply chains, what the consequences of inaction in terms of adaptation and mitigation may be to those companies, and what the possible downstream impacts to society are if Saskatchewan firms are ill-prepared for climate change.

### Literature Review

First and foremost, climate change driven weather events can have significant direct impacts on facilities of an organization that are difficult to prepare and account for. Second, as NATO Secretary-General Jens Stoltenberg said on Politico's *Global Insider* podcast, climate change becomes a security concern, with impacts forcing people to change locations and emigrate to new countries, which could have consequences on companies' ability to produce and market their goods (Stoltenberg, 2021). Third, it could become likely that the shift to a 'greener' or 'cleaner' economy paves the way for greater social safety nets and assistance for people, which could impact some organization's business models, even if good for society; leaders need to be prepared for economic changes just as they do for environmental disruptions. Schwartz (2007) as stated in Winn et al. (2010) summarizes the sentiment well:

*...events such as sea level rise, extreme droughts or fires 'become security concerns for businesses when people are forced to flee, infrastructure is destroyed, ecosystems fail, agriculture is disrupted, economic volatility increases, and some regions become uninhabitable'. (p. 166)*

Canada, the country in which Saskatchewan is located, comprises ten provinces and three territories. The territories rely on a different form of government, varying from how provinces operate and are therefore excluded from this paper. Each of the ten provinces has autonomy in the choices they make when it comes to provincial taxes, local regulations, healthcare, education, and much more (Parliament of Canada, n.d.). Given climate change's acute ability to be caused by and impact many regions of the country and the world simultaneously, the Canadian Federal Government imposed a national carbon tax and rebate system in 2019 to help motivate individuals and organizations into making more environmentally-conscious decisions (Government of Canada, 2021). The ability for the federal government to implement a national carbon tax and rebate program was then confirmed to be legal in 2021 by a Supreme Court decision (Joselow, 2021), with the case being brought on by some of the highest polluting Canadian provinces: Alberta, Saskatchewan, Ontario (Government of Canada, 2021).

Saskatchewan, a province of just over one million inhabitants (Government of Saskatchewan, 2021), is known for its resource-based economy. Specifically, Saskatchewan's biggest industries excluding Services are Mining and Oil and Gas, and Agriculture based on GDP contribution

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(Government of Saskatchewan, 2021). The current Saskatchewan government was ardently opposed to the Canadian Federal Government's climate plan (Olive, 2019), primarily composed of the national carbon tax and rebate plan they established. Not unlike many others in resource-based economies, Saskatchewan politicians are financially supported by, and publicly support, fossil fuel industries (PressProgress, 2020) – with the Premier going as far as to threaten municipalities' funding if they choose to remove or reduce fossil fuel sponsorships (Djuric, 2021; The Canadian Press, 2021).

In 'fighting back' against the federal government's prescriptions for climate change, Saskatchewan aimed to implement its own program that would likely not reduce emissions as fast as necessary, according to the federal government (Guignard, 2021). While the Province of Saskatchewan purports to take climate change seriously (Government of Saskatchewan, n.d.), the province has the highest per-capita emissions (CBC News, 2021) and recently cut the funding for the climate change policy office in half (PressProgress, 2021). Additionally, while many would think that Saskatchewan would be insulated from the impacts of climate change, there is no place on earth that is fully able to escape the consequences of a changing planet (Peach, 2019).

The Canadian Prairies are somewhat insulated from the direct impacts of climate change, such as sea-level rise, given the landlocked nature of the geographic area. However, the benefit of being landlocked and escaping some of the consequences of climate change also serves as a downside, with Saskatchewan relying on transportation networks (ports, roads, rail, air, etc.) to import many goods that the province requires.

The consequences of climate change are much vaster than many likely realize. Take for example the Covid-19 Pandemic, which has captured the minds of everyone over the last few years. Covid-19 will not be the last pandemic the world deals with; in fact, pandemics are much more likely to occur, given our motor vehicle, urban sprawl dependent nature of living that brings humans in closer contact with wild animals, allowing for disease spread to happen much quicker (Tollefson, 2020). In addition, a connection can be made between the impacts that urban sprawl has on climate change, all the way to a warmer climate, which brings with it impacts such as melting permafrost in the Arctic, possibly releasing pathogens, viruses, and bacteria that have not been seen in humans for hundreds of years (El-Sayed & Kamel, 2021). In 2016, a child in Siberia came upon a reindeer carcass that had melted out of the permafrost – largely due to climate

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change – exposing the child to anthrax that had frozen with the carcass, killing the child (El-Sayed & Kamel, 2021; Wallace-Wells, 2020).

Saskatchewan felt the consequences of climate change explicitly in the summer of 2020: a major heatwave overcame the province that scientific attribution experts say “almost certainly” would not have happened without climate change (Fountain, 2021). The 2020 Heatwave in North America directly caused almost 600 deaths in the Canadian province of British Columbia alone (Woo, 2021). Heatwaves put stress on humans, such as what occurred with the European heatwaves of 2003 causing upwards of 70,000 deaths and heat-related illnesses (Robine et al., 2008); heatwaves also put stress on economies: not only can infrastructure be impacted, from roads and rails buckling (Mulholland & Feyen, 2021), or trains having to slow down (CBC News, 2012; Wanek-Libman, 2021), but outputs of crops, something an agricultural-dependent region such as Saskatchewan knows – can suffer dramatically. The impacts the drop in cereal exports from the Canadian Prairies in 2020 had on the world market were significant; oat prices doubled in 2020 following Canada’s production of the commodity decreasing by 44% because of the heatwave and associated drought (Terazono & Bruce-Lockhart, 2021).

While some state that higher commodity prices are good for the economies of the regions that can still produce under new climatic conditions by raising incomes (Lustgarten, 2020), higher commodity prices can otherwise be devastating for less wealthy countries (International Monetary Fund, 2017). Commodities are inputs into almost every produced good, and less wealthy nations, which will be referred to in this paper as the ‘Global Majority’ countries (Thelwell, 2019) find it difficult to afford food and other necessities when production is impacted, whether from climate change or other causes.

Severe weather events are becoming more likely to occur and of the harsher variety, leading to devastating impacts on infrastructure. Take Hurricane Sandy for example: while the superstorm had the direct impact of taking the electrical systems offline in the region of New York State, those electrical systems were also required to move or pump gas fuels – the backup systems in the event of an electrical outage – meaning that the backup systems were not resilient or adapted to the new reality that climate change brought (Sandalow, 2012).

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A lot of the focus in this paper will be on the resiliency of our supply systems to the major impacts of climate change, but one major point should be made at the beginning: **efficiency often comes at the expense of resilience.**

Over the last few decades, with the shift to global just-in-time networks of supply chains, this case has been made time and time again. Organizations slim down supply chains to the point that any disruption, no matter how minor, can be detrimental to their operations. 'Economies of Scale' or reducing the level of capital investment to the point where regular, 95% or 99% uptime is conducive to 'maximum efficiency' fails in the times where people cannot get to work because of a storm, or in cases where goods on a just-in-time schedule cannot be delivered because of disruptions at a port. Furthermore, as Andreoni and Miola (2015) touch on, local disruptions and actions can have an impact on the whole economic system. We have seen evidence of this in numerous situations, but remaining Saskatchewan specific: for about a decade from the late 1990s to the early 2000s, Saskatchewan subsidized biofuel production to the tune of hundreds of millions of dollars; because the subsidies made it more economical for agricultural producers to send their bad crops to be converted into fuel instead of sending to less wealthy nations, staple food prices in global majority world countries increased (Boyle, 2008).

Supply chains are a combination of machinery and labour, with important systems requiring essential workers to staff and operate. For example, mega container ships operate with as few as 20 staff on board, transporting upwards of 20,000 containers across the world in a matter of days (The Associated Press, 2009). Over the last few years, supply chains have become a hot topic; often relegated to discussion between professionals within industries or academia, they have now moved into the limelight. Like the saying, 'everything works until it does not' illustrates, supply chains work great when there are little to no external factors influencing the effectiveness and efficiency of the operation; however, when something happens, supply chains must adapt and consider new variables.

Climate change is one of the factors responsible for creating new variables that supply chain professionals and academics need to consider when evaluating risk to an organization's ability to effectively operate. For much of modern history, climate change has been considered a serious but far-off threat to businesses. Many leaders consider climate change to be a societal issue that will be solved through market-based interventions (carbon taxes, cap and trade, regulation, etc.).

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While market-based interventions for climate change are good, those types of interventions are often led by those that believe economics and society are able to control the natural environment, rather than the natural environment having 'ultimate sway' over the economies and societies of the world.

Anecdotally, there seems to be a disconnect in terms of the thinking around climate change; civil society is concerned that the leaders responsible for governments and organizations do not understand the magnitude of the issue, while those that are in charge do understand but are less willing to make meaningful impacts because of the changes to their business models or society that would be required. I see this as a problem of framing; where some would establish the environment as a pillar of modern society alongside the economy, I instead take the perspective that the natural environment is the foundation for other pillars of society, like the economy and population health.

Decades of globalization and removal of a line of sight to the production of consumer goods has made society oblivious to the length of transportation and the multiple countries required to produce their daily necessities. Even items such as fruits and vegetables likely come from faraway places, where one's salad could be a mix of inputs from multiple locations around the world, with little consideration given to the systems, people, and processes required to make a 'fresh' salad in the middle of the desert or the prairies.

Organizations and leaders must think about climate change and the impacts it could have on the ability of their firms to operate in an ever-changing world.

### Efficient and Interdependent... Failures

In 2021, society saw the failures of our 'efficient' supply chains: nearly everything has been disrupted, whether due to the direct impacts of the COVID-19 Pandemic, or the indirect impacts drawing from the increased demand for consumer goods (Goodman, 2021). In the Global North/Minority World countries - US, Canada, Europe, etc. - people have become so accustomed to going to the store or a website and having items they want in their hands no later than the next day (Mull, 2021). During disruptions when frictionless consumerism is not able to occur, people opine that it is supply chain problems that led to it, without considering that because our systems are built for 'normal' demand, they are not able to easily cope with major disruptions. Recently, disruptions have been a large factor in the inability for many firms to supply an increased

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demand for consumer goods, and an inability to find the cheap, often underpaid, labour that makes our supply chains work in our connected world.

Supply chain delays in 2021 were the result of many factors: reduced labour forces because of the pandemic (Bachman, 2021), increased demand for consumer goods because of the greater disposable income and reduced demand for services, reduced capacity for transportation, a shortage of semiconductors (Vakil & Linton, 2021), as well as numerous climatic events – a hurricane on the southwest coast of US (Diaz, 2021); floods in China (Hollingsworth, 2021), Europe (Cornwall, 2021), and North America (Schmunk, 2021).

Global supply chains are significantly interdependent and rely on people from all around the world to function. Agriculture relies on resources and land in the prairies, global energy is heavily dependent on North America, the Middle East, and North Africa, many of our consumer goods leave a port in Asia; modern organizations might rely on dozens or hundreds of countries for inputs to their operations. Even worse, many organizations may not have the line of sight to understand where the inputs for their goods are coming from; a manufacturing operation for a consumer good may be disrupted because a third-order supplier of commodities to their operations had issues fulfilling contracts because of extreme heat or flooding in one of its production areas.

Climate change will not only make it more difficult for organizations to forecast and prepare properly in terms of their needed production and facilities (Er-Kara et al., 2020), but supply chains are a major factor in causing climate change with their emissions. Focusing on the former, however, is what this paper will do; while the role of supply chains in causing climate change should be increasingly studied as well, the risks to systems are too great to not focus on. To illustrate this, consider the 2011 Floods in Thailand: while the direct impacts and costs were over 800 deaths and USD \$4.65 billion in damages, the indirect costs were much greater. Honda, which relied on Thai manufacturing – had to delay production in Japanese and American facilities, costing the company operating profits around USD \$1.4 billion (Katsuyuki, 2021).

Sussman and Freed (2008) as quoted in Dasaklis and Pappis (2013), illustrate risks to firms by organizing climate risks into three categories: **risks to core operations**, **risks to value chains**, and **risks that arise from changes in the economy and infrastructure**. In Saskatchewan, we could illustrate this using the example of any number of companies based in the province. For



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example, an agricultural products producer could experience risks to core operations in severe weather events that threaten their operations at various mines or farms. Risks to value chains could come with disturbances in transportation/logistics, either downstream or upstream, or risks from changes in the economy and infrastructure if critical infrastructure is disrupted. Notably, while much of the concern and consideration for these types of risks and the mitigation strategies around them would be closely-guarded corporate information, it is not difficult to imagine how small impacts could have significant consequences on a Saskatchewan firm and Saskatchewan society.

In terms of Saskatchewan specifically, there is limited literature directly on firms' attitudes towards climate change as a risk. There could be many reasons for this limited literature, including the size – both population and economic – of the province and its companies, a hesitation for researchers to focus attention on the negative aspects of major economic drivers, or simply a bad search of the literature. In terms of the first reason – Saskatchewan being too small – this reason somewhat falls apart when considering the number of industries that rely on Saskatchewan's commodity exports, whether that be in food, energy, or other supplies. The second reason, that researchers are hesitant to look into some industries given their connections to institutions or the power they wield could be part of the reason – a researcher at the University of Regina, Emily Eaton, had to request court access to files detailing the University of Regina's financial relationships with fossil fuel companies (Germano, 2021), illustrating the difficulties researchers have in understanding firms that could perceive negative attention. The third reason, that my search was not extensive enough, is plausible. For this specific search, I used the terms 'Saskatchewan', 'organizatio\*', 'compan\*', 'climat\*', and 'supply' or 'value chain' in various searches.

However, one important article from Pittman, Wittrock, Kulshreshtha, & Wheaton (2011) looked at the impacts of climate change on a Saskatchewan Municipality, Rudy No. 284, questioning rural community populations on their feelings towards climate change's impact on their livelihoods, specifically surrounding the region's dependency on agriculture. Many farmers and other residents were interviewed, with main concerns surrounding drought and the economic differences in those able to afford climate adaptation techniques, such as irrigation technology.

However, the most interesting part of this article in application to Saskatchewan was the following excerpt:

*...climate sensitivities do not manifest in isolation, however; they are related to socioeconomic and other biophysical sensitivities that exist at the community and regional levels. (p. 83)*

This is a major point that the article makes; the vulnerability and sensitivities to major climatic changes and events manifest not only in environmental changes, but the ability to prepare for the changes mentally, physically, financially, politically, culturally, and socially (Pittman et al., 2011).

These points about preparations for climate change being multivariate spill over into the consequences of unabated climate change as well. For example, literature often suggests that regions can enter a state of instability when food security decreases (Asfahani, Kadiyala, & Ghattas, 2019), which would often be associated with an increase in the price of food, although the claims are hard to empirically measure (Demarest, 2015). Food insecurity is often described as a “threat multiplier for conflict” (Asfahani et al., 2019, p. 70), acting as a catalyst for insecurity rather than a cause. The literature on food insecurity driving conflict speaks to the interviews that took place with Saskatchewan residents in the RM of Rudy, namely that the interdependencies and the many various factors can compound into stress over the future.

### Risks and Adaptation

Each year, the World Economic Forum, a consortium of the world's government and private sector leaders puts out a Global Risks Report, which for the last few years has named climate change related risks, such as failure of mitigation and adaptation as the most likely and impactful risks to businesses around the world (Goldstein, Turner, Gladstone, & Hole, 2019). Goldstein et al., (2019) classify company-related adaptation activities into three categories:

- **Soft Adaptation Approaches:** planning and de-risking, financial activities, knowledge generation, HR development, supply chain measures, physically intangible
- **Hard Adaptation Approaches:** capital investments, built structures, engineered infrastructure

- **Ecosystem-based Approaches:** sustainable management, conservation, restoration of ecosystems

Within those categories of approaches, most companies are aiming for 'Soft Adaptation Approaches', but nearly one-fifth of companies that reported facing a physical climate risk did not disclose any strategies for adaptation methods (Goldstein et al., 2019). The article from Goldstein et al. (2019) mentions that the most significant blind spot for companies and their leaders is that climate change appears to be a long-term issue, too far away time-wise for leaders to care about.

Averchenkova et al. (2016) echo Goldstein et al. (2019) in classifying firm-based adaptation approaches into soft and hard strategies, with soft adaptation referring to adapting existing procedures and operations to be more flexible and/or resilient, and hard adaptation referring to investment into machinery, facilities, and other fixed assets. However, Averchenkova et al. (2016) also state:

*A key question that remains is whether emerging strategies and projects on climate change are truly forms of adaptation or simply examples of business as usual or 'green washing'. (p. 530)*

Greenwashing can be defined as "the practice of making unwarranted or overblown claims of sustainability or environmental friendliness in an attempt to gain [or maintain] market share" (Dahl, 2010). In essence, while adaptation measures are welcome, if the measures are simply for public relations or marketing and do not truly improve the resilience of the company, they are useless.

For those who work in supply chain management, time uncertainty is not an unknown factor. In supply chain management, the further in the future an impact, decision, risk, or other factor is, the more difficult it is accurately forecast (Slawinski, Pinkse, Busch, & Banerjee, 2017). Climate change's impact on supply chains and the role of leaders in making decisions concerning that matter is not any different; the further out the impacts of climate change, the more difficult it is to prepare for the consequences of (in)action adequately and accurately (Slawinski et al., 2017). As Slawinski et al., (2017) note,

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*...the market logic's preoccupation with the share price and competition puts the climate change issue outside the scope of the manager as having relevance to core business practices because the potential impact is not concrete and is surrounded by too much uncertainty. (p. 26)*

Part of the uncertainty organizations face is the dilemma brought on by possible regulations, and where they sit competitively. Morally and ethically, some organizations and their leaders may feel the need to reorganize their operations in a manner that not only reduces their impact on the environment but also puts forth some principles of adaptation that the organization can use to positively navigate shifting environmental effects for enhanced financial performance. However, many corporations take the following Milton Friedman statement as their guiding principle:

*There is one and only one social responsibility of business—to use its resources and engage in activities designed to increase its profits so long as it stays within the rules of the game, which is to say, engages in open and free competition without deception fraud. (Friedman, 1970)*

This principle is ever-relevant to this paper, especially with examples of leaders – like Emmanuel Faber at Danone – supposedly being forced out of their companies because they chose to focus holistically on society and the environment, rather than focus all their attention on shareholder returns (Walt, 2021).

As Wright and Nyberg (2015) point out, businesses are often complicit in causing the problems they are asked to solve, and the inability of governments to regulate corporations to make progress on climate change is, in large part, because of those same corporations' lobbying on the regulations that would apply to them. As they write:

*Meaningfully responding to many of the grand challenges facing the world requires systemic intervention based around central authority. Nation states have traditionally confronted major crises such as wars and economic depressions through active government intervention and the regulation of economic and social activity. However, in the current age of neoliberalism, the role of government is explicitly rejected in favor of market solutions and corporate innovation (Crouch, 2011). Indeed, the political strata have become*

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*increasingly subservient to corporate interests (Barley, 2007). Governments increasingly favor economic interventions that ensure profit maximization, irrespective of the social and environmental costs. (p. 1656)*

This push and pull of voluntary actions by corporations pitted against the regulations they do not want is actively ongoing, even in 2021 (Pontecorvo, 2021). When corporations have to choose between financial goals and societal goals, firms often lean to the former, choosing to satisfy stockholders over society writ large (Wright & Nyberg, 2017).

Of course, it would be nearly impossible to change the incentives given to companies in service of the market without changing the market economy itself, something that does not seem likely to happen anytime soon.

### Impacts to Organizations

Businesses are often reactive, experiencing how a shock impacts their systems and then adjusting for those same shocks to occur in the future. This reactivity occurs in place of proactively simulating impacts to their systems, and proactively investing in mitigation and adaptation techniques (Lim-Camacho et al., 2017). This reactive approach is easy to comprehend when one recognizes that mainstream business models assume current economic and social conditions will continue to work, regardless of "...unfavorable biophysical conditions in Earth's natural and climate systems" (Winn et al., 2010, p. 158). As Winn et al. (2010) show, although the impacts of climate change are felt across a wide range of industries, and described as a "predictable surprise", there is a bias in organizations towards the predominance of stable states. In other words, climate change is less of a black swan event – one that is unexpected with significant impacts – and more of a gray rhino event: predictable and expected, with significant impacts (Wucker, 2016).

The geographically spread nature of multinational corporations – that is, having critical operations in many different regions of the world – means that responses to climate change will have local impacts all around the world (Averchenkova et al., 2016). As Averchenkova et al. (2016) explain, MNCs are in a unique position, as not only can measures taken by them improve their resiliency and the resiliency of the communities around them, but they are most likely to be financially impacted by climate change given the fact that close to 80% of global trade passes through their supply chains. On the opposite side of that argument, if MNCs do not prepare their

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supply chains for climate change, they can have adverse impacts on local communities as well; for example, if a chemical company is ill-prepared for flooding in a production region, harmful products could be released into communities – more than already are with pollution (Barrish, 2021).

For adaptation, much of the work that firms do is driven by external factors, such as weather events and changes in the climate; however, as of recently, significant factors driving firms to undertake more ambitious climate strategies are public opinion, market demand, and regulatory changes (Averchenkova et al., 2016).

When looking at supply chains specifically, there is much to be concerned about. Many primary industries that produce commodities – the base goods that provide the inputs for all other goods that modern society relies on – are dealing with more severe climate disruptions (Lim-Camacho et al., 2017). Commodities are an interesting part of the supply chain of numerous companies and industries, and their susceptibility to climate shocks is an important aspect to focus on. Since commodities are almost always used in a different location than they are produced, they require complicated systems of production, transport, and storage. Ray et al. (2015) as quoted in Lim-Camacho et al., (2017) illustrate how volatile the price of commodities stemming from agriculture has been recently: “In the last decade, price volatility has been 30-40% higher than previously, partly due to climate-related shocks, such as droughts, floods, storms and fires” (p. 129). With an expectation that those events will rise in frequency and severity in the coming decades, past volatility is likely to look like small inflections rather than major shocks.

Lim-Camacho et al. (2017) illustrate how climate can impact economic systems with an example of the Australian Millennium Drought and Australia's rice production:

*In 2007–08, for example only 2100 ha of land was under rice cultivation due to the Australian Millennium Drought (1995–2009), producing 17,000 t of rice – only one per cent of production two years prior. (p. 129)*

While Australia is a small producer of rice globally (FAO, 2021), the example illustrates how climate-driven events could have major impacts on firms' – and therefore the world's – ability to produce necessities, let alone unnecessary consumer goods.

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The Lim-Camacho et al. (2017) study looks at how the level of complexity in a supply chain impacts a firm's ability to respond to climate disruptions, finding that in a simulation approach, more complex supply chains are more resilient to expected climate impacts. Complex supply chains – those with multiple nodes – typically can shift supply and demand to different locations if they are impacted, whereas simpler supply chains are typically reliant on single points of failure. However, the Lim-Camacho et al. (2017) study also shows that “all [*supply*] chains, regardless of their complexity, will have diminished resilience as disruptions become more frequent, particularly if key elements are impacted on an annual basis” (p. 135). Climate-driven events that knock out more than one link in a given supply chain would be even more catastrophic, impacting numerous parts of the same supply chain and making resiliency preparations even more difficult (Lim-Camacho et al., 2017).

Becker et al. (2017) make the same point about complexity in their article on port management and climate change:

...all supply chains will have diminished resilience as climate disruptions increase ... a more complex supply chain, with a higher number of nodes and links, will tend to be more resilient to climate-related shocks. (p. 4)

In our globalized world, the interconnectedness of our economic systems makes supplying goods a complicated, yet fragile task (Tenggren et al., 2019). Attempting to understand how resilient an organization is can be a difficult process. The author of this paper has experienced the failure of resiliency (or risk) management firsthand during the Covid-19 Pandemic during employment with a global energy company, and the exact example is described – with the emphasis – by Tenggren et al. (2019):

“Multiple suppliers in supply chains with high asset specificity (Joskow, 1988) could be less efficient and therefore economically indefensible (Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007), or **sourcing from dual ‘first-tier’ suppliers might not be enough if, in fact, they share the same ‘second-tier’ supplier** (Oke & Gopalakrishnan, 2009). (p. 4)

The second-tier supplier aspect is an important point to dwell on; much of our globalized economy focuses on extracting as much wealth as possible, and the goal of many profit-driven firms is to exploit the intellectual property they have. In doing so, some firms become the sole

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supplier of key components. If a firm is multiple steps away from critical primary suppliers, understanding and preparing for disruptions to those primary firms' operations is an imperative part of ensuring resiliency. The ability for firms to be prepared relies not only on their ability to understand the problem of climate change, but to be able to model the impacts it could have on their supply chains and the supply chains of their suppliers.

Furthermore, when thinking about supply chains, it is important to note that the resilience and preparations of supply chains for climate events could be an important factor in whether the world can successfully act on climate change. For example, many technologies required for transitioning away from fossil fuel energy require the significant use of semiconductor chips and critical minerals such as Rare Earth Elements (Government of Canada, 2021). Both of those inputs are susceptible to the impacts of climate change, and even presently, a disruption to the ability for firms to have access to semiconductors or Rare Earths would be devastating to the world economy (King, Wu, & Pogkas, 2021; Whalen, 2021).

### Critical Infrastructure

Firms must understand how their operations are impacted by disruptions to critical infrastructure. Critical infrastructure can include energy and electricity infrastructure, information and communication technology, transportation infrastructure, utilities, health, safety, and government (Forzieri et al., 2018; Warren & Lulham, 2021). Critical infrastructure susceptibility and resiliency are imperative to understand as firms are reliant on infrastructure to allow their operations to function.

While it is good to focus on critical inputs such as semiconductors and Rare Earths, it is also important that firms consider how the climate could impact the ability of regions they operate in to supply the necessities of life – food, water, and shelter, let alone utilities such as electricity, sewage, and internet – and how the inability to supply those in an environment conducive to human life could mean an increase in the migration of people. Migration is one of the issues commonly associated with climate change, and it could lead to a lack of labour in a market, or the complete change in where consumers are available to buy firms' products (Raleigh et al., 2008).



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Migration, not unlike climate change as a whole, creates vast changes in the security landscape for states and their leaders. The arctic is one region commonly thought about by security professionals and government leaders in Canada, given its proximity to Canada, the United States, and Russia, and the changing reality of the region due to climate change (European Union Copernicus, 2021; Gricius, 2021). In addition to the arctic, many regions' discontents and inequities will be amplified because of climate change, with increasing threats to critical resources required to sustain human life (Heslin, 2021; Rice & Zegart, 2018). Firms often rely on the governments in the areas they operate to ensure the security of the firms' assets with state security services, but firms may need to be prepared to do so themselves, by preparing backup supply chains should their assets not be accessible any longer in any given region.

In addition to human security threats arising from climate change, climate change can also increase the threats of natural, human security issues, such as pandemics (Bernstein, 2020). These events can make it more difficult for supply chains to be resilient. While firms ensuring their supply chains are resilient to the impacts of climate change is imperative, it is crucial to note that efforts to decarbonize and reduce energy usage are not included in those efforts. Decarbonization and reducing the impacts a firm has on the natural environment are ultimately more important than anything else concerning climate change, even resiliency measures. Resiliency is important, but reducing the likelihood that resiliency measures are required is better.

However, there are measures firms can take that both reduce their impact on the environment and enhance resiliency. Measures could include reducing input or energy usage such as what Molson Coors did at one of their production facilities, installing new technology in their processing vessels that reduced the water required for their products (Kalaitzi et al., 2018). Other measures such as optimizing transportation networks with different modes like bicycles could not only make moving goods more efficient, but improves resiliency with reduced reliance on fuel for movement (Becker & Rudolf, 2018; Cheng et al., 2021).

If we consider one of the most important aspects of global supply chains, seaports, the effects of climate change become acutely known. About a third of the world's ports are in areas prone to tropical storms, with narrow margins of error acceptable (Becker et al., 2017). Global ports have already sustained billions of dollars of damage related to tropical storms; however, while short-

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term disruptions, such as tropical storms, are relatively easy for port management and reliant industries to plan and mitigate against, long-term stresses such as sea-level rise, wave climatology, and the salinity of the sea – causing higher rates of corrosion – are not typically factored into port management (Becker et al., 2017). In addition, as Becker et al. (2017) explain, as ports are impacted, so too are other aspects of firms' supply chains – whether it be the transportation carriers, warehouses, or railway companies. Ports are fundamentally important to the effective operation of modern society – and the adaptation of them in preparation for climate disruptions will not only be expensive, but it will also require “multiple actors, policies, and practices”, with “many sectors of society” impacted if ports are not adequately ready for new environmental conditions (Becker et al., 2017).

As illustrated above with ports, no supply chain operates in isolation; all nodes in a global supply chain are interdependent with another node. Kong and Sun (2021) reference this type of interdependency in supply chains with the concept of “catastrophe risk”, or the ability of a local event to have global consequences when spread through supply chains. The example of the 2009 volcanic eruptions in Iceland is given, which led to the cancellation of more than 60,000 flights globally, illustrating how relatively small environmental events can have major consequences for the world economy; each one of those flights would be carrying people and cargo that would have been delayed for significant amounts of time (Kong & Sun, 2021).

The fact that supply chains rely on critical infrastructure that is largely outside of their control makes planning for climate change difficult for organizations. For example, while a firm might be prepared to pause operations if a storm hits a major node in their network – such as a distribution centre – if the infrastructure, such as electricity transmission or roadways are disrupted, the firm must rely on other organizations and governments to return to regular ability and capacity. BSI, a British business standards and consultancy company, released their 2021 Supply Chain Risk Insights report that touches on the “...multifaceted impact of natural disasters and man-made disruption,” which shows the myriad of challenges that climate-driven events can pose, including interruptions to utilities and delays to those working to restore access to critical infrastructure (The British Standards Institution, 2021). It is not only how the firm itself can respond to disruption, but also how the firm's suppliers and providers of critical goods and infrastructure can respond to disruption(s).

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In addition, infrastructure that may have been suitable for the weather and climate of years ago may no longer be suitable for events occurring today or in the future. Quantifying the impacts of climate change is challenging, given the local nature of many different types of infrastructure, the different lifetimes of infrastructure, incomplete scientific methodologies in assessing the infrastructure, and the variety of risk levels (Forzieri et al., 2018). The Forzieri et al. (2018) study looked at infrastructure in Europe, assessing that infrastructure damages will,

*...amount to approximately €9.3 billion (€5.2–14.2 billion uncertainty range), €19.6 billion (€12.5–34.0 billion) and €37.0 billion (€21.3–53.2 billion) per year by the 2020s, 2050s, and 2080s, respectively, only as a result of the effects of climate change. (p. 101)*

In Europe, it was assessed that drought and heatwaves will make up around 90% of climate damage. Damages come from fires, buckling of roads, melting of asphalt, lost navigation capacity because of low water in rivers, sea level rise and increased storm surges, and structural damages from floods and windstorms. While adaptation measures are being undertaken, they are not being taken equally across the continent, nor are they deemed adequate – costs to make infrastructure more resilient could “exceed €200 billion” (Forzieri et al., 2018, p. 102).

Furthermore, as Forzieri et al. (2018) illustrate, the risks to infrastructure that come with climate change reinforce and create new risks, leading to cascading, multifaceted impacts. An interesting example of this was the societal hazards created with the 2018 Camp Fire in California – metal parts holding electricity transmission lines in place had severely degraded over decades of use and a changing climate. The PG&E utility company – who owned and managed the infrastructure – failed to replace the parts as required. The result was live transmission lines sending sparks flying into vegetation, creating one of the biggest and deadliest fires in North American history (Rittiman, 2021).

### Local Impacts

Closer to Saskatchewan, we recently saw cascading, multifaceted impacts with the atmospheric river in British Columbia. The fires of the past few years destroyed vegetation that would be crucial in limiting flooding and landslides (Austen & Isai, 2021); when combined with a warmer

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climate with bigger storms, the results were catastrophic: roads and railways were washed out, and numerous lives were claimed (Schmunk, 2021).

Specific to Canada, climate change has had and will have many impacts on our ability to maintain the same standards of modern society that we are used to. In the Canadian Federal Government's National Issues Report, the authors state how communities around the country are being impacted, and that, "a changing climate affects all sectors of Canada's economy through impacts on production, operations and/or disruption to supply chains" (p. 12).

The National Issues Report on Canada's climate stresses that the country must look beyond its borders when dealing with an issue as complex as climate change, because "...climate change impacts occurring elsewhere in the world, as well as the steps that other countries take – or do not take – to adapt, can strongly affect food availability, trade and immigration" (Warren & Lulham, 2021, p. 12). One of the key messages in the National Issues Report is that climate change is a major threat to Canada's ageing infrastructure, with climate change increasing risks of structural damage, "...compromising system reliability and threatening health and safety" (Warren & Lulham, 2021, p. 30). While the report does list numerous ways that various entities – cities, towns, Indigenous peoples, etc. – are adapting for future impacts, the challenges are massive. Saskatchewan itself faces increased drought and extreme precipitation scenarios in the future, which could have harsh impacts for the province and the world (Wheaton et al., 2013).

While Saskatchewan firms need to understand the impacts of climate change on infrastructure in Canada, many firms today operate in global marketplaces with global supply chains, reliant on infrastructure worldwide to conduct their operations. Saskatchewan is reliant on other geographic locations to get its export products to market – whether pipelines to transport fossil fuels to markets, roads and railways to move goods, or airports and seaports to get goods to other locations. In relying on those different infrastructures, companies that operate in Saskatchewan are innately relying on the infrastructure in those areas as well, whether public or privately operated.

This reliance on infrastructure raises some important questions, namely: how do companies evaluate the worthiness of the critical infrastructure systems in other locations that could threaten their ability to operate successfully, especially in a time of a changing environment? What type of modelling are firms doing to assess the readiness of their supply chains should a climate-

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driven event occur, damaging the systems that the firm relies on? What kind of line-of-sight do firms have into the resiliency of their suppliers and providers, specifically when it comes to those that provide critical goods or services to the firm's operations? Those are just some of the questions this paper aims to answer about major Saskatchewan firms and how they are adapting and mitigating their supply chains for climate change.

## Methodology

For the paper, interviews were set up with executives and leaders in the business community in Saskatchewan. Interviewees were selected to ensure their companies were major firms<sup>1</sup>.

Interviewees were contacted through connections with me or the supervisor on this project, Dr. Keith Willoughby, which may induce some bias in the participants' responses.

Interviews were conducted in a semi-structured method, with nine pre-established questions for participants to respond to, with interviewees asked follow-up questions and taking interviews in directions appropriate to their industry. Participants were encouraged to not limit their responses to exactly what the question(s) were asking and were encouraged to give as much detail as they can. The interviews were conducted over Zoom, due to gathering limits to prevent the spread of Covid-19 in 2022. Interviews lasted around 60 minutes each and were recorded to transcribe the results from the answers participants gave.

Once the responses for each participant were gathered, the interviews were transcribed.

Following transcription, interviewees were given time – three weeks post-interview – to review the transcripts to ensure that they concurred with the recorded and noted answers they gave.

Once approved, transcriptions were then anonymized and identifying data – of either the individual or the firms in question – was removed to the best of the ability of the author.

Given the small sample and population size of major Saskatchewan firms, as defined, there may be some limits to confidentiality. Responses were made in the aggregate and generalized form of specific industries. Participants were made aware of confidentiality limits and their decisions to consent to the interviews were respected.

The questions proposed to participants can be found in Appendix A. The guiding themes of the interviews were as follows:

- Company/industry thoughts about climate change
- The ability of firms to adapt to climate realities
- The ability of firms to mitigate climate damage

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<sup>1</sup> “Major firms” represents both firms with revenues >\$10 million, which were confirmed through public financial filings, or firms with an outsized importance/role in Saskatchewan society. Some interviewees have worked with/for “Major firms” in the past or present, but chose not to recognize or associate with them due to confidentiality reasons.

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- Firm preparedness for climate-driven disasters
- Firm supply chain readiness
- Firm line-of-sight into upstream suppliers' supply chain readiness and downstream impacts on people and communities if firm's operations are disrupted
- Motivating factors for firms and leaders focus on climate change

In addition to the interviews conducted, a review of any company statements and reports was undertaken to better understand the various firms' positions on environmental regulations, climate change impact modelling, supply chain risk mitigation efforts, and adaptation implementations.

### Discussion of Findings

Interviewees came from a variety of backgrounds – supply chain, finance, consulting, and sustainability work – across various industries like energy, agriculture and agri-value, industrials, and logistics. The discussion around the topics covered and important mentions are below.

#### Initial Reactions

Every single interviewee was concerned about the possible impacts climate change – or climate change related legislation (e.g., carbon cap and trade programs) could have on their business. Notably, while every interviewee did mention the changes in society since the Covid-19 Pandemic began, another event was more dominant in many interviewees establishing their concerns: the atmospheric river, which are getting worse because of climate change, that occurred in British Columbia, washing out critical infrastructure like highways, bridges, and railroads, effectively cutting off the Port of Vancouver – Canada's biggest seaport – from the rest of the country (CBC Explains, 2021). One interviewee, Purchasing Interviewee 1 (PI1) put it this way:

*...the floods in BC and cutting off the port... actually probably did even more than Covid because just about everything we buy that comes in internationally comes in through that port, and if its down or isolated, we can't get what we need... I've never heard of a port being cut off, I've heard of them go on strike and that's very disruptive but... those out-of-control [climate-induced] factors are something that, certainly the last five years, there's been a lot more of. If that recent history is an indicator of the future... we're going to have to think about this kind of stuff a lot more.*

While interviewees did mention awareness of climate change, it is as though the events in British Columbia in 2021 with the atmospheric river led to some re-evaluation of the possibility of impacts to their businesses. This resonates with the idea that many establish their understanding of the world on the 'predominance of stable states' – but as those climate and other disruptions become more acute and impactful, instability is being added into an already fraught equation.

Of the six interviews conducted with six participants, only two from larger corporations (Energy Interviewee 1, 'EI1' and Agriculture Interviewee 1, 'AI1') mentioned their abilities to model and



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make proactive adjustments to their strategic plans. The other four stated that their companies either lack the ability to model climate impacts on their supply chains, never thought about it or did not see the necessity, or relied more heavily on the government to make the appropriate decisions.

For one of the major corporations in the agriculture industry, modelling of climate impacts has become a crucial part of their business for about a decade since the company began experiencing harsher weather and more severe impacts to their operations. Since then, the company has measured all of their carbon emissions across all three scopes (emissions from their operations, emissions from their use of energy/electricity, and emissions from their supply chains), their use of various resources like water and energy, and started looking at their supply chain vulnerabilities to address them with soft- and hard- mitigation/adaptation techniques.

For example, the company has administrative controls in place to ensure transportation of livestock and certain commodities does not happen when temperatures hit certain pre-established safety levels, but the company has also ensured their facilities have backup food, water, self-sufficient energy generation, as well as shelter should employees be required to spend time at a facility if it is inaccessible due to harsh weather. The company chooses to build to the highest standards for weather-resiliency, ensuring facilities are able to withstand more impactful storms. While having these emergency management procedures set up and ready if they are required is great, the fact that they are relatively voluntary (and seen as competitive advantages rather than necessary) for the different companies, says something about the state of the preparations for climate change.

Elsewhere, the lack of modelling – one of the first steps in understanding what parts of their supply chains could be vulnerable – is somewhat worrying to an outsider. While some interviewees gave reasons for their lack of modelling (e.g., not enough resources, or misaligned incentives), a few placed their hope in governments and regulation to address structural risks to the system. One executive at an agri-value firm (Agri-Value Interviewee 1 or 'AV1') noted their displeasure with the Saskatchewan Government in addressing these issues, stating "...the one thing that concerns me, aside from not having control [over climate change and its effects] would be the regulatory [environment], especially our provincial government and where they're at. And not just with the politicians, even... the administrators... they're still always on my case about

exporting... while the rest of the industry is focused on how to create a local supply system, a local ecosystem.” The AV1 executive in question was referring to the topic of re- or on-shoring, moving supply closer to its end customer to increase resiliency by decreasing reliance on global supply chains, displeased with the government’s focus on sales abroad rather than assistance in becoming more resilient.

Overall, the message throughout all the interviews was similar; collectively as a society – and more specifically the business community – we have focused on efficiency in our global supply chains at the expense of resiliency. This comes in many shapes and forms, such as just-in-time logistics reducing stock levels to reduce costs, offshoring production to exploit lower wage workers and less regulations, increased use of technology which adds vulnerabilities of the servers those technologies communicate with, and an overall focus on shareholder value above all else.

### Climate Modelling and Understanding

As established above, only a few of the firms and individuals interviewed mentioned the ability for their firms to proactively model and understand how climate change could have an impact on their operations. However, all of the interviewees agreed on the fact that the modelling rarely extends to aspects of society that they take for granted (e.g., critical infrastructure, such as highways or utilities). This was evident in the surprise and comments about the atmospheric river in British Columbia in 2021 – many of the interviewees were acutely aware of how climate or stronger storms in recent history could impact their facilities, but none of them had ever thought they would witness one – or their only – major port be disconnected from the rest of their operations. Given that Vancouver serves as a major logistics hub for all of Western Canada, this event caused major disruptions that meant businesses had to react in different ways, such as re-routing traffic through the U.S. (dealing with customs), airlifting goods (more expensive), or paying more for the limited cargo transport available. However, as will be touched on in the Security Implications section, an energy producer in Saskatchewan did mention concerns around infrastructure – roadways and electricity infrastructure, specifically – and emergency response abilities given their industry.

The pain point touched on by interviewees in this area of understanding and modelling climate change’s impact on supply chains was simply the inaccessibility or the lack of knowledge as to

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how to best to do this, including a lack of knowledge of which tools would be available for these purposes. An interviewee that has worked in Industrials, I1, mentioned this explicitly in that they were not aware of any great tools available to help model climate change impacts on supply chains, and that is worrying given the globalized nature of supply chains, requiring decisionmakers to have insight into operations on multiple continents. Conversations about climate modelling almost always touched on aspects of transparency when dealing with suppliers – while companies often aim to understand their suppliers' financial health, seldom do they also seek to understand their suppliers' climate adaptation and preparedness. And largely, there is good reason why companies rarely understand their suppliers to this level: it is difficult, time consuming, and expensive. It is much cheaper and easier in the short-run to rely on norms and a structural understanding that those suppliers are doing their utmost to ensure stable supply.

All of the interviewees understood that climate change could, and likely will, have drastic impacts on their businesses and their supply chains as currently constructed. However, as one consultant (C11) put it when talking about climate modelling, “[Organizations] are really just doing this on a subjective basis... at the mercy of the weather... aware of the changes.” The consultant, when talking about climate modelling, also commented on how the energy systems – like electricity and gas – have misaligned incentives in some of the areas, with the shift to renewable energy internally having exogenous impacts on the communities they operate. To illustrate this, C11 stated how, if a facility a company operates becomes more self-sufficient with solar panels, and less reliant on the networked electricity grid, the costs to residential users rises because costs are now spread across less participants in the market. In essence, what is good for the environment and the resiliency of organizations may not be good for the economy of the region, largely due to the natural or government-regulated monopoly positions that some energy utilities have in providing service to an area – the economic incentives are misaligned. An energy producer interviewee, E11, mentioned how they are now seeing more focus from major institutional investors on climate-related initiatives (e.g., net zero, carbon emission reduction, etc.), which is shifting incentives without major input from policymakers.

Literature notes this misalignment of incentives in another way: suppliers of energy to customers often hold a natural or government-regulated monopoly, which often means that if they are profiting off the sale of energy that is making climate change worse, they likely do not have any

incentive to shift to cleaner energy. As has been seen in many jurisdictions around North America, utilities will often purposely lobby against further clean energy initiatives (Stokes, 2020) – or in Saskatchewan's case, reduce subsidies to these cleaner sources (Hunter, 2019) – making it more difficult for commercial and residential customers to feasibly transition.

Because of these factors, the interviewee in the agricultural industry, AI1, noted that their company's facilities in the prairies (Alberta and Saskatchewan, specifically) are at the top of the list for renewable energy investments from the company. Not only do those investments reduce the companies Scope 2 emissions, but they increase the company's resiliency. However, the concerning element of this future investment in the Prairies is that the investment is largely due to the failures of the governments and utilities in those areas to invest in cleaner electricity production – the Prairies are at the top of the list because we are the worst in terms of impacts on environment from electricity production, due to our over-reliance on coal and natural (methane) gas, instead of hydro-, wind-, and solar-power. This drive by an individual corporation – that spells out carbon neutrality as a key element of their competitive advantage – to invest in their facilities in the Prairies brings up questions of responsibility and morality: Should the market ultimately dictate who is able to afford clean energy? Can country- and world-wide climate goals be achieved through individual responsibility, instead of government investment and collective work? The answer to these questions lies more in philosophy, economics, and science – but given the interconnected and interdependent nature of climate change as a “super-wicked problem”, one would presume that some level of collective responsibility is necessary for a collective problem. Furthermore, this interviewee, AI1 closed their statements on climate change by referencing the way in which climate change is a collective issue and requires collaboration: “It's super important and we're not going to get there as one company doing it all by themselves – it has to be a collaboration of many supply chain actors.”

### Adaptation and Mitigation

Adaptation and mitigation are large topics that cover a lot of ground in the climate space. All interviewees mentioned some sort of soft-based adaptation approaches (planning and de-risking, financial activities, knowledge generation, HR development, supply chain measures, physically intangible, etc.), primarily in the spaces of risk management, financial activities, and knowledge generation. These adaptation approaches are easy and relatively inexpensive, allowing

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organizations of all sizes to have some basic understanding of climate change and put a minimum level of effort into preparing for its possible effects on their supply chains.

Two of the interviewees directly talked about hard-adaptation approaches (capital investments, built structures, engineered infrastructure, etc.), directly referencing facility upgrades to ensure continuity during climate change and weather events, but only AI1 touched on nature- or ecosystem-based adaptations (sustainable management, conservation, restoration of ecosystems). Now, the focus on ecosystem-based adaptations could be due to the proximity of the agricultural organization to the ecosystems they require – but it is notable that of all the interviewees, the one whose organization has spent the most resources on measuring and understanding climate change has also spent the most resources on adaptation measures. This could be viewed as an extension of the economic concept of sunk-cost fallacy (the organization has put such significant resources into climate change measures already, they continue doing so to feel warranted about their initial investments), or it could be viewed as those that understand the problem of climate change are more inclined to act on it. Speaking with this interviewee, AI1, I believe it to be the latter – the organization is genuinely concerned about not only their actions and impacts on the climate but is making changes to their long-term strategy in order to be a viable organization in the future. AI1 also spoke about the remoteness of some of their operations, which contributes to the need to have their facilities prepared for isolated events that are not within reach of public first responders. Another interviewee, EI1, spoke of the adaptations their firm has made is expanding the 'fire breaks' (i.e., the distance from the exterior of their properties to forests) six-fold over the last few decades, as forest fires have gotten more severe and frequent.

The more knowledge and understanding an organization or institution has about climate change, the more they are motivated to act on it – and not strictly in a moral or ethical sense. It is making greater economic sense to invest in understanding and adapting/mitigating to climate change. On the flipside, the less the organizations – and the interviewees – understood about the problem and the interconnected nature of climate change, the less likely their organizations have made any preparations for issues that could arise in the future because of impacts.

Importantly, and this will also be touched on in the Political Comments section below, one interviewee in the agri-value sector, AV1, placed significant blame on the provincial government's political leadership and bureaucracy for not focusing more attention and resources

on climate change adaptation techniques. The conversation with AV1 also brought up a more significant issue: smaller firms are facing greater challenges because larger firms are able to invest in proactive measures much easier (e.g., opening facilities in other countries, or adding distribution centres), as well as respond to events with greater resources (e.g., having dedicated emergency response departments). Because of this, smaller firms already do – and will likely – find it difficult to compete on traditional factors such as price and distribution ability.

This interviewee, AV1, brought up their organization's mitigation measures for dealing with supplier issues: ordering greater quantities of supplies. At first read, ordering more supplies to ensure stability of stock seems like a great idea – and it likely is for the organization to maintain the ability to do business. However, those who understand the supply chain in greater detail will note the fact that this will create a “bullwhip-effect”, causing ripples in planned production volumes all the way up the production line. In the just-in-time supply chain that organizations around the world have created over the last few decades, there is limited capacity for sharp increases in demand – in fact, that was partly the reason behind a significant amount of disruptions to goods during the Covid-19 Pandemic. In the short-term, increasing purchase volumes of critical inputs may be an okay method for smaller organizations – as long as they can afford the cash outflow – to mitigate against disruptions, but the higher upstream climate disruptions get, the decreased ability any firm has to respond. Longer-term thinking is necessary to ensure that infrastructure and organizations are prepared for the changes in the world.

### Global Nature and Structural Issues of Supply Chains

Due to the nature of climate change, firms and other stakeholders must consider factors outside of their direct geographical areas of operation or headquarters. This consideration comes in many different shapes and forms, with some of the larger firms that interviewees were from taking actions to ensure facility readiness in different areas of the world. At the other end, some firms were watching global financial markets, especially for commodities – and the underlying factors in driving those markets – much closer. One interviewee, AV1, mentioned this explicitly:

*Ultimately, you know just about everything these days is a global market, [but] obviously there's some advantages that we can leverage because [some commodities] are grown here... so I mean, we're already kind of connected in with [local producers], but you're still negotiating with global markets.*

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In addition to thinking about the global markets of commodities and ensuring facilities are prepared for impacts, it is also important to mention that almost all interviewees mentioned the structural nature of supply chains in relying on various firms in many different locations. In terms of climate change, this was mentioned in some anger over Canada attempting to address climate change when other nations like China and India have a greater absolute impact on the environment. While it is accurate to say there are many other countries that have a greater impact on the environment, it is an unfair characterization due to the fact that those countries may have significantly greater population (lower per capita emission rates) and the countries that have a greater impact typically do so because of their position in the production process for the world's goods (i.e., Chinese manufacturing of goods for Canadian consumers). The structural nature was also mentioned by interviewees in addressing access to critical inputs, such as semi-conductors/computer chips, but also in dealing with disruptions to transportation (e.g., highways, ports, etc.) and vulnerabilities of regions to political shocks.

In terms of the global nature of supply chains, a few interviewees did specifically mention their firms' goals of "on- or re-shoring" or "localization/regionalization" of their supply chains. In this context, interviewees were talking about their firms' goals of bringing supply closer to their operations, reducing reliance on other areas of the world and transportation networks. While there are downsides to these types of moves as well – such as increasing reliance on a single country/state leading to vulnerabilities with points of failure – the "localization" of supply chains was an element of almost all the interviews. However, when further discussing this issue, the goal to "localize" supply chains, firms must consider second- and third-order suppliers that could be vulnerable, regardless of how much of their supply chain is "localized"; for example, a firm could re-shore a production facility, but the commodity supply needed to operate that production facility may still be vulnerable to disruptions.

### Political Comments

A few interviewees did mention politics as an issue but described that they were taking cues from larger organizations – especially energy firms engaging in the "transition" to guide their thoughts on climate change. One interviewee, AV1, did mention how they would like to see greater political leadership on subsidizing capital investments in renewable energy generation in the province of Saskatchewan, and expressed their displeasure with how the bare minimum of

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choices in environmental protection – like recycling – was viewed by the company responsible for the recycling. In response to the question on how their location in Saskatchewan impacts their decisions on climate change, this was the interviewee said:

*There's never a single easy answer, right. It's regulation, it's the climate, where you live, it's the public perception, where you're at in your business growth phase... it's all of those things. Some people do look at us as being leaders in [environmental protection/climate change] and I'm not trying to run down Saskatchewan, but we're just not great at it. Like we recycle all our cardboard packaging and, like the company that does the recycling for us, they wanted to nominate us for an award, and I was like, 'well, we just recycled cardboard like who cares like this is like the basics.'*

*And she said, 'no, most businesses in Saskatchewan - they can't be bothered, they don't want to do it, they just throw it all in the garbage, they just view it as an extra cost that they don't want to take on.'*

*I don't think I'm doing anything special by recycling cardboard.*

And while recycling cardboard is not going to be the solution to solving climate change, the fact that basic elements of environmental protection are not required in Saskatchewan likely says quite a bit about where the province is in terms of climate change.

Even an interviewee that described themselves as leaning more Libertarian recognized the nature of the issue and the consequences of climate change requiring some sort of collective intervention – without wading too much into political theory, one can recognize how climate change can fit into the non-aggression or harm principle set out by Libertarian thinkers (Torpman, 2021).

### Company Statements and Reports

Company reporting is a critical aspect of our global financial systems. While most of those companies that had an interviewee did have explicit, transparent reports on their environmental impacts and climate change measures, others were private firms or simply did not make information public. Some information was able to be confirmed with the use of non-profits such



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as the Carbon Disclosure Project (CDP), which is a global organization that rates companies' voluntary submissions of environmental plans with a letter grade (Carbon Disclosure Project, 2022). The CDP was useful in confirming some of the statements that various interviewees made; however, as mentioned, many firms do not disclose their climate impacts or measures to CDP or publicly within their investor information. The lack of a central reporting mechanism for organizational effects on, and because of, climate change was an element touched on in a few interviews.

### Security Implications

While the security implications of their firms' services or products was not a major concern for all of the interviewees – likely given many interviewees' positions in supply chain or sustainability rather than risk departments – some did reference concerns over their ability to supply their goods to customers, given the critical nature of their operations. One energy producer which is a critical supplier of inputs that utilities around the world rely on to power their electricity grids; a failure to supply those customers with the inputs required to create electricity would have devastating impacts the world over. To address this, the energy producer in question has stringent inventory policies with their own suppliers and internally and has reduced its reliance on global supply chains over the past few decades. The energy producer interviewee did also note susceptibility should publicly provided infrastructure fail in various communities in Saskatchewan. An agricultural company which provided an interviewee, AI1, for this research, mentioned their ability to have facilities run independent of any other systems, whether due to inclement weather events or other disruptions. The products this agricultural company produces are critically important to the functioning of Canadian society, and an inability to sell these products would not only have devastating impacts on the company's brand but would contribute significant to the prices of food in Canada, which can have additional consequences as established in the Literature Review section.

### Other Thoughts and Final Comments

One interviewee, PI1, at a major Saskatchewan firm commented on how it was great to see supply chain students at Edwards focusing on climate change's impact on supply chains and thinking about increasing resiliency instead of focusing entirely on efficiency improvements. There was some apprehension when I mentioned that the focus on climate change within

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Edwards is limited to a few slides in a Business Strategy course, and that this focus is my independent work. That conversation leads to a larger point – those coming out of educational institutions are trained in methods and models useful for the past world, before climate change and its disruptions were prevalent.

Overall, all interviewees recognized the disruptions that are possible due to climate change but stopped short of – except for one firm – stating they felt their firm was prepared for the coming consequences. In general, while climate change was the focus of this research project, many of the interviewees focused on the broader topic of disruptions; climate change was important, but it is not the only factor in causing many of the disruptions supply chains are seeing today and will see tomorrow. With that said, it is difficult to explain the interconnected nature of climate change in contributing to many of those other issues – political changes, labour issues, conflict, etc. – to individuals in an hour of an interview.

### Recommendations

Throughout the interviews, there were common themes that warrant some additional attention from industry and policymakers alike. While this paper is more focused on past and present decisions and understandings, it is important to draw out some recommendations that I believe firms and governments in Saskatchewan – and Canada – need to further consider to become less vulnerable and more aware of the work necessary with regard to climate change.

#### Recommendation #1: Standardized “Climate Audits” on Supply Chains and General Firm Operations

The idea of – and issues with – climate audits or environmental vulnerability assessments came up in interviews with a few of the larger firms. In essence, while it is great for firms to undertake assessments of their vulnerabilities and risks independently, without standardized and regulatorily-enforced methods of reporting emissions, risks to supply chains, and susceptibility to weather events, firms have less pressure to prepare for the impacts. While there is something to be said for insurance companies requiring their own standardized assessments and relying on the market to address vulnerabilities – some risks are too great to leave to independent firms. For example, these standardized, regulatorily-enforced types of assessments may have led to improvements to the Texas electricity grid prior to Winter Storm Uri in 2021, which caused residents and firms to lose power for days, largely due to failed regulatory enforcement of winterization requirements, and fossil fuel energy sources performing worse than the worst-case scenario; renewables did falter as well but performed better than the worst-case scenario (Busby et al., 2021).

#### Recommendation #2: Supply Chain Disruption “Working Groups”

Multiple interviewees touched on the concepts of interconnectedness and relationships, and how it is not plausible for their firm to truly accomplish anything (in terms of climate change, disruptions, etc.) without working with their counterparts in other companies, governments, and civil society. While attention is focused on working with governments, there is room to enhance communication between supply chain partners to further alleviate disruptions as they occur. Supply chain disruption “working groups” within the province – or country – could be established to ensure policymakers, corporate leaders, and civil society are on board and recognize the issues, generating solutions that can push Saskatchewan (and Canadian) society

forward towards a cleaner, more prosperous future. The sharing of foundational, institutional knowledge in an efficient manner could allow for climate adaptation and mitigation decisions to be made in a more effective and equitable way.

### **Recommendation #3: Further Education on Supply Chain Disruptions**

While this may seem biased based on the content of this author's paper, the idea of further education on supply chain disruptions did arise in multiple interviews. For this author's post-secondary education in supply chain management, climate change was only touched on in a business strategy course; there are limited conversations about the topic – or about disruptions in general – in Supply Chain Management courses. While this may vary by school, educator, and textbook, it seems to reason that if students are taught methods that assume that “predominance of stable states”, dealing with disruptions, however minute, may prove more difficult.

### Limitations and Further Study

While much can be learned from the statements and information presented above, there are limitations to the study of climate change's impacts on supply chains in Saskatchewan. First of all, although Saskatchewan is home to many significant firms, there are firms and industries not captured in this research that would need to be to understand the full essence of risk to Saskatchewan society. Second, this study was qualitative, with a small sample size of interviewees, and relied on statements from interviewees in positions across Saskatchewan and Canada. In addition, while industry is a key part of society, relying entirely on their perspectives and statements is not going to capture all stakeholders' views. Third, while there are numerous academics, activists, and journalists focused on these issues, there is relatively little focus and attention within the public imagination in Saskatchewan.

Finally, further study is necessary to determine exact vulnerabilities in the supply chains that Saskatchewan relies on, but those determinations would require further, private details from firms. In addition, further study should be considered on the methods, models, and techniques that students need to be trained in to prepare themselves for climate disruptions. In the realm of education and further study, it would also be worthwhile to further develop attribution work (e.g. attributing weather events' impact and timing to climate change) to look at how supply chain disruptions can be attributed to those events – and climate change – as well. In this way, leaders can better understand the risks their firms' supply chains will face in the future, while the public can begin to understand the consequences of climate change.

### Conclusion

Climate change is a 'super wicked' problem that acts not only as a direct disruption to present and future supply chain operations, but also as a 'threat multiplier', being the initial domino to fall, leading to numerous other consequences – too many to list. Supply chains have been vulnerable to disruptions for a long time, but outside of those that work or study the systems, few in society understand the consequences of disruptions if they happen to certain industries at certain times.

In Saskatchewan, given the location of the province in one of the richest countries in the world, few ever would consider how a ship getting stuck in a canal in the Middle East would impact them, let alone think about the consequences of a changing environment leading to their major port in Vancouver being cut off from the rest of the country. It is those very disruptions and thinking processes that I have tried to highlight in this project, especially around Saskatchewan's vulnerabilities due to its reliance on other jurisdictions for much of the items and services critical to the province's functioning. Interviewees from some of Saskatchewan's (and Canada's) major firms in a variety of industries echoed the literature evaluated, with concern being shared because of climate-driven events affecting the resiliency of supply chain networks much closer to home (e.g., B.C. atmospheric river washing out roads and rail). While much was discussed, interviewees tended to focus on a lack of attention or ability to model impacts, the structural issues with global supply chains, government involvement – or lack thereof, and general attitudes towards decades of single-minded focus on efficiency versus resiliency, in part because of financial incentives.

Fundamentally, climate change is an issue that impacts all of us in the world – whether directly through the impacts on the weather, or indirectly through global supply chains; understanding the vulnerabilities in our systems is the first step to recognizing how they can be set up better for all.

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Last, but certainly not least, I would be remised if I did not thank all the workers in various global supply chains that have kept my equipment available, food on my shelves, and kept the utilities functioning, all with the added pressure of the pandemic; I can look at these issues as much as possible, but fundamentally, supply chains are just people doing their jobs, susceptible to the same issues, hardships, and events that we all are on a daily basis – and we far too often forget about those that keep our lights on, our sewage systems working, that deliver our food from thousands of kilometers away, or pilot a 20,000 container ship in the middle of the ocean so that we can have technology to do our work on.

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## Appendix A: Interview Guide & Questions

### Interview Guide

#### Introduction & Consent:

Thank you for agreeing to participate in the research study entitled: **How is climate change impacting major Saskatchewan firms' supply chains, what are the methods those companies are using for mitigating and adapting supply chains, and what are the possible downstream impacts to society?**

Purpose and procedures of study: The purpose of this study is to understand how major Saskatchewan corporations are preparing for the effects of climate change, specifically how those corporations' supply chains will be adapted for or mitigated against climate change. We expect that companies will gain a better understanding of the possible methods they can use to adapt for and mitigate against climate change in their supply chains. This is a qualitative study involving an interview that will take approximately 60 minutes.

Overview of consent form: The interview will be audio and video recorded with your consent. Your name will not be used in any of the research reports or presentations and any quotations used in the final report will be introduced in general terms, and without your name to protect your confidentiality. Your participation is voluntary, and you can answer only those questions that you are comfortable with. You may withdraw from the research project for any reason, and at any time during the interview without explanation or penalty of any sort. Please note that your right to withdraw data from the study will apply until a week after you have had time to review your statements from the transcript of which you will receive a copy after the interview. After this date, it is possible that some form of research dissemination will have already occurred, and it may not be possible to withdraw your data.

Do you have any questions or concerns before we sign the consent form?

#### Interview Questions:

1) What methods is your company currently using to understand climate impacts on your supply chain(s)? How does your company model said impacts?

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2) Do you consider your company's preparations for climate change impacts globally as sufficient?

3) How does your company quantify the costs/benefits of certain climate adaptation and mitigation measures, especially given short term market impacts vs long term business reliance impacts?

4) How are your company's measures to adapt for/mitigate against climate change's impacts in the company's supply chain primarily driven? (I.e., Regulation, public or stakeholder pressure, internal pressure with modelling, etc.)

5) Is the profit motive, or the ability to continue to make the same amount of financial gains the primary motivator in your climate change measures? Do ethics or morality play into the consideration at all?

6) How does the location of your headquarters impact the decisions you make on climate change measures in your global supply chains?

7) How does your organization consider the downstream (second, third order) impacts that any disruptions to your supply chains could have on the world?

8) How does your organization model and think about climate impacts on the infrastructure in the regions you operate?

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9) What does your organization consider with regard to your suppliers' climate preparations?