Centre for International
Governance Innovation

CIGI Papers No. 216 – June 2019

Climate Scenarios for the Canadian Lending and Investment Industry

Olaf Weber and Adeboye Oyegunle

Centre for International
Governance Innovation

CIGI Papers No. 216 — June 2019

Climate Scenarios for the Canadian Lending and Investment Industry

Olaf Weber and Adeboye Oyegunle

CIGI Masthead

Executive

President Rohinton P. Medhora
Deputy Director, International Intellectual Property Law and Innovation Bassem Awad
Chief Financial Officer and Director of Operations Shelley Boettger
Director of the Global Economy Program Robert Fay
Director of the International Law Research Program Oonagh Fitzgerald
Director of the Global Security & Politics Program Fen Osler Hampson
Director of Human Resources Laura Kacur
Deputy Director, International Environmental Law Silvia Maciunas
Deputy Director, International Economic Law Hugo Perezcano Díaz
Managing Director and General Counsel Aaron Shull
Director of Communications and Digital Media Spencer Tripp

Publications

Publisher Carol Bonnett
Senior Publications Editor Jennifer Goyder
Senior Publications Editor Nicole Langlois
Publications Editor Susan Bubak
Publications Editor Patricia Holmes
Publications Editor Lynn Schellenberg
Graphic Designer Brooklynn Schwartz
Graphic Designer Melodie Wakefield

For publications enquiries, please contact publications@cigionline.org.

Communications

For media enquiries, please contact communications@cigionline.org.

@cigionline

Printed in Canada on paper containing 100% post-consumer fibre and certified by the Forest Stewardship Council® and the Sustainable Forestry Initiative.

Centre for International Governance Innovation

67 Erb Street West
Waterloo, ON, Canada N2L 6C2
www.cigionline.org

Table of Contents

About the Authors

Olaf Weber joined CIGI as a senior fellow in March 2015. His research with CIGI focuses on sustainability and the banking sector, including sustainability guidelines and regulations for central banks and regulatory bodies. He is currently associate professor and program director of the master's program in sustainability management, as well as a professor in the School of Environment, Enterprise and Development at the University of Waterloo. Since 2010, Olaf has held the Export Development Canada Chair in Environmental Finance.

Olaf 's background is in the areas of environmental and sustainable finance, with emphasis on sustainable credit risk management, socially responsible investment, social banking and the link between sustainability and financial performance of enterprises. His current research interests include financial risk and opportunities caused by climate change and environmental regulations. Previously, Olaf was managing partner at GOE in Zurich, Switzerland, developing credit risk management and sustainability rating systems, and was head of the sustainable finance group at the Swiss Federal Institute of Technology, Zurich. He earned his Ph.D. from the Technical Faculty, University of Bielefeld, Germany, and his M.A. from the Department of Psychology, University of Mannheim, Germany.

Adeboye Oyegunle is a graduate research student currently undertaking his Ph.D. in sustainability management at the University of Waterloo. His research interest cuts across climate finance and environmental and social governance integration into financial institutions' portfolio and decision-making process.

Adeboye has worked extensively in the corporate sustainability field especially in the financial and travel/tourism industries. He was a member of the Strategic Sustainability Working Group, which was responsible for the drafting of the Nigerian Sustainable Banking Principles and has been a member of several other sustainability steering committees across industries. His current research interest investigates how climate finance can help aid the actualization of the United Nation's Sustainable Development Goals and integration of environmental and social governance in financial institutions.

About the Global Economy Program

Addressing limitations in the ways nations tackle shared economic challenges, the Global Economy Program at CIGI strives to inform and guide policy debates through world-leading research and sustained stakeholder engagement.

With experts from academia, national agencies, international institutions and the private sector, the Global Economy Program supports research in the following areas: management of severe sovereign debt crises; central banking and international financial regulation; China's role in the global economy; governance and policies of the Bretton Woods institutions; the Group of Twenty; global, plurilateral and regional trade agreements; and financing sustainable development. Each year, the Global Economy Program hosts, co-hosts and participates in many events worldwide, working with trusted international partners, which allows the program to disseminate policy recommendations to an international audience of policy makers.

Through its research, collaboration and publications, the Global Economy Program informs decision makers, fosters dialogue and debate on policy-relevant ideas and strengthens multilateral responses to the most pressing international governance issues.

Executive Summary

The purpose of the analysis presented in this paper is to identify the most important factors for measuring climate change risk for the financial industry. This paper uses a scenario analysis approach to identify climate-related risks for Canadian lenders and investors. The approach follows a proposal from the Group of Twenty (G20) Task Force on Climate-related Financial Disclosures (TCFD) asking the financial industry to develop climate-related scenarios to assess their exposure to climate-related financial risk, to assess these risks and to generate strategies to address the risks. Based on the indicators proposed by TCFD, the authors conducted an impact analysis that explored the direct and indirect impacts of the risk indicators on each other. A mathematical approach, cross impact matrix-multiplication applied to classification (MICMAC Analysis), was used to analyze the impact of transition risks and physical risks. Transition risks occur through the transition of an economy to a low-carbon economy. Physical risks are risks that occur through the direct effects of climate change, such as extreme weather events. The method identified "increased production costs due to changing input prices (for example, energy and water) and output requirements," "abrupt and unexpected shifts in energy costs," "increased capital costs (for example, damage to facilities)," "reduced revenues from lower sales/output" and "increased insurance premiums and potential for reduced availability of insurance on assets in 'high-risk' locations" as the most important risk indicators for climate change scenarios.

In addition, three scenarios were generated: a business as usual scenario; a reduced climate policies scenario; and a strong climate policies scenario. To address these scenarios, recommendations include that the Canadian financial sector should develop strategies and tools to address transition risks, and that the sector should be prepared for investments in the low-carbon economy. The industry has to consider physical risks for itself and for clients because these risks will increase for a certain time, independent of current climate policies. Finally, investing in a low-carbon economy makes sense for the financial industry, independent of current policies, to avoid the negative impacts of climate change.

Introduction

Recently, a task force has been established by the Financial Stability Board that addresses climate risks for the financial industry. The TCFD has published reports starting with recommendations for standardized disclosure about climate-related risks (TCFD 2017a). Furthermore, it has proposed developing scenario analyses to address climate-related risks for the financial industry.

This policy paper will present the development of climate scenarios using a formative scenario-building approach (Godet 1986), which addresses climate-related risks for the Canadian investment and lending industry. Before the scenario development is described, climate-related risks for the financial industry will be discussed. Then, the work of the TCFD will be reported on. Third, the scenario method will be examined. The next section contains the results of the impact analysis as the first part of the scenario analysis, followed by a description of the scenarios. The final section will provide recommendations for the financial industry to address climate-related financial risks.

The Scenario Method

As mentioned above, one main recommendation of the TCFD is the development of scenarios to build strategies to address future climate-related risks (TCFD 2017b). The creation and analysis of climate-related scenarios, however, is not a trivial task and needs sophisticated methods. This section describes the scenario method, and the remaining sections of this paper follow the steps of the scenario method presented in Figure 1.

Scenario analysis is a method to describe the future in the form of scenarios. It has been used in business contexts (Cornelius, Van de Putte and Romani 2005; Shell 2013; TCFD 2017b) to generate business strategies that are robust with regard to different future development. It has also been used in climate research to predict different trajectories with regard to climate change (Barron et al. 2018; Rogelj et al. 2018; Westphal et al. 2015) and to manage transition processes

for sustainable development (Swart, Raskin, and Robinson 2004; Wiek, Binder, and Scholz 2006).

In contrast to other forecasting methods, scenario analysis does not try to find the one most likely future development but opens a space for possible directions. The advantage of this method is that it helps to be prepared for uncertain future developments instead of focusing on the most likely one.

The paper will use a formative scenario analysis approach based on matrix analysis, called MICMAC analysis (Godet 1986). This established method uses matrix multiplication to analyze indirect impacts between the indicators. MICMAC is able to quantify the impact of indicators by calculating row and column sums to analyze the degree of activeness and passiveness of the indicators. Strategies will be developed that mainly address active indicators because of their ability to influence the system.

Overall, the research is based on steps presented in Figure 1, and each of these steps is described in the following sections, after which recommendations for the Canadian financial industry, as well as for policy makers, are made. First, the literature that has been used as the basis for the impact evaluation is described.

Case and Goal Definition

This section describes the case, climate-related risks for the investment and lending industry, the activities of the TCFD and current activities of the industry.

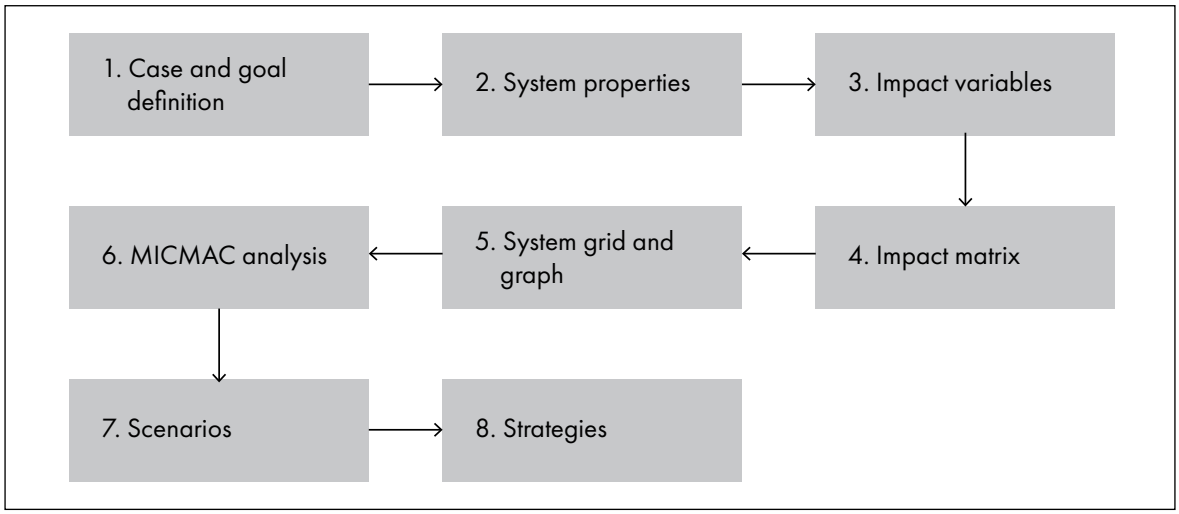
Climate-related Risks for the Investment and Lending Industry

Often an understanding of climate-related risk is focused on whether the risks being considered are physical risks or risks due to costs of high greenhouse gas (GHG) emissions. Many climate-related risks, however, are indirect and occur because of the transition to a low-carbon economy, which might affect borrowers and investees. An example is presented in Box 1.

To enable the financial industry to analyze and respond to climate-related risks and opportunities, the Financial Stability Board established the TCFD (2017a). The TCFD developed a set of indicators that can be used by the financial industry to analyze climate-related risks, published a report on how to implement these indicators and recommended that scenario analyses be conducted to understand better how the financial industry might react to different climate scenarios.

Financial risks could be caused by stranded assets due to a depreciation of the value of oil, coal

Figure 1: Steps of the Scenario



Source: Authors.
Note: This paper does not present system graphs.

Box 1: The Pacific Gas and Electric Company Case

Pacific Gas and Electric Company, a US-based utility, informed shareholders and stakeholders repeatedly that weather-related disasters were a material risk. But many did not realize these risks until the utility filed for bankruptcy, mainly because of the impact of the California wildfires in fall 2018. Usually, utilities are relatively low-risk investments and loans, but an industry's risk exposure might change because of climate change. The fire did not have direct impacts on lenders of the utility.

For more information, see www.bloomberg.com/news/articles/2019-01-16/pg-e-warned-investors-about-disasters-it-was-mostly-ignored.

and gas resources because only a fraction of the fossil-fuel resources can be burned if the 2°C goal

is achieved through a transition to a low-carbon economy. Furthermore, physical risks, such as the increasing frequency of extreme weather events, affect both industries in vulnerable regions and the insurance sector because claims for damage due to floods or droughts will increase significantly because of climate change.

Regulatory changes, such as the introduction of carbon pricing that influences the cash flows of borrowers, might influence lender risks. Reputational or legal risks may occur if the financial industry offers its services to controversial projects, such as oil pipelines. Transition risks may affect the financial industry because it has to adapt its risk assessment strategies and tools, as the transition to a low-carbon economy will affect the structure of commercial borrowers.

Finally, and of great importance, green energy development needs significant investments. To meet the Paris Agreement goal, the global renewable energy sector needs US$1 trillion annually (Zuckerman et al. 2016). Consequently, the Canadian financial sector will be involved in financing activities for renewable energy.

The TCFD

Formed by the Financial Stability Board, the purpose of the TCFD was to develop voluntary, consistent climate-related financial risk disclosure mechanisms for use by companies to provide standardized information to investors, lenders, insurers and other stakeholders (TCFD 2017a). The recommendations made by the TCFD are intended to address key gaps identified around the climate-related aspects of an organization's business and their financial implications. They are also intended to address inconsistencies in disclosure practices and non-comparable reporting methods that are often cited as major obstacles in incorporating climate-related risks and opportunities as considerations in investment, lending and insurance underwriting decisions in the medium and long-term (ibid.). The TCFD has recognized that inadequate information about risks can lead to a mispricing of assets, a misallocation of capital and give rise to potential concerns about financial stability since markets are generally vulnerable to abrupt corrections (ibid.).

In an attempt to promote a standardized climate-related financial disclosure framework, the TCFD first defined climate-related risks and opportunities across G20 jurisdictions. The climate-related risks are divided into two major categories: first, risks related to the transition to a lower-carbon economy; and second, risks related to the physical impacts of climate change (ibid.). The TCFD then highlighted areas of risk under each category that are most relevant and that pose varying levels of financial and reputational risks to organizations. The transitional risks included policy and legal, technology, market and reputational risk. The physical risks were simply organized as acute (event-driven risks, such as extreme weather events) or chronic (such as sustained higher global temperatures) (ibid.). Climate-related opportunities were identified in several areas by the TCFD through resource efficiency and cost savings from efforts to mitigate and adapt to climate change, including innovation of products and services, resilience, resource efficiency, energy source and new markets (ibid.). The TCFD identified these climate-related risks and opportunities to facilitate better disclosure of their financial impacts. This helps organizations understand their exposure to these risks and opportunities and how they might affect the organizations' future financial position (ibid.). The risk indicators are presented in Table 1.

Scenario analysis is cited throughout the report as an important and useful tool for understanding the strategic implications of climate-related risks and opportunities. It is defined as the analysis of future possible system states (Wiek, Binder and Scholz 2006), for instance, different climate change scenarios. TCFD acknowledges that for many organizations, this type of analysis would be largely qualitative. However, organizations with more significant exposure to transition risks or physical risks should undertake more rigorous qualitative and quantitative analysis concerning key drivers and trends that may affect their operations. TCFD suggests that all organizations exposed to climate-related risks should consider using scenario analysis to help inform strategic and financial planning processes and disclose how resilient their strategies are to a range of plausible scenarios.

The TCFD recommendations were accompanied by a list of indicators that should be considered by organizations in all sectors as they seek to understand the financial impacts that are most relevant to them (TCFD 2017c). This included a high-level overview of four major areas of financial impact on climate-related issues: revenues; expenditure; assets and liabilities; and capital and financing. Each of these areas can be affected by the aforementioned transition and physical risks, and they may be affected differently depending on the organization's exposure to and anticipated effects of climate-related risks and opportunities. The financial industry, banks, insurers, asset owners and asset managers are all subject to impacts on revenues, assets and liabilities, with insurers experiencing an additional impact on expenditures. The indicators for the energy sector, transportation, materials and building, and agriculture sectors were grouped together. These indicators have been used as the main impacts in the scenario analysis presented in this paper.

Table 1: TCFD Climate Risk Indicators

Type	Climate-related Risks	Potential Financial Impacts
Transition Risks	Policy and Legal	
	→ Increased pricing of GHG emissions → Enhanced emissions-reporting obligations → Mandates on and regulation of existing products and services → Exposure to litigation	→ Increased operating costs (for example, higher compliance costs and increased insurance premiums) → Write-offs, asset impairment and early retirement of existing assets due to policy changes → Increased costs and/or reduced demand for products and services resulting from fines and judgments
	Technology	
	→ Substitution of existing products and services with lower emissions options → Unsuccessful investment in new technologies → Costs to transition to lower emissions technology	→ Write-offs and early retirement of existing assets → Reduced demand for products and services → Research and development (R&D) expenditures in new and alternative technologies → Capital investments in technology development → Costs to adopt/deploy new practices and processes

Type	Climate-related Risk	Potential Financial Impacts
Transition Risks	**Market**	
	→ Changing customer behaviour → Uncertainty in market signals → Increased cost of raw materials	→ Reduced demand for goods and services due to shifts in consumer preferences → Increased production costs due to changing input processes (for example, energy and water) and output requirements (for example, waste treatment) → Abrupt and unexpected shifts in energy costs → Change in revenue mix and sources, resulting in decreased revenues → Re-pricing of assets (for example, fossil fuel reserves, land valuations and securities valuations)
	Reputation	
	→ Shifts in consumer preferences → Stigmatization of sector → Increased stakeholder concern or negative stakeholder feedback	→ Reduced revenue from decreased demand for goods/services → Reduced revenue from decreased production capacity (for example, delayed planning approvals and supply chain interruptions) → Reduced revenue from negative impacts on workforce management and planning (for example, employee attraction and retention) → Reduction in capital availability
Physical Risks	**Acute**	
	→ Increased severity of extreme weather events, such as cyclones and floods	→ Reduced revenue from decreased production capacity (for example, transport difficulties and supply chain interruptions) → Reduced revenue and higher costs from negative impacts on the workforce (for example, sickness, injury and absenteeism)
	Chronic	
	→ Changes in precipitation patterns and extreme variability in weather patterns → Rising mean temperatures → Rising sea levels	→ Write-offs and early retirement of existing assets (for example, damage to property and assets in high-risk locations) → Increased operating costs (for example, inadequate water supply for hydroelectric plants or to cool nuclear and fossil fuel plants) → Increased capital costs (for example, damage to facilities) → Reduced revenues from lower sales/output → Increased insurance premiums and potential for reduced availability of insurance on assets in high-risk locations

Source: (TCFD 2017a).

Current Activities of Banks with Regard to Climate-related Financial Risks

As described above, banks are exposed to many climate-related risks through the diverse range of sectors they finance (Folger-Laronde and Weber 2018), including the fossil-fuel sector (Hunt and Weber 2019). A 2008 study selected and ranked 40 of the world's largest publicly traded banks and financial services companies based on how they address climate change in different areas, including board oversight, management execution, public disclosure, GHG emissions and strategic planning (Cogan 2008).

Now, as more banks realize that climate change is a big business issue, a trend is beginning to form where some institutions are implementing plans to tackle the issue. However, banks have to establish distinct metrics with regard to climate change and go beyond vague statements about addressing climate-related risks. With the recommendations of the TCFD in place, banks have the opportunity to implement the recommendations and develop scenarios, models and metrics to enable a forward-looking assessment and disclosure of climate-related risks and opportunities.

The UN Environment Programme (UNEP) Finance Initiative (UNEPFI), together with 16 of the world's leading banks, began a pilot project on implementing the TCFD recommendations for banks (UNEP Finance Initiative 2019). The pilot project will work to publish scenarios, models and metrics and will contribute to a harmonized, industry-wide approach to the TCFD's recommendations, as banks worldwide will be able to adopt and build upon them (ibid.). All 16 participating banks have committed to publishing an initial TCFD disclosure by mid-2019 (ibid.). Based on information on UNEPFI's website and on research conducted by the authors, current activities of banks with regard to climate-related financial risks are presented in Table 2.

Scenario Properties

The scenario analysis addresses the Canadian lending and investment industries, and banks in particular. Physical risks are discussed as they affect Canada. The basic data for transition risks is drawn from Canada's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy (Environment and Climate Change Canada 2016). This plan describes Canada's Nationally Determined Contributions (NDC). NDCs describe Canada's committed contribution to achieving the climate goals as agreed at the twenty-first session of the Conference of the Parties (COP 21) to the United Nations Framework Convention on Climate Change in Paris.

Impact Variables

The following section describes the impact variables. This step analyzes the influence the different indicators have on each other to determine which indicators are most important to use for the scenario. Usually, those indicators that strongly influence many other indicators are addressed in a scenario because they are able to change the outcome of the scenario if addressed properly.

The financial indicators provided by the TCFD (TCFD 2017a) presented in Table 1 were used.

Transition Risks

Policy and Legal Risks: Climate change policies are expected to impact several industries. This creates a set of climate-related impacts, especially in key energy-intensive areas (Labatt and White 2007). The reason behind this is partly that there is a severe cost of climate change, regardless of the climate solution approach that is taken. For example, Dannenberg et al. (2009) noted that the cost of new technology may require making preventative and primary provisions for the effects of climate change, such as the funding of research and development of new technologies that may not be attractive for policy makers since it is a cost that does not require urgent attention unlike extreme weather events that may cause extensive damage both at the physical and political levels.

Table 2: Climate-related Strategies of Major Banks

Institution	Strategy
ABN AMRO	Committed to Dutch bank climate declaration. Establishing a deal-team dedicated to financing renewable energy to reduce its indirect carbon footprint over time.
ANZ	Member of UNEP FI TCFD recommendations pilot program.
Bank of America	Committed US$125 billion to low-carbon financing and sustainable business activities implemented by 2025.
Barclays	Member of UNEP FI TCFD recommendations pilot program.
Banco Bilbao Vizcaya Argentaria	Member of UNEP FI TCFD recommendations pilot program.
BNP Paribas	Member of UNEP FI TCFD recommendations pilot program.
Bradesco	Member of UNEP FI TCFD recommendations pilot program.
Citi	Member of UNEP FI TCFD recommendations pilot program.
Deutsche Bank AG	Part of "Putting a Price on Carbon" campaign. Adopted energy and climate strategy in 2007.
DNB	Member of UNEP FI TCFD recommendations pilot program.
HSBC	Key member of Green Bond Principles Executive Committee.
Itaú	Member of UNEP FI TCFD recommendations pilot program.
ING group	Sustainability-linked loans where the cost of capital fluctuates depending on the environmental impact of the borrower.
NAB	Member of UNEP FI TCFD recommendations pilot program.
Rabobank	Member of UNEP FI TCFD recommendations pilot program.
Royal Bank of Canada	Member of UNEP FI TCFD recommendations pilot program.
Reserve Bank of New Zealand	Committed to calculating its carbon footprint and publishing an emissions breakdown in its annual report. Established a target for reducing and mitigating future emissions.
Santander	Member of UNEP FI TCFD recommendations pilot program.
Société Générale	Member of UNEP FI TCFD recommendations pilot program.
Standard Chartered	Member of UNEP FI TCFD recommendations pilot program.
TD	Member of UNEP FI TCFD recommendations pilot program.
UBS	Member of UNEP FI TCFD recommendations pilot program and implemented a sustainable investing strategy in its wealth management arm.

Source: Authors.

Climate-related regulations and policies might have a significant material impact on businesses. For instance, regulated carbon pricing has a serious effects on the costs of businesses with high GHG emissions. Climate-related regulations, such as emission standards, might also lead to the need for implementing technologies and, consequently, require financing. Therefore, there is a need for regulations and policy to help manage the indirect impact of climate change risks to prevent wasteful capital expenses that may lead to increased losses for financial institutions (Weyzig et al. 2014). It should be noted that policy impacts can be both transitory and physical, which are not mutually exclusive (McKibbin et al. 2017). For example, the impacts of disruptive climate policy, such as a stringent constraint on GHG emissions, can cause an increase in fuel and energy prices, but the impact on the existing capital from that source could be transitory (ibid.).

Technology Risks: The emergence of new technologies can have a disruptive impact on existing businesses and their operations, which would have financial implications (World Economic Forum 2018). For example, asset value may decline due to disruptions or changes in the technological, economic or legal environment, while products that affect the market share of the firm could be developed by competitors, which may have a severe impact on products and services, operations and sales (Linnenluecke et al. 2015). Beyond this, policy developments focusing on alternative technologies are springing up daily, which could have disruptive tendencies and are creating restrictions on particular segments, while strengthening others (World Economic Forum 2018) leading to a negative impact on sales. Lower costs and higher efficiency of solar panels, for instance, made solar-based electricity production competitive with fossil fuel-based production and might still disrupt the energy industry.

Describing how technological development could have an impact on the demand for goods and services, Mercer (2015) argued that it is a particularly difficult task for investors to identify or manage technological changes. They argue that technology development creates disparity between old and new players as technology evolves, with the former running the risk of being left behind and losing demand for their products and services. Coal-powered electricity, for instance, has been on a constant decline for some years because of the competitiveness of alternatives that emit less during electricity production.

Market Risks: Climate change could have financial consequences that create market risks in diverse ways. For example, the effects of the transition to a low-carbon economy might cause changes in how energy is produced and used, leading to large-scale labour-market disruptions and employee layoffs (World Economic Forum 2018) in affected industries.

This is further compounded by the uncertain atmosphere of climate-related scenarios as markets may react differently to different high-risk scenarios due to uncertain socio-economic consequences that have to be considered by investors and lenders (Buhr et al. 2018). These consequences also include the risk of stranded assets in the fossil fuel industry, caused by the devaluation of fossil fuel resources that cannot be burned if the 2°C goal is to be achieved (Lutz, Stadelmann and Horster 2017), and carbon pricing, which might have positive effects on some industries and negative effects on others (Weber and Kholodova 2017).

Reputational Risks: These climate change risks are tied mainly to the potential eroding of trust and change in customer perception of an organization's contribution to or detraction from the transition to a lower carbon economy (TCFD 2016). As Rory Sullivan (2014) has noted, climate change will have an impact on all sectors, which makes it critical for investors and financial institutions. However, some sectors, such as those that are high emitters, might be more exposed to reputational risk, for instance, if they are connected with climate change denial (Dunlap and McCright 2011). Such issues may create an extensive reputational risk that might affect a firm's share prices and, consequently, capital costs (Negri 2018).

Acute and Chronic Physical Risks

The scenarios that may arise from the physical impact of climate change will require a high demand for capital and have extensive effects on assets and investments (Sullivan 2014). Furthermore, direct physical risks, such as higher frequencies of extreme weather events, will continue at least for the next three decades because of the accumulation of GHGs already in the atmosphere and the expected increase of GHGs in the coming years, no matter what climate change mitigation policies will be

adopted (IPCC 2018; Thistlethwaite et al. 2018; Hausfather 2017, Matthews and Weaver 2010; Rahmstorf and Levermann 2017).

The consequences of physical risks could be significant. The insurance sector is expected to bear these consequences with a reverberating effect on the value of financial assets due to the extent of climate-related events, damage of property or trade disruptions (Thistlethwaite and Wood 2018). This may lead to a lack of availability of funds and an extensive reduction in the assets and investment values for the insurance industry. Lenders and investors could be affected by the physical risks of their clients because insurance rates will become unaffordable for many exposed clients or because these risks are not insurable anymore (Kunreuther, Michel-Kerjan and Ranger 2013; Williams and Case 2016).

Sullivan (2014) argues that under these circumstances, government policies would have a crucial impact in driving adaptation efforts as it looks to private sector funds to provide much of the capital that would be required to help reduce and respond to climate impacts. These impacts will influence financial sector investment decisions in key areas, which may lead to challenges of accessing capital and the inability to keep up with changing customer needs and costs of doing business due to the unpredictability of climate change's physical impacts (Mills 2005).

Customer needs are not the only reason that sales will be impacted due to climate change. For example, for the production of goods, inputs such as energy are required. Furthermore, firms need a supply chain to transport and deliver the products to market. Hence, any effect on these inputs may have an impact on the cost of goods and services and consequently on sales. Physical climate change impacts, such as damages on one of these inputs, may, in turn, multiply damages and costs in others (Schenker 2013).

The aggregate of these effects, which are mainly driven by diverse events of climate change, can have a lasting impact on employee health and well-being (Balanagarajan and Gajapathy 2018), with far-reaching impacts that could lead to reduced productivity and output from employees (Nilsson and Kjellstrom 2010). These impacts could affect the overall performance of firms, which inevitably puts them at risk of loss of productivity, capital and profit.

The point is that the effect of climate change on one sector could have an impact on another related sector (Lutz, Stadelmann and Horster 2017). Hence, it is not only the high-emitting industries or the fossil fuel industry that are exposed to climate change. Physical risks exist for all industries dependent on their location and their type of business.

Finally, as noted by the TCFD, the potential climate-related risks discussed are not mutually exclusive (TCFD 2017a). For this reason, it is not unusual to have situations where the impact of climate action, such as a policy disruption, could create impacts that could be both transitional and physical (Lutz, Stadelmann and Horster 2017). The same is true for the inherent risks for the costs of insurance. For example, the risks faced by different insurance firms for physical damage and weather events could lead to insurers not being able to pay the claims, to reductions in insurance available to exposed clients and to increased premiums (Dannenberg et al. 2009).

Impact Matrix

The influences of the impact variables (described above) on each other have been rated using a four-point scale:

0: No influence
1: Weak
2: Moderate influence
3: Strong influence.

The following sections explain the justification of the ratings, as organized on the TCFD's structure, and as presented in Table 1.

It is important to reiterate that the impact ratings are not based on likelihoods but on impacts. The ratings are based on whether their impact is low or high and not how likely the impact is.

Table 3 presents the sum of row sums and column sums of the matrix. The higher the row sum, the more active the indicator. Active indicators influence other indicators. The higher the column sum, the more passive the indicator. Passive indicators are influenced by other indicators. The indicators with the highest sums are indicated through bold and italic (red) fonts.

Table 3: Row and Column Sums of the Indicators

			Variable	Sum of rows	Sum of columns
Transition Risks	Policy and Legal	1	Increased operating cost	39	46
		2	Write-offs, asset impairments or early retirement of asset	32	18
		3	Increased costs and/or reduced demand for purchases and sales due to policy change	37	43
	Technology	4	Write-offs and early retirement of technological assets	17	23
		5	Reduced demand for products and services	36	36
		6	R&D expenditures in new and alternative technologies	25	47
		7	Capital investments in technology development	35	**58**
		8	Costs to adopt/deploy new practices and processes	30	47
	Market	9	Reduced demand for goods and services due to shifting consumer preferences	33	25
		10	Increased production costs due to changing input prices (for example, energy or water) and output requirements	**48**	33
		11	Abrupt and unexpected shifts in energy costs	**51**	16
		12	Change in revenue mix and sources, resulting in decreased revenues	29	39
		13	Re-pricing of assets	22	31
	Reputational	14	Reduced revenue from decreased demand for goods/services	41	26
		15	Reduced revenue from decreased production capacity (for example, delayed planning approvals or supply chain interruptions)	42	42
		16	Reduced revenue from negative impacts on workforce management and planning (for example, employee attraction and retention)	29	33
		17	Reduction in capital availability	31	**58**
Physical Risks	Acute and Chronic	18	Reduced revenue from decreased production capacity (for example, transport difficulties, supply chain interruptions)	36	35
		19	Reduced revenue and higher costs from negative impacts on workforce (for example, sickness, injury and absenteeism)	30	28
		20	Write-offs and early retirement of existing assets (for example, damage to property and assets in high-risk locations)	34	19
		21	Increased operating costs (for example, inadequate water supply for hydroelectric plants or to cool nuclear and fossil fuel plants)	41	34
		22	Increased capital costs (for example, damage to facilities)	**51**	35
		23	Reduced revenues from lower sales/output	47	**52**
		24	Increased insurance premiums and potential for reduced availability of insurance on assets in high-risk locations	**47**	39
			Total	863	863

Source: Authors.

The threshold to define a value as "high" is the significant decrease of the slope of the line that connects the values ordered from high to low.

The most active and passive indicators have been selected based on the change in the slope of the listed indicators in order of their column and row sums. Hence, the most active indicators are: indicator 10, increased production costs due to changing input prices and output requirements (market); indicator 11, abrupt and unexpected shifts in energy costs (market); indicator 22, increased capital costs through physical risks; and indicator 24, increased insurance premiums in high-risk locations. The most passive indicators are: indicator 7, capital investments in technology development that are needed to address the transition to a low-carbon economy; indicator 17, reduction in capital availability because of reputational risks; and indicator 23, reduced revenues from lower sales/output due to physical risks.

MICMAC Analysis

To analyze indirect impacts, such as the impact of indicator 1 on indicator 15 through indicator 5, the direct influences are multiplied with themselves using matrix multiplication until the ranks of the column sums and row sums of the matrix are stable. This method is called MICMAC analysis (Godet 1986). As a result of the MICMAC analysis, the impacts of each indicator considers indirect influences, including feedback loops and the length of influence paths, based on matrix multiplication. Usually, the indirect impact matrix is used to develop scenarios because it considers both indirect and direct influences. The values represent indirect influence rates. The higher the number, the higher the impact of an indicator listed in the rows on an indicator listed in a column.

The results (see Table 5 in the Appendix) suggest that indicator 10, increased production costs due to changing input and output requirements, indicator 11, abrupt and unexpected shifts in energy costs, indicator 22, increased capital costs, indicator 23, reduced revenues from lower sales/output, and indicator 24, increased insurance premiums and potential for reduced availability of insurance on assets in high-risk locations, are the most active indicators in the system. Therefore, these indicators have strong influences on other indicators. Again, indicator 23 has high values for both activity and passivity, meaning that it is also influenced strongly by other indicators.

System Grid

The system grid of indirect influences is presented in Figure 2. It can be split into four quadrants using the median of the indirect impacts. The upper right quadrant contains indicators that are both active and passive. They influence other indicators and are influenced by them as well. Hence, they are central to the system. Indicators with high values on the y-axis are active and influence other indicators. Indicators with high values on the x-axis are influenced by other indicators. The indicators with the highest impacts on others are: indicator 11, abrupt and unexpected shifts in energy costs; indicator 10, increased production costs due to changing input prices; indicator 22, increased capital costs; indicator 24, increased insurance premiums and potential for reduced availability of insurance on assets in high-risk locations; and indicator 23, reduced revenues from lower sales/output. Based on the change in the slope of the line between the sorted indicators, their activity values are higher than those of the other indicators.

Scenarios

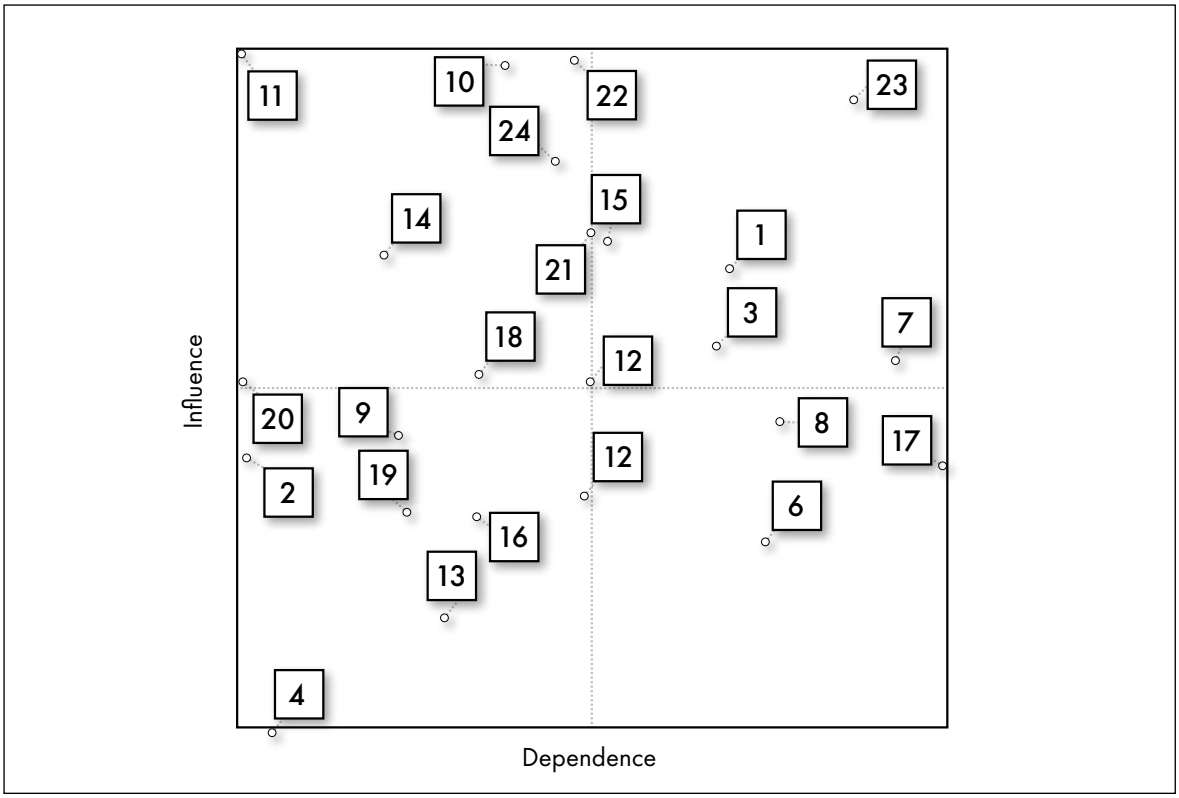
This section presents the specific indicators used in the scenarios and the selection of the scenarios.

Selection of Indicators

Because the purpose of this method is to identify the most influential indicators for future climate-related scenarios, the most active indicators of the matrix of indirect influences have been selected. Hence, the indicators used for the scenario are listed in Table 4.

All these risks have a crucial impact on the financial performance of financial institutions, such as banks, investors, lenders and insurance companies. Furthermore, they have a strong influence on

Figure 2: Indirect System Grid



Source: Authors.

Notes: The legend for the data points is as follows:

1. Increased operating cost
2. Write-offs, asset impairments or early retirement of assets
3. Increased costs and/or reduced demand for purchases and sales due to policy change
4. Write-offs and early retirement of technological assets
5. Reduced demand for products and services
6. R&D expenditures in new and alternative technologies
7. Capital investments in technology development
8. Costs to adopt/deploy new practices and processes
9. Reduced demand for goods and services due to shifting consumer preferences
10. Increased production costs due to changing input prices (for example, energy and water) and output requirements
11. Abrupt and unexpected shifts in energy costs
12. Change in revenue mix and sources, resulting in decreased revenues
13. Re-pricing of assets
14. Reduced revenue from decreased demand for goods/services
15. Reduced revenue from decreased production capacity (for example, delayed planning approvals and supply chain interruptions)
16. Reduced revenue from negative impacts on workforce management and planning (for example, employee attraction and retention)
17. Reduction in capital availability
18. Reduced revenue from decreased production capacity (for example, transport difficulties and supply chain interruptions)
19. Reduced revenue and higher costs from negative impacts on workforce (for example, sickness, injury and absenteeism)
20. Write-offs and early retirement of existing assets (for example, damage to property and assets in high-risk locations)
21. Increased operating costs (for example, inadequate water supply for hydroelectric plants or to cool nuclear and fossil fuel plants)
22. Increased capital costs (for example, damage to facilities)
23. Reduced revenues from lower sales/output
24. Increased insurance premiums and potential for reduced availability of insurance on assets in high-risk locations

Table 4: Indicators Used for the Scenario

Type of Risk	Number	Indicator
Market-related transition risk	10	Increased production costs due to changing input prices (for example, energy and water) and output requirements
Market-related transition risk	11	Abrupt and unexpected shifts in energy costs
Physical risk	22	Increased capital costs (for example, damage to facilities)
Physical risk	23	Reduced revenues from lower sales/output
Physical risk	24	Increased insurance premiums and potential for reduced availability of insurance on assets in high-risk locations

Source: Authors.

many of the other indicators in the system. Hence, when they are well managed, climate exposure of the financial industry can be mitigated.

Scenario Development

This section will describe the construction of three scenarios and how the indicators presented will have an impact on the financial industry given these three scenarios. Carbon policy scenarios have been conducted in a number of jurisdictions, for instance, in the European Union (Russ, van Regemorter and Wiesenthal 2008) and the United States (McFarland et al. 2018). In Canada, however, no such scenarios exist. Furthermore, existing scenarios do not particularly address the financial industry.

Results of scenarios from the European Union and the United States generally found a significant effect of carbon pricing on GHG emissions reduction. However, a reductions scenario would have consequences for all industries, not only for high emitters, and only a low impact on the economy. Peter Russ, Denise van Regemorter, and Tobias Wiesenthal (2008) estimate the impact on GDP far below 0.5 percent for the European Union. Martin Ross (2018) also found relatively low impacts of a carbon tax on the economy except for regions that are dependent on fossil fuel generation and are carbon intensive. Hence, the financial industry might use regional risk analyses for lending and investment decisions.

Economic evidence demonstrates that emissions pricing is the most cost-effective way to reduce carbon dioxide emissions from the combustion of fossil fuels (Goulder and Hafstead 2018). The type of pricing — tax versus cap-and-trade — does not differ greatly with regard to their effectiveness for reducing emissions, nor with regard to economic impacts. Generally, taxes are less vulnerable to volatile markets and allow for more just distributions of income (Goulder and Schein 2013). Both taxes and cap-and-trade will increase wind and solar energy (Barron et al. 2018) that might offer financing opportunities for the financial industry. In contrast, fossil fuel-based electricity usage might rise if it is not decarbonized through the application of carbon pricing (ibid.).

Studies also found that the recycling scheme, rather than the amount of the carbon price, is important (Arora et al. 2018). Depending on how the income of a carbon price is recycled, economic consequences can be different.

With regard to differences in industries, studies demonstrate that coal is most affected by a carbon tax. In a Canadian scenario, this impact is less important than in a US scenario because the Canadian electricity grid depends less on coal, and out-phasing of coal power plants has already been conducted or started in many provinces (Barron et al. 2018).

Based on the studies described, carbon pricing is the most likely policy to be implemented to reduce GHG emissions and is currently the most popular way to address carbon emissions. It is applied in 46 countries and 28 supranational jurisdictions covering nearly 20 percent of all emissions.[1] Furthermore, even regulations that

1 For more detail, see https://carbonpricingdashboard.worldbank.org.

do not introduce a price on carbon create higher costs for carbon emissions. However, although the price might be very low, there is some likelihood that carbon pricing will not be introduced in Canada in the future, due to political opposition.

Consequently, the following scenarios are defined:

- **Scenario 1, business as usual:** There will be only marginal measures to mitigate and adapt to climate change. A price on carbon — if used — will be low and will not affect the economy or certain industries.
- **Scenario 2, reduced climate policies:** There will be some political activities to mitigate and to adapt to climate change. These policies, such as a price on carbon emissions, will be moderate and consequences for the financial industry are also moderate. High emitters and industries dependent on high amounts of energy might be affected by a carbon price. The same is true for certain regions that are dependent on fossil fuel-based industries. Because of a modest increase in carbon pricing, these changes will not be disruptive.
- **Scenario 3, strong climate policies:** Canada will employ all efforts to achieve Canada's Mid-Century Long-Term Low Greenhouse Gas Development Strategy (Environment and Climate Change Canada 2016) until 2050 (Gibson et al. 2019). This will lead to a significant shift toward a low-carbon economy that affects nearly all industries and every facet of society. The main policies will be carbon pricing as well as regulatory policies, such as changes in building codes or plans to out-phase combustion engine vehicles to electrify mobility, housing and industrial energy. Investments will be needed to finance the transition to a low-carbon economy. These investments will be in green tech, sustainable infrastructure and ion-transforming carbon-emitting industries. Estimates for sustainable infrastructure investments alone are CDN$186 billion.

In all three scenarios, it is assumed that physical risks will increase during the next half-decade because even strong climate policies will not have an immediate effect on physical risks, such as extreme weather events (IPCC 2018; Thistlethwaite et al. 2018; Hausfather 2017; Matthews and Weaver 2010; Rahmstorf and Levermann 2017). Therefore, the authors assume at least the same physical risks will be present as during the last five years. Long term, physical risks will be reduced under Scenario 3 and will increase under Scenario 1. Hence, the effect of physical risks on lending and investment portfolios will increase under Scenario 1 and decrease under Scenario 3.

Under these scenarios, the indicators presented in Table 4 would materialize as follows:

In Scenario 1, production costs would not change significantly because the transition to a low-carbon economy would take place slowly, if at all. Hence, no additional short- to mid-term strategies to assess these risks will be needed. The same is valid for energy costs. Energy costs might be influenced by other impacts, such as geopolitical abruptions, but not by a transition to a low-carbon economy. Long term, however, climate change will have significant impacts on the economy because of extreme weather events and the costs to adapt to climate change. Therefore, long-term investors, such as health and life insurance firms and pension funds, should develop strategies to assess the effects of climate change on long-term investments, such as building or forestry projects.

In Scenario 2, production costs would increase marginally for energy-intensive production because of the introduction of taxes or cap-and-trade for carbon emissions. However, the price increase will not have disruptive effects as other studies have found (Baranzini et al. 2017; Barron et al. 2018). Hence, a shadow carbon price could be used if carbon pricing can be expected but is not in place. Furthermore, assessments of the price elasticity for products should be conducted to analyze whether production cost increases will cause lower sales. With regard to energy costs, higher prices should be expected for industries that depend on fossil fuel-based energy. However, as the costs for renewables and energy storage are decreasing, this change should not be disruptive. Lenders and investors must make sure that their clients are prepared for these price increases. On the other hand, the financial industry should take the opportunity to lend to and invest in industries that do not depend on fossil fuel, or that offer solutions for a transition to a low-carbon economy. For these industries, Scenario 2 offers more reliable opportunities compared to a scenario without carbon pricing (Bak 2017) because it increases the likelihood of success of green industries in the domestic market.

In Scenario 3, production costs would increase significantly in energy-intensive industries until they adapt to a low-carbon economy. These industries are not candidates for long-term lending or investments until they have adapted to the low-carbon economy. Significant shifts will take place for industries with lower fossil fuel energy inputs and reduced GHG emissions. This will also provide opportunities to engage financially in low-carbon sectors. The financial industry, however, has to develop strategies to identify these opportunities and to mitigate risks due to the new characteristics of these low-carbon industries. Increased production costs and increasing energy prices will mainly affect high-emitting industries, such as the oil and gas sector and heavy industry. But it will also affect buildings and the transport industry, and even industries that provide services to these industries. Hence, in addition to climate-related risk management, the financial industry should look at opportunities to invest in industries that support a transition to a low-carbon economy. What is needed in this case are experts that are able to analyze the risks and opportunities of these new industries. Furthermore, this scenario offers opportunities for sustainability-related financial products, such as green bonds and green loans, to support sustainable infrastructure and the transition of industries to low-carbon industries.

For all three scenarios, a standardized disclosure of at least the five indicators listed here is needed. The financial industry should develop strategies and tools to assess the risks with regard to these indicators, to manage these risks and to explore opportunities for investment and lending for clients that address these risks.

As explained above, physical risks will be the same for all scenarios at least for the following three decades because given the current level of emissions, the world is certain to be impacted by climate change. Depending on the location, firms have to account for increased capital costs, for instance, damage to facilities because of extreme weather events, such as flooding and its consequences. Combined with the risk of increased insurance premiums or even the unavailability of insurance in affected regions, this risk can have a strong impact on the ability of commercial borrowers to pay back loans or bonds, or for investees to meet their targets.

Reduced revenues from lower sales/output are also affected by physical risks. Because of business interruption, the risk of lower sales and outputs increases. This has an effect on revenues and, consequently, on the ability of borrowers to pay back loans or pay dividends. Hence, additional plans should be put into action to assess and mitigate the risk of lower sales and outputs of clients.

Increased insurance premiums and the potential for reduced availability of insurance on assets in high-risk locations are the third major risk for the financial industries and, in particular, lenders. So far, lenders and investors rely on insurers to pay for damage and production disruptions. Insurers, however, will probably have to increase premiums for regions at risk, or stop insuring some regions against extreme weather events. This exposes lenders and investors to significant financial risks. Even the mortgage business could be affected by this risk because of the location of the houses.

Obviously, the insurance industry will be affected by this risk. Furthermore, the insurance industry may be vulnerable to additional risk because of payments for damages due to reduced numbers of clients, increasing premiums and because specific regions will become uninsurable with regard to climate change induced risks.

Strategies to Address Risk

The following strategies focus on how the Canadian banking sector can prepare for different climate change scenarios. The strategies should help to address all three scenarios and focus on the risks presented in Table 4.

Strategies and Tools to Address Transition Risks

Lenders and investors should develop strategies and tools to assess and manage the most important transition risks, such as increased production costs due to changing input prices (for example, energy and water) and output requirements, as well as abrupt and unexpected shifts in energy costs. These risks will mainly affect industries that are energy intensive or that are involved in the fossil fuel business. Although all three scenarios have a relatively low negative impact on the economy, they might affect high carbon-

emitting industries, the fossil fuel industry and regions that are dependent on fossil fuels. Hence, indicators evaluating the impact of changing input prices on production costs and outputs, as well as for impacts of energy costs on the financial performance of borrowers and investees, should be established as a first step. In a second step, lenders and investors can develop strategies to reduce the exposure of their financial portfolios to industries that are mainly affected by these risks.

Be Prepared to Invest in the Low-carbon Economy

Although a transition to a low-carbon economy and current and future physical risks of climate change might expose the Canadian financial industry to climate-related risk, there will also be opportunities for the financial industry. The transition to a low-carbon economy needs investments in green tech, sustainable infrastructure and energy. This need for finance offers an opportunity for lenders and investors. So far, however, the Canadian financial industry is not well prepared to invest in new fields such as clean tech. Strategies and expertise are needed to take advantage of these opportunities, such as credit management systems that address the characteristics of the clean-tech industry, as well as mitigate risks for industries that suffer under the transition. Instead of being reactive, the financial industry should follow a proactive strategy that may increase the likelihood of Scenarios 2 and 3. Taking these opportunities would also decrease portfolio risk connected with the exposure to carbon-dependent industries and regions.

Recognize that Physical Risks Are Real and Will Increase No Matter What Policies Will Be Implemented

Physical risks will increase. Even strong policies will not change the frequency and the magnitude of extreme weather events in the short term. Increased capital costs because of damage to facilities, reduced revenues from lower sales/output and increased insurance premiums and the potential for a reduced availability of insurance on assets will be the new normal in high-risk locations. Hence, lenders and investors should use standardized indicators to assess these risks. Furthermore, they need to be prepared that losses will not be insured in each case anymore because premiums will be too high for their clients, or insurers will no longer insure certain damages caused by climate change (Thistlethwaite and Wood 2018).

Financing Climate Change Adaptation Is An Opportunity

Financing climate change adaptation for affected regions could be another opportunity for lenders and investors that occur from all three scenarios. The question remains, however, who will pay for climate change adaptations. New financial products, such as resilience bonds or climate change adaptation bonds, may also offer an opportunity for the financial industry to be involved in climate change adaptation. In addition, the green bond market (Weber and Saravade 2019) might be a model for climate adaptation-related bonds and other financial products.

Climate Finance Makes Sense

Investing in low-carbon industries and in the transformation of emitting industries into low-carbon industries makes financial sense in the short term because it avoids exposure to transition risks. In the long term, this transition makes sense because it helps mitigate consequences of climate change that will also affect the financial industry in the future. This strategy even makes sense under Scenario 1 because it avoids long-term exposure to physical risks caused by climate change. Hence, reducing the exposure of lending and investment portfolios to industries and regions that are most affected by physical and transitional climate risks has an amplifying effect. On the one hand, it reduces the risk exposure for lenders and investors, and on the other hand, it supports green industry and green infrastructure that will mitigate climate change in the future.

Works Cited

Arora, Vipin, David Daniels, Ian Mead and Russel Tarver. 2018. "EMF32 results from NEMS: Revenue recycling." *Journal of Climate Change Economics* 09 (01): 1840014. doi:10.1142/s2010007818400146.

Bak, Céline. 2017. *Generating Growth from Innovation for the Low-carbon Economy: Exploring Safeguards in Finance and Regulation.* CIGI Paper No. 117. Waterloo, ON: CIGI.

Balanagarajan, K. and V. Gajapathy. 2018. "Climate Changes and its Impact on Employee Productivity." *International Journal of Applied Engineering Research* 13 (1): 27–29.

Baranzini, Andrea, Jeroen C. J. M. van den Bergh, Stefano Carattini, Richard B. Howarth, Emilio Padilla and Jordi Roca. 2017. "Carbon pricing in climate policy: seven reasons, complementary instruments, and political economy considerations." *WIREs Climate Change* 8 (4): e462. doi:10.1002/wcc.462.

Barron, Alexander R., Allen A. Fawcett, Marc A.C. Hafstead, James R. McFarland and Adele C. Morris. 2018. "Policy insights from the EMF 32 study on U.S. carbon tax scenarios." *Climate Change Economics* 09 (01): 1840003. doi:10.1142/s2010007818400031.

Buhr, Bob, Charles Donovan, Gerhard Kling, Yuen Lo, Victor Murinde, Natalie Pullin and Ulrich Volz. 2018. *Climate Change and the Cost of Capital in Developing Countries.* London: SOAS.

Cogan, Douglas G. 2008. *Corporate Governance and Climate Change — The Banking Sector.* Boston, MA: Ceres.

Cornelius, Peter, Alexander Van de Putte and Mattia Romani. 2005. "Three Decades of Scenario Planning in Shell." *California Management Review* 48 (1): 92–109.

Dannenberg, Astrid, Tim Mennel, Daniel Osberghaus and Bodo Sturm. 2009. *The Economics of Adaptation to Climate Change — The Case of Germany.* Mannheim, Germany: Zentrum für Europäische Wirtschaftsforschung.

Dunlap, Riley E and Aaron M. McCright. 2011. "Organized climate change denial." In *The Oxford Handbook of Climate Change and Society,* edited by John S. Dryzek, Richard B. Norgaard and David Schlosberg, 144–60. Oxford, UK: Oxford University Press.

Environment and Climate Change Canada. 2016. "Canada's Mid-Century Long-Term Low Greenhouse Gas Development Strategy." Gatineau, QC: Environment and Climate Change Canada.

Folger-Laronde, Zachary and Olaf Weber. 2018. *Climate Change Disclosure of the Financial Sector.* Waterloo, ON: CIGI.

Gibson, Robert B., Karine Péloffy, Daniel Horen Greenford, Meinhard Doelle, H. Damon Matthews, Christian Holz, Kiri Staples, Bradley Wiseman and Frédérique Grenier. 2019. *From Paris to Projects: : Clarifying the implications of Canada's climate change mitigation commitments for the planning and assessment of projects and strategic undertakings.* Toronto, ON: Metcalf Foundation.

Godet, Michel. 1986. "Introduction to *La Prospective*: Seven Key Ideas and one Scenario Method." *Futures* 18 (2): 134–57.

Goulder, Lawrence and Marc Hafstead. 2018. *Confronting the Climate Challenge: U.S. Policy Options*. New York: Columbia University Press.

Goulder, Lawrence H. and Andrew R. Schein. 2013. "Carbon taxes versus cap and trade: a critical review." *Journal of Climate Change Economics* 4 (03): 1350010.

Hausfather, Zeke. 2017. "Meeting Paris pledges would prevent at least 1ºC of global warming." *Carbon Brief.* www.carbonbrief.org/analysis-meeting-paris-pledges-would-prevent-at-least-one-celsius-global-warming.

Hunt, Chelsie and Olaf Weber. 2019. "Fossil fuel divestment strategies: Financial and carbon related consequences." *Organization & Environment* 32 (1): 41–61. doi:10.1177/1086026618773985.

IPCC. 2018. "Global warming of 1.5°C." Geneva, Switzerland: IPCC.

Kunreuther, Howard C., Erwann Michel-Kerjan and Nicola Ranger. 2013. "Insuring future climate catastrophes." *Climatic Change* 118 (2): 339–54.

Labatt, S. and Rodney R. White. 2007. *Carbon Finance.* Hoboken, NJ: Wiley.

Linnenluecke, Martina, K., Cristyn Meath, Saphira Rekker, K. Baljit Sidhu and Tom Smith. 2015. "Divestment from fossil fuel companies: Confluence between policy and strategic viewpoints." *Australian Journal of Management* 40 (3): 478–87. doi:10.1177/0312896215569794.

Lutz, Viola, Martin Stadelmann and Maximilian Horster. 2017. "Potential Impact of Climate Change on Financial Market Stability." Munich, Germany: Munich Re.

Matthews, H. Damon and Andrew Weaver. 2010. "Committed climate warming." *Nature Geoscience* 3 (3): 142.

McFarland, James R., Allen A. Fawcett, Adele C. Morris, John M. Reilly and Peter J. Wilcoxen. 2018. "Overview of the EMF 32 Study on U.S. carbon tax scenarios." *Climate Change Economics* 09 (01): 1840002. doi:10.1142/s201000781840002x.

McKibbin, Warwick J., Adele C. Morris, Augustus Panton and Peter Wilcoxen. 2017. "Climate Change and Monetary Policy: Dealing with Disruption." CAMA Working Papers No. 77.

Mercer LLC. 2015. "Investing in a time of climate change." London, UK: Mercer International Finance Corporation and the UK Department for International Development.

Mills, Evan. 2005. "Insurance in a Climate of Change." *Science* 309 (5737): 1040–44.

Negri, Pietro. 2018. "Sustainable Finance and Non-Financial Disclosure: The Impact for the Insurance Industry." *Symphonya. Emerging Issues in Management* 1: 110–26.

Nilsson, Maria and Tord Kjellstrom. 2010. "Climate change impacts on working people: how to develop prevention policies." *Global Health Action* 3 (1): 5774. doi:10.3402/gha.v3i0.5774.

Rahmstorf, Stefan and Anders Levermann. 2017. "Why global emissions must peak by 2020." *RealClimate*. www.realclimate.org/index.php/archives/2017/06/why-global-emissions-must-peak-by-2020/.

Rogelj, Joeri, Alexander Popp, Katherine V. Calvin, Gunnar Luderer, Johannes Emmerling, David Gernaat, Shinichiro Fujimori, Jessica Strefler, Tomoko Hasegawa and Giacomo Marangoni. 2018. "Scenarios towards limiting global mean temperature increase below 1.5°C." *Nature Climate Change* 8 (4): 325–32.

Ross, Martin T. 2018. "Regional implications of national carbon taxes." *Journal of Climate Change Economics* 09 (01): 1840008. doi:10.1142/s2010007818400080.

Russ, Peter, Denise van Regemorter and Tobias Wiesenthal. 2007. "Global Climate Policy Scenarios for 2030 and beyond: Analysis of Greenhouse Gas Emission Reduction Pathway Scenarios with the POLES and GEM-E3 models." Seville, Spain: Joint Research Centre of the European Commission.

Schenker, Oliver. 2013. "Exchanging Goods and Damages: The Role of Trade on the Distribution of Climate Change Costs." *Journal of Environmental Resource Economics* 54 (2): 261–82. doi:10.1007/s10640-012-9593-z.

Shell. 2013. "New Lens Scenarios." www.shell.com/energy-and-innovation/the-energy-future/scenarios/new-lenses-on-the-future.html.

Sullivan, Rory. 2014. "Climate Change: Implications for Investors and Financial Institutions." June. SSRN. https://ssrn.com/abstract=2469894.

Swart, R. J., Paul Raskin and John Robinson. 2004. "The problem of the future: sustainability science and scenario analysis." *Global Environmental Change* 14 (2): 137–46. doi:10.1016/j.gloenvcha.2003.10.002.

TFCD. 2016. "Recommendations of the Task Force on Climate-related Financial Disclosures." Basel, Switzerland: TFCD.

———. 2017a. "Recommendations of the Task Force on Climate-related Financial Disclosures." Basel, Switzerland: TFCD.

———. 2017b. “The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities.” Basel, Switzerland: TFCD.

———. 2017c. “Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures.” Basel, Switzerland: TFCD.

Thistlethwaite, Jason, Andrea Minano, Jordan A. Blake, Daniel Henstra and Daniel Scott. 2018. “Application of re/insurance models to estimate increases in flood risk due to climate change.” *Journal of Geoenvironmental Disasters* 5 (1): 8.

Thistlethwaite, Jason and Michael O. Wood. 2018. “Insurance and Climate Change Risk Management: Rescaling to Look Beyond the Horizon.” *British Journal of Management* 29 (2): 279–98. doi:10.1111/1467-8551.12302.

UNEPFI. 2019. “Pilot project on implementing the TCFD recommendations for banks.” UNEPFI. www.unepfi.org/banking/tcfd/.

Weber, Olaf and Olena Kholodova. 2017. *Climate Change and the Canadian Financial Sector.* Waterloo, ON: CIGI.

Weber, Olaf and Vasundhara Saravade. 2019. *Green Bonds: Current Development and Their Future.* CIGI Paper No. 210. Waterloo, ON: CIGI.

Westphal, Michael, Pascal Canfin, Athena Ballesteros and Jennifer Morgan. 2015. “Getting to $100 Billion: Climate Finance Scenarios and Projections to 2020.” World Resources Institute Working Paper. Washington, DC: World Resources Institute.

Weyzig, Francis, Barbara Kuepper, Jan Willem van Gelder and Rens van Tilburg. 2014. “The price of doing too little too late: The impact of the carbon bubble on the EU financial system.” Brussels, Belgium: Sustainable Finance Lab, Profundo, Green European Foundation.

Wiek, Arnim, Claudia Binder and Roland W. Scholz. 2006. “Functions of scenarios in transition processes.” *Futures* 38 (7): 740–66. doi:10.1016/j.futures.2005.12.003.

Williams, Jon and Phil Case. 2016. *Climate policy risk: How does this become a credit risk for banks?* London: PWC.

World Economic Forum. 2018. *The Global Risks Report 2018.* Geneva, Switzerland: World Economic Forum.

Zuckerman, Julia, Jana Frejova, Ilmi Granoff and David Nelson. 2016. “Investing at Least a Trillion Dollars a Year in Clean Energy. Contributing paper for Seizing the Global Opportunity: Partnerships for Better Growth and a Better Climate.” London and Washington, DC: New Climate Economy.

Appendix

Table 5: Columns and Row Sums of the Indirect Influence Matrix

			Variable	Sum of rows	Sum of columns
Transition Risks	Policy and Legal	1	Increased operating cost	51990	58920
		2	Write-offs, asset impairments or early retirement of asset	41173	22647
		3	Increased costs and/or reduced demand for purchases and sales due to policy change	47214	57621
	Technology	4	Write-offs and early retirement of technological assets	22385	26032
		5	Reduced demand for products and services	44864	49019
		6	Research and development (R&D) expenditures in new and alternative technologies	34805	**64839**
		7	Capital investments in technology development	46537	**73917**
		8	Costs to adopt/deploy new practices and processes	42163	**65653**
	Market	9	Reduced demand for goods and services due to shifting consumer preferences	41130	34259
		10	Increased production costs due to changing input prices (e.g., energy, water) and output requirements	**65225**	45758
		11	Abrupt and unexpected shifts in energy costs	**65959**	22895
		12	Change in revenue mix and sources, resulting in decreased revenues	37462	48604
		13	Re-pricing of assets	29992	38532
	Reputational	14	Reduced revenue from decreased demand for goods/services.	53165	34152
		15	Reduced revenue from decreased production capacity (e.g., delayed planning approvals, supply chain interruptions)	53448	49898
		16	Reduced revenue from negative impacts on workforce management and planning (e.g., employee attraction and retention).	35974	40996
		17	Reduction in capital availability	39593	**77378**
Physical Risks	Acute and Chronic	18	Reduced revenue from decreased production capacity (e.g., transport difficulties, supply chain interruptions).	45466	41165
		19	Reduced revenue and higher costs from negative impacts on workforce (e.g., sickness, injury absenteeism)	36980	35410
		20	Write-offs and early retirement of existing assets (e.g., damage to property and assets in "high-risk" locations)	45014	23137
		21	Increased operating costs (e.g., inadequate water supply for hydroelectric plants or to cool nuclear and fossil fuel plants)	54276	48935
		22	Increased capital costs (e.g., damage to facilities).	**65552**	47620
		23	Reduced revenues from lower sales/output	**62740**	**67743**
		24	Increased insurance premiums and potential for reduced availability of insurance on assets in "high-risk" locations	**58950**	46927
			Totals	1122057	1122057

About CIGI

We are the Centre for International Governance Innovation: an independent, non-partisan think tank with an objective and uniquely global perspective. Our research, opinions and public voice make a difference in today's world by bringing clarity and innovative thinking to global policy making. By working across disciplines and in partnership with the best peers and experts, we are the benchmark for influential research and trusted analysis.

Our research programs focus on governance of the global economy, global security and politics, and international law in collaboration with a range of strategic partners and support from the Government of Canada, the Government of Ontario, as well as founder Jim Balsillie.

À propos du CIGI

Au Centre pour l'innovation dans la gouvernance internationale (CIGI), nous formons un groupe de réflexion indépendant et non partisan doté d'un point de vue objectif et unique de portée mondiale. Nos recherches, nos avis et nos interventions publiques ont des effets réels sur le monde d'aujourd'hui car ils apportent de la clarté et une réflexion novatrice pour l'élaboration des politiques à l'échelle internationale. En raison des travaux accomplis en collaboration et en partenariat avec des pairs et des spécialistes interdisciplinaires des plus compétents, nous sommes devenus une référence grâce à l'influence de nos recherches et à la fiabilité de nos analyses.

Nos programmes de recherche ont trait à la gouvernance dans les domaines suivants : l'économie mondiale, la sécurité et les politiques mondiales, et le droit international, et nous les exécutons avec la collaboration de nombreux partenaires stratégiques et le soutien des gouvernements du Canada et de l'Ontario ainsi que du fondateur du CIGI, Jim Balsillie.

Centre for International
Governance Innovation

67 Erb Street West
Waterloo, ON, Canada N2L 6C2
www.cigionline.org

@cigionline