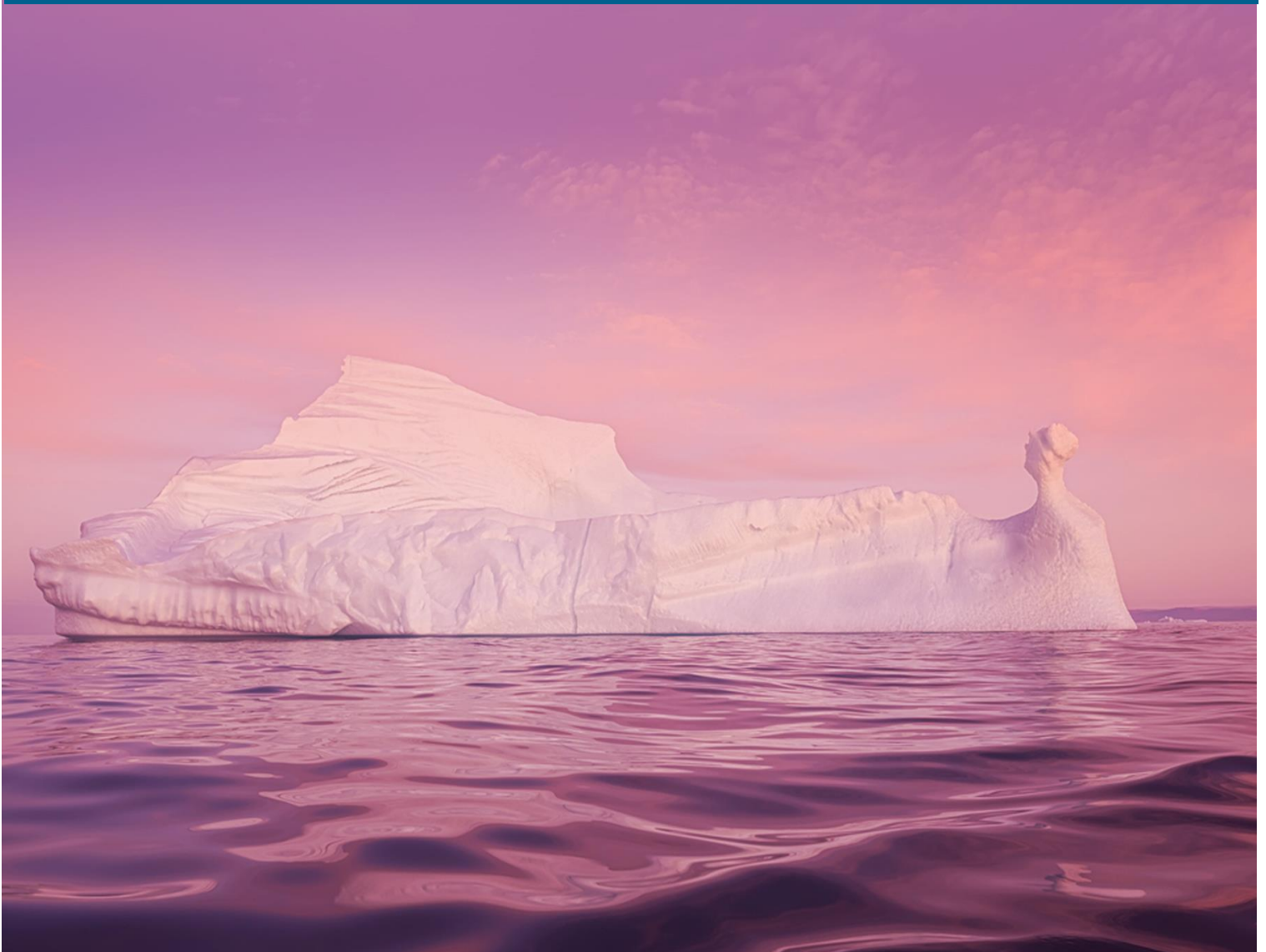


Impact of Climate Change on Investors

Uncertain Assumptions over Long Time Horizons



Catastrophe
and Climate



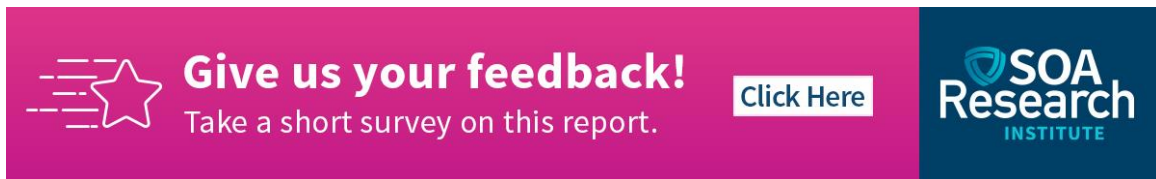


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Impact of Climate Change on Investors

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Introduction

The earth's ecosystem appears to be leaving the 10,000-year Holocene epoch that featured a stable environment. For homo sapiens, this stability encouraged a move from hunter/gatherer to farming and urban lifestyles. The new period showcases climate risk, resulting in higher temperatures and more extreme weather. These conditions lead to greater exposures to properties and economies when events like hurricanes and wildfires occur. Financial losses (rarely gains) occur based on extreme weather events becoming more common and a buildup of these influences over time (e.g., temperature increases, sea level rise). This creates stress on the global economy, slowing and potentially leading to negative economic growth.

If the Paris conference pledges were kept, global temperatures could be held to a 2.7°C rise from pre-industrial baseline by 2100, only 0.2°C better than the level achieved from policies currently in place.¹ They were already higher by 1.2°C in 2020, with model uncertainty due to complex interactions and feedback loops. The impacts as temperatures rise aren't expected to be linear but that they will rise more steeply with each increment.² Differences in temperature will occur regionally, by latitude, by vertical height, by time of day (lowest night temperature may be more important than highest day time temperature) and duration of heatwaves (multiple days). It will be hard to reverse the momentum caused by greenhouse gas (GHG) emissions, with ramifications for level and rate of change to temperature, ocean acidification, soil moisture, humidity and deglaciation. Some areas will reach levels of heat and humidity that discourage humans from living there. Others will see increasingly dry conditions. Agriculture stresses are likely to increase food insecurity and crop uncertainty. The changes are quicker than nature can react to without disruption. Biodiversity is an important component of climate change. Plants, animals, fish and insects can only adapt so quickly, raising concerns about their future in a fast-changing environment. But what about *our* future? What is our plan when pollinators emerge at a different time than plants are anticipating their appearance?

Robert Malthus and Benjamin Franklin long ago noted the interaction between population and food security, noting that population would ultimately be limited by food production.³ As the number of extreme weather events accelerates, agricultural methods are constrained based on impact to climate and the natural environment, and fertility rates drop it is not a certainty that world population will reach its projected 11 billion by 2100.⁴

Reducing greenhouse gases in the United States will be difficult, but paths toward reduction have been presented for transportation, electricity, industry, commercial and residential. One of the big challenges will likely be agriculture. One farming component is nitrous oxide, a by-product of fertilizer, 300 times more powerful as a GHG than carbon dioxide.⁵ It also depletes the ozone layer, which protects us from ultraviolet radiation.

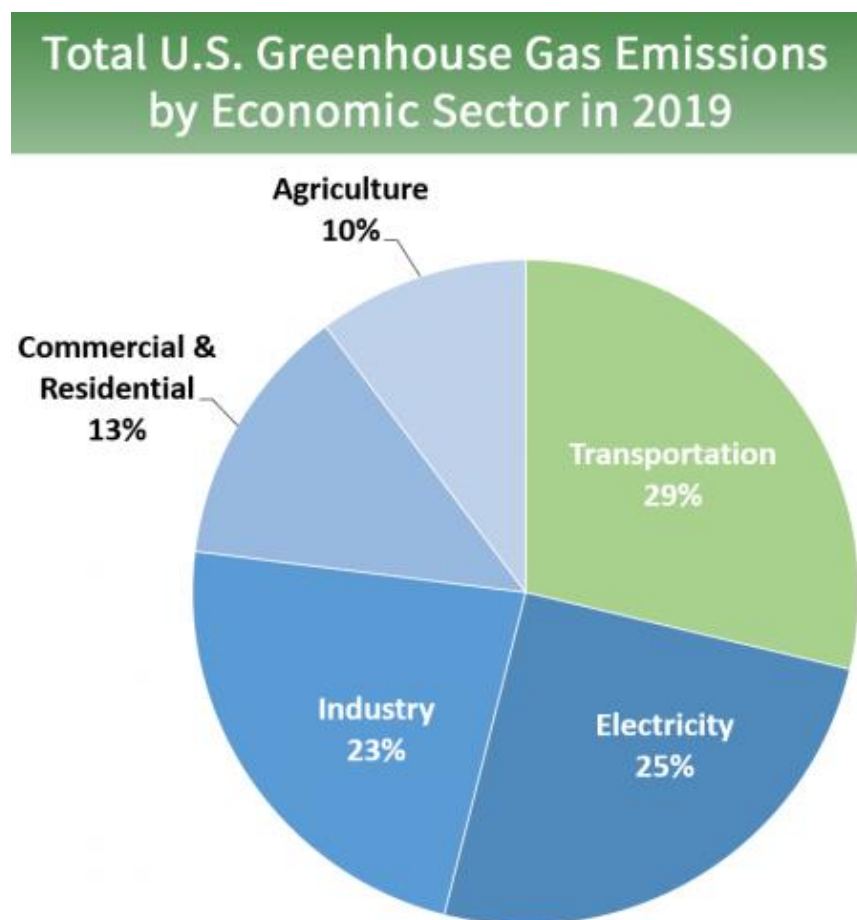
¹ This paragraph is based generally on an article in The Economist. *Briefing, the three-degree world: Burning down the house*. The Economist. July 24, 2021. <https://www.economist.com/briefing/2021/07/24/three-degrees-of-global-warming-is-quite-plausible-and-truly-disastrous>

² Lynas, Mark. *Six Degrees: Our future on a hotter planet*. National Geographic Society. 2008.

³ Rudolph, Max J. *Was Malthus right, but early?* Society of Actuaries Environmental Sustainability Call for Essays. 2017. <https://www.soa.org/research/opportunities/environmental-essays.pdf>

⁴ UN population projection <https://population.un.org/wpp/Graphs/DemographicProfiles/Line/900>

⁵ Shankman, Sabrina. *What is Nitrous Oxide and why is it a Climate Threat?* Inside Climate News. September 11, 2019. <https://insideclimatenews.org/news/11092019/nitrous-oxide-climate-pollutant-explainer-greenhouse-gas-agriculture-livestock/>

FIGURE 1 SOURCES OF GREENHOUSE GAS EMISSIONS IN THE UNITED STATES⁶

How do these potential scenarios impact investment practice? Those looking at individual entities in the private markets generate an intrinsic value by discounting future contingent cash flows to today. The moving parts that could be impacted by climate change include discount rate, the probability distribution of the cash flows (both signal and noise) and how that distribution may change in the future.

Asset-liability management (ALM) can also play a role. Some institutional investors, primarily insurers and pension plans, write liabilities that are then backed with intermediate and long duration bonds. In some cases, these investors are the primary buyers of these asset classes. Disclosures aligned with the Task Force on Climate-related Financial Disclosures (TCFD) use transparency and peer pressure to incent firms to improve their environmental, social and governance (ESG) practices. Other terms often used interchangeably with ESG investing are sustainable investing, impact investing and socially responsible investing (SRI).

This paper is written from the perspective of an investor in the United States or Canada, but global investors will share many of the concerns raised here. It is not investment advice and is for educational purposes only.

⁶ Retrieved from U.S. Environmental Protection Agency on September 7, 2021. <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>

Impacts of climate change that matter to investors

PHYSICAL RISK

Climate change impacts economic development in many ways and is not limited to countries with certain characteristics. Stronger hurricanes occur more frequently, droughts and heat waves become more severe, and ocean warming, acidification and sea level rise all result from climate change. Each of these risks is changing in ways that challenge species and increase the likelihood of extinction. These risks also impact man-made objects, along with human morbidity and mortality in varying ways. They often lead to greater destruction and higher losses for owners of property, along with their insurers. Have investors considered how this risk could evolve across the length of the corresponding asset time horizon and impact their financial results?

As the earth warms, ice melts. Ice already floating in the ocean will not by itself raise sea levels, but as land ice melts, especially on Greenland and Antarctica, the impact on sea level rise will be material. In addition, melting ice reduces the salinity of the oceans and impacts ocean currents. Thermal expansion of the oceans as temperatures increase is another source of sea level rise, as is human use of land surface water like aquifers that are extracted from the ground and end up in the oceans.

Not all areas will see the same amount of sea level rise. For example, Norfolk, Virginia is depleting its aquifer and that is causing the land above it to sink. Other areas are lifting up as ice melts and the land under it rebounds from the weight. Some areas are still recovering from the most recent Ice Age.

Traditional property insurance policies are repriced each year, while infrastructure investments have longer time horizons. For example, Delhi is experiencing more frequent droughts, making it harder to absorb water deluges during the monsoon season. Their investment in new water-processing facilities, financed assuming many years of use, could be at risk. Ports and industrial complexes located in the Gulf of Mexico are subject to greater hurricane risk along with sea level rise. Communities are impacted as infrastructure needs to evolve, increasing municipal bond risk.⁷

Sea level rise can turn coastal properties into an offshore ruin defined by a new and evolving coast. In addition to destroying wetlands and beach forests that form a natural buffer against weather events, some areas have high-end vacation homes and tourist destinations with high exposure to storm surge and wind damage. Coastal property is especially vulnerable when hurricanes strike during a full moon and tides are high.

Strong drought conditions can make idyllic forest homes susceptible to wildfires. Previously, sustainable premiums have aligned with historical claims data but it now appears that a better measure of forward-looking exposure may reflect the accumulated undergrowth in an area that provides dry tinder. In areas already suffering from drought, too little precipitation can lead to calamitous results. While physical, drought indirectly destabilizes other parts of the economy. For example, when water levels are low in reservoirs, risks increase for both the local fresh water supply as well as renewable energy provided by damsites (e.g., Lake Powell and the Glen Canyon Dam, or Lake Mead and the Hoover Dam).

Proactive governments will store supplies and build infrastructure to deal with the losses that accompany these extreme events.

⁷ Funds Global Asia. *Inside view: How Asian insurers can counter climate risks*. July 12, 2021. (Interview with Tim Antonelli of Wellington Management) <http://fundsglobalasia.com/digital-features/inside-view-how-asian-insurers-can-counter-climate-risks>

As governments feel strain from indebtedness and are forced to make hard decisions on items that aren't in a typical annual budget, amounts allocated to weather-related disaster area declarations may need to be cut back. The forward-looking investor should start considering these types of issues now.

The intrinsic value of an asset decreases as the risk, reflected in the discount rate, increases. Volatility also increases as the likelihood and severity of loss increases. It becomes a risk management problem, ripe with interactions. The social discount rate can be interpreted in many ways, as Sam Gutterman showed in his 2020 research paper.⁸

In the long run, markets will determine the appropriate additions to the discount rate, or capital, used by investors through the mechanism of supply and demand at the margins. Human cognitive biases and extended time horizons will allow a rational investor to make better decisions.

TRANSITION RISK

Transition risks include risks associated with policy actions, litigation risk, technology risk (e.g., development of renewable energy options) and market risk (e.g., changes in supply and demand for commodities).⁹ As public policy leads to adaptation and building resilience, strategies will likely include de-carbonization and de-methanization as fossil fuels are left in the ground.

If humans are successful in mitigating climate change through strategies such as reducing fossil fuel extraction, stranded assets will be left behind. In addition to sequestered oil and gas, assets that run on fossil fuels or that become economically unsustainable are included in this group. Examples may include gasoline powered vehicles, non-recyclable plastics and vacation rentals that require long airplane flights to utilize them.

One strategy to manage this risk would be to nationalize companies with large carbon footprints using the U.S. Federal Reserve's Quantitative Easing (QE) program that is currently buying private assets, providing liquidity to existing shareholders. That way incentives can be aligned between risk owners and energy users, and fossil fuel use could be phased out in a publicly optimized way that leaves lobbyists out of the discussion.

Liability for risks arising from litigation relating to the consideration of climate change in decision making or inadequate disclosure can also become a big deal as a result of a policy. Asbestos cases are still being felt, and litigation is currently underway for many instances where clients claim coverage under COVID-19 for business interruption insurance.

INDIRECT RISKS

Military planners speak of threat multipliers, interactions where risks amplify each other, making conflict more likely. Climate change and the strategies to counter it, like de-carbonization, will indirectly impact many facets of everyday life. Resources like fresh water and demographic trends lead to increased instability when combined with climate change. Regional conflicts and immigration driven by climate refugees are already being seen. Tensions will rise, increasing the threat of wars that utilize large amounts of fossil fuel and the obvious feedback loops.

Solutions to climate change will require "out of the box" or lateral thinking. Traditional critical thinking methods are not as effective in a world where historical risks and neither predictive or linear, the unknown known reality that

⁸ Gutterman, Sam. *Social Discounting: Application to the Risk Management of Climate Change*. August 2020. Society of Actuaries. <https://www.soa.org/resources/research-reports/2020/social-discounting-climate-change/> A summary is available in the October 2020 Catastrophic & Climate Strategic Research Program Newsletter. <https://www.soa.org/publications/catastrophe-climate/>

⁹ Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures. June 2017. <https://assets.bbhub.io/company/sites/60/2020/10/FINAL-2017-TCFD-Report-11052018.pdf>

requires experience to recognize.¹⁰ In an unknown known environment, the probability distribution of future events differs from those in the past and makes it more difficult for statistical methods and predictive modeling to be effective.¹¹ Thinking over long time horizons requires more than linear extrapolation and artificial intelligence techniques. Experience, knowledge of history and first principles are all needed to anticipate the future when change comes at you quickly.

The interactions between so many segments of the earth's ecosystem (e.g., energy cycle, water cycle, nitrogen cycle) are hard to model. Much of this analysis will need to be done qualitatively, at least for a while, as data is collected and interpreted. Experienced investors and risk managers can work with quantitative models to improve the capabilities of each on their own.

AGRICULTURE

Agriculture may need to pivot away from nitrogen as a fertilizer or find ways to capture nitrogen present in the air or water to meet GHG emission goals. Farmers using traditional European methods of farming may need to revisit their practices to be more sustainable. No till farming is a good start, but agriculture's role in biodiversity loss and GHG emissions must go beyond crop rotation, considering methods indigenous farmers have traditionally used to maintain soil quality. Farming is an already extremely challenging business, so changes in practice have repercussions throughout the investment world. Failed crops have proven to be inflationary in the past, leading to global food insecurity issues (COVID's impact on the supply chain is also a concern, and populations tend to focus on food first before other items of trade). Technological solutions for agriculture may also be susceptible to cyber hacking as techniques become more dependent on computing.

Concerns for agriculture and nutrition that highlight the interactions between climate and living things are due to the rate of change of the current climate. Plants and animals need time to evolve adaptive traits as temperatures warm and ecosystems change.¹² Biodiversity builds ecosystem resilience. As useful as monoculture practices have been to feeding growing populations, they also pose a threat since they are designed for the environment at a specific point in time. Threats need only avoid one defense system to become a systemic risk. This type of risk is often described using a metaphor: we often design systems that reduce the likelihood of a small accident over short time horizons while increasing the chance of a major accident over longer time horizons.

The insect population has already been decimated by chemicals and removal of native habitat.¹³ Now scientists worry that plants adjust more quickly to an earlier spring and will be ready for pollination before the pollinators are available to do so.

SOCIAL STABILITY

The earth ecosystem's stability since the last Ice Age is positively correlated to man's evolution from hunter/gatherer to farmer, manufacturer and trader that defines our economy today. Temperature changes, even what seems like a small amount of a few degrees, is enough to bring broad changes to the environment, especially given the rate of change we are experiencing. Over the last 22,000 years, temperatures have increased by 4.3°C

¹⁰ Werther, Guntram and Rudolph, Max. *Resurrecting the White Swan Mindset: How much more can be forecast?*

<https://www.soa.org/resources/research-reports/2021/resurrecting-white-swan/>

¹¹ Rudolph, Max. *Unknown Knowns: Time Horizon*. SOA Climate and Environmental Sustainability 2018 Call for Essays. May 2019.

<https://www.soa.org/globalassets/assets/files/resources/research-report/2019/climate-env-sustainability-2018-call-for-essays.pdf>

¹² A good example showing that humans have similar issues is the wine industry, where growing vines is a slow process. Moving a vineyard to an area better suited in tomorrow's climate is not an exact science but has started to occur.

¹³ Halsch, Christopher et al. *Insects and recent climate change*. PNAS (Proceedings of the National Academy of Sciences of the United States of America). January 12, 2021. <https://www.pnas.org/content/118/2/e2002543117>

with the last 2° occurring in the last 12,500 years (about when the last Ice Age ended).¹⁴ GHG emissions and temperature increases are happening at rates that remind scientists of major volcanic events that led to five previous mass extinctions.¹⁵ Social stability is at risk due to food availability and price volatility, as well as regional conflict. The immigration crisis in Europe and the southern border of the United States are at least partly due to climate change, as the Middle East and Central America become less hospitable to crops and humans. Investors have entered a less certain world.

PRODUCTIVITY

The most common metric for economic growth is gross domestic product (GDP).¹⁶ It includes productivity and population components. Developed countries have fertility rates below sustainable levels so need to use immigration policy if they want the working population to grow without asking groups not currently in the work force to join. Disadvantaged socioeconomic groups could also generate GDP growth as they are provided opportunities previously denied them.

Productivity is constrained by climate change in multiple ways. Damage that has already been done needs to be fixed, efforts made to avoid future damage, and working outdoors with increasing heat stress is challenging. Each lowers potential productivity as money becomes unavailable for other purposes, and costs go up as events become more frequent and changes accumulate. An environment with low economic growth creates many challenges for investors, but that scenario should be considered as possible or even likely.¹⁷

Extreme events covering the spectrum of possibilities, like heat waves, floods and drought, will lower productivity through business interruption and supply chain interruption.

CRYPTOCURRENCIES

Digital assets (e.g., bitcoin) that are not backed by another asset (e.g., fiat currency or physical gold) are created using large amounts of electricity (as much as some European countries) as it is mined.¹⁸ This electricity is either created from non-renewable sources, adding to GHG emissions, or diverts renewable sources away from other uses.

Conceptually, a block chain process with no centralized authority and promising anonymity has some positive aspects, but the lack of value stability and the climate impact has made bitcoin and other cryptocurrencies a challenge to make sustainable.

As electricity is the power source of choice to provide renewable energy to the masses, there could be pressure to reduce uses that participate in a climate feedback loop and warm the planet further. Cryptocurrencies are not a direct driver of climate change, but certainly have an indirect role in its rate of change.

It remains to be seen if cryptocurrencies are inherently stabilizing or destabilizing forces, but in a setting lacking in renewable energy they are not environmentally friendly and so indirectly increase financial risk.

¹⁴ Attribution Visual Capitalist. www.visualcapitalist.com/stunning-graphic-earths-temperature-22000-years/

¹⁵ Brannen, Peter. *The Ends of the World*. 2017. HarperCollins.

¹⁶ GDP is not the only measure of economic welfare and society well-being, and many are starting to challenge if it should be the primary metric used. A change in metric could affect investors in many ways, likely imposing costs on investments that degrade the environment or use scarce resources.

¹⁷ Alberts, Mark and Rudolph, Max. *A Low-Growth World: Implications for the Insurance Industry and Pension Plans*. June 2019.

<https://www.soa.org/globalassets/assets/files/resources/research-report/2019/low-growth.pdf>

¹⁸ Carter, Nic. *How Much Electricity does Bitcoin Actually Consume?* Harvard Business Review. May 5, 2021. <https://hbr.org/2021/05/how-much-energy-does-bitcoin-actually-consume>

CHALLENGES

In order to slow the effects of climate change, the world's political entities must move quickly to avoid feedback loops that become irreversible. Potential examples include melting of the Greenland ice cover, leading to a weakened Gulf Stream and higher sea levels,¹⁹ and converting the Amazon from rain forest to savannah (making it a net source of carbon dioxide rather than its historical store that sequestered emissions). There are many uncertainties going forward. Modelers have expressed concerns with tipping points, making it important to limit global warming to two degrees Celsius since it appears that feedback loops (e.g., permafrost and ice melting) are accelerating warming beyond the linear relationship with emissions, resulting in several additional degrees of warming being nearly guaranteed to occur as albedo changes and new sources of GHG enter the atmosphere.²⁰

For example, some climate models anticipate an environment where certain types of clouds no longer form. What else is not fully understood that will surprise us in the future? These uncertainties will be reflected in investment risk.

RISK REPORTING

Traditional ledger accounting systems use debits and credits to develop balance sheets, income statements and other reporting mechanisms. These are then used by investors to make decisions about whether to move forward with projects, and how aggressively to do so. The problem is that the Italian merchants who developed double-entry bookkeeping before the year 1500 did not take into account the impact of using a limited resource or one that would harm the general population. The tragedy of the commons describes such a situation, where practices like overfishing, use of groundwater or grazing sheep on public lands all lead to exploitation with no formal economic impact. This should be considered by investors for decision making even if accountants ignore it. Recognition can be accomplished either by raising the discount rate, adding a capital requirement or assessing an explicit charge.

Efforts to standardize company disclosures, even quantifying the levels of GHG emissions, are being proposed by regulators. Gary Gensler, SEC (Securities and Exchange Commission) Chair, has asked his staff to develop mandatory climate-risk disclosure to ensure consistency, comparability and reliability.²¹ Perhaps federal governments around the globe could start by analyzing their own impact on emissions, with disclosures by both governments and companies audited and standards developed for consistency and transparency developed.

INSURERS AS CLIMATE GATEKEEPERS

Insurers provide important financial incentives for the public to mitigate specific risks to reduce premiums. When property insurance is sustainable this leads to behavior modifications that reduce premiums and maintain coverage.²² The National Flood Insurance Program (NFIP) is currently taking steps to accomplish this through higher premiums, especially for larger coastal homes which had previously been subsidized by taxpayers.²³

In some cases, premiums will increase, but in many jurisdictions rate increases must be approved by regulators. Coverage may be canceled if they can't be written profitably. States sometimes act as an insurer of last resort. In

¹⁹ IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press. August 2021. <https://www.ipcc.ch/report/ar6/wg1/>

²⁰ Lynas, Mark. *Six Degrees: Our future on a hotter planet*. National Geographic Society. 2008.

²¹ Eaglesham, Jean and Shifflett, Shane. *How Much Carbon Comes from a Liter of Coke? Companies Grapple with Climate Change Math*. Wall Street Journal. August 10, 2021. <https://www.wsj.com/articles/climate-change-accounting-for-companies-looms-with-all-its-complexities-11628608324>

²² Holley, Eric Holley et al. *Climate Change and Market-Based Insurance Feedbacks*. Society of Actuaries. August 2020. <https://www.soa.org/publications/catastrophe-climate/>

²³ Flavelle, Christopher. *The Cost of Insuring Expensive Waterfront Homes is about to Skyrocket*. New York Times. September 24, 2021. <https://www.nytimes.com/2021/09/24/climate/federal-flood-insurance-cost.html>

Florida, for example, the state has set up its own insurer to cover homeowners who can't get coverage elsewhere, similar to the Affordable Care Act (Obamacare) for health insurance in the U.S. Due to the increase in risk there are concerns that the premium levels are not sustainable.²⁴

Insurance companies provide private capital that spreads risk and makes it affordable to live or work in certain locations. By leveraging the law of large numbers, entities do not need to individually maintain a large contingency fund for risks like those that result in fire or water damage. The insurer, after a deductible, covers the financial loss for the policyholder (often capped). Some risks are systemic to a region, like earthquake or flood risk, so government often acts as an insurer, reinsurer or provides disaster recovery funds.

Ties to low growth

There are numerous headwinds to future global economic growth, including demographics and rising inequality, but climate change may have the greatest impact.²⁵ Damage done to the ecosystem (both environmental and financial) in previous events need to be addressed, mainly through repairing or replacing infrastructure and improving social safety nets, but proactive mitigation and adaptation are just as important. Constantly reacting to extreme events that destroy existing structures distracts from economic growth prospects and pulls funds that could be used to proactively avoid future events. In one scenario, by 2050 global temperatures could rise by 3°C and global GDP shrink by up to 18%.²⁶ Positive economic growth could be impossible as the planet warms.

The indirect impacts are much more noticeable in a low economic growth environment. When economic growth is low, choices must be made. It is much more apparent that money spent on one thing is not available for others. If governments and insurers are constantly replacing and repairing, that money is not available for other important programs like education, health care, international development and building a social safety net. It redirects time and resources to non-economic repairs and pursuits.

One incentive that makes economic sense, but struggles politically in some jurisdictions, is a tax on carbon used to provide funds to repair and improve infrastructure. Some U.S. proposals currently would collect a carbon tax and pay it out to citizens equally or based on socioeconomic status.²⁷ Given that time is short to make drastic changes, negotiations to enact these proposals will likely not be enough to hold off climate change.

Many companies and jurisdictions have pledged to be carbon net zero, some by 2050 or earlier. This allows them to continue to utilize fossil fuels as long as they buy carbon offsets (e.g., planting trees to sequester carbon). This sounds good on paper, like other rule-based approaches, but may be easy to manipulate and could become a paper shuffling exercise.

The 2015 Paris Agreement, signed at COP21, has had mixed results. Some countries have taken it seriously, but global efforts to date are well short of what was promised. A cumulative level of GHG emissions was calculated and remaining budget to accomplish the targets identified. As with any budget where cumulative sums are restricted, each year of limited progress increases the challenge of meeting the overall goal. Many things will have to go right,

²⁴ Saunders, Jim. *Florida Leaders try to tame soaring property-insurance premiums with reform bill*. Orlando Sentinel. April 30, 2021.

<https://www.orlandosentinel.com/business/real-estate/os-bz-property-insurance-changes-florida-20210430-ojpyun2b4dujehxnzrfxuclqg-story.html>

²⁵ Alberts, Mark and Rudolph, Max. *A Low-Growth World: Implications for the Insurance Industry and Pension Plans*. June 2019.

<https://www.soa.org/globalassets/assets/files/resources/research-report/2019/low-growth.pdf>

²⁶ Swiss Re Group. *World Economy set to lose up to 18% GDP from climate change if no action taken*. April 22, 2021 <https://www.swissre.com/media/news-releases/nr-20210422-economics-of-climate-change-risks.html>

²⁷ Taylor, Yesim Sayin. *The carbon tax is not a freebie*. D.C. Policy Center. June 18, 2018. <https://www.dcpolicycenter.org/publications/carbon-tax-impacts/>

both scientifically and politically, for the Paris Agreement to be fully successful, but it has at least moved the discussion in an appropriate direction.

To successfully combat climate change, private capital may have to be diverted from other uses, lowering economic growth and expected returns. In the low growth, low interest rate environment many anticipate, companies may find it more effective in the short-term to use financial engineering to buy back shares rather than take on the risk of investment in new ventures. Resources of time, effort and money that focus on short-term results may not be available for creating value over longer time horizons.

Incentives need to be aligned with the desired results. Encouragement of fossil fuel extraction should be replaced by motives that lead to reduced GHG emissions and carbon capture. The eighth wonder of the world may be compound interest, according to Albert Einstein, but a changing climate is likely to negate this traditional growth engine.

Insurance Companies as Investments

Many climate risks are self-insured, especially those of the most vulnerable socioeconomic classes. Their risks are great, relying financially on help from governments and charities. This section discusses publicly traded insurers, noting that insurers with other governance structures would also be impacted.

In addition to being institutional investors and accepting risks from others as their primary business, many insurers are public companies or owned by their policy holders as mutual companies. Their carbon footprint from operations is similar in many ways to other service companies, providing tactical methods to participate in reducing climate change in addition to their traditional role as a risk aggregator.

Insurers that accept climate risk in their traditional lines of business will lead investors to reevaluate, incorporating how the pricing and product management processes have adapted to determine their intrinsic value. A class action lawsuit could lead to liability insurance claims and policyholder litigation.

Life insurance and annuity businesses are typically managed in a more integrated way between assets and liabilities (using ALM), while property and health forms of insurance focus more on liquidity to manage the interactions due to shorter duration risks. While this will play out more slowly for life insurance and annuity blocks of business, health and property risks are already seeing changes. Mega events, like hurricanes and earthquakes, remain important, but clusters of second-tier events like the 2021 floods in Europe or the deep freeze in Texas are happening more frequently. Intensity of hail, drought, wildfire, snow, flash floods and landslides are also increasing.²⁸ Reinsurers are particularly susceptible to such increases in insured losses as they tend to cover risks that are more severe and solvency threatening to direct writers.

Other financial institutions, including banks, accept similar risks. Financial products like derivatives allow counterparties to use supply and demand to share risk. Loan rates and prices are flexible, adjusting with changes to mitigation and the local environment.

Insurers must balance many complex and interacting risks and opportunities. If they follow strict underwriting guidelines, they run the risk of being shut out of some markets. In contrast, too much leniency could lead to reduced profits and higher solvency risk.

²⁸ Steinberg, Julie. *Insurers Hit by Smaller Perils: Climate change and urban sprawl are leading to more localized events*. Wall Street Journal. July 23, 2021 Pg B10. <https://www.wsj.com/articles/smaller-but-more-frequent-catastrophes-loom-over-insurance-sector-11626959906>

DURATION OF ASSUMPTION STABILITY

An investment that made sense in the past may now put an investor's goals and objectives at risk through loss of principal and increased uncertainty due to environmental factors.

Companies that sell widgets have little concern for matching asset and liability cash flows, but firms with longer time horizons add complexity to the decision of whether to invest. A life insurer provides such an example, as would a defined benefit pension plan.

Pricing of financial products is only sustainable if assumptions are stable over a product's life. A few examples will help to express the concept. A car insurance policy is re-priced every six months, so adding in a slight margin for uncertainty minimizes the risk to the risk owner. A life insurance policy (whole life) issued to parents just starting a family may be expected to remain in force for over 50 years. Will mortality trends reverse their tendency to improve or increase volatility as extreme weather events become more common (risks driven by obesity and alcohol/drug intake are other considerations)? Just as important is the need for investment assumptions to be stable for at least as long as those for liabilities. Interactions between sea level rise, sinking land and overdevelopment of ocean front property will make assumption stability a reasonable question to address in actuarial opinions that extend beyond 10 years.

The southern Florida Surfside condo collapse in June 2021 is encouraging a review of the current protocol of volunteer condominium boards and 40-year safety reviews. Analysts need to revisit rules of thumb, reverting to first principles, as climate change interacts with low economic growth and low interest rates. Investors should regularly monitor assets owned, develop early warning systems (leading indicators) and obtain objective second opinions.

An extended drought will lead to assumption volatility for property, mortality and morbidity product lines. Pensions will be impacted by higher mortality that reduces liabilities, but also by lower return assumptions for investments. The recent shortfalls in funding encourage investors to reach for yield and use leverage make volatile results more likely.

Are there Climate Opportunities?

ESG (Environmental, Social and Governance) style investing is becoming an asset class used in some asset allocation schemes. Passive investors who want the exposure, whether to be socially responsible (with a greater emphasis on ethical guidelines by company) or an asset class with low correlation, have made ETFs (exchange traded funds) and mutual funds with positive ESG ratings very popular.

When a new asset class is developing, demand is initially greater than supply, raising prices. This leads to higher initial returns for favored assets and lower returns for unpopular assets. Investors should recognize that this is a backward looking metric and likely not representative of future returns once a stable level of supply and demand is reached.

Value is said to be found in the eye of the beholder, and there are many books and websites that can help a new investor. There are several versions of the efficient market hypothesis, and ESG as a new asset class may not capture its strong form (where all information is included in the stock price). Investors should be aware of this phenomenon as ESG offerings are ramped up. Greenwashing is a broad category where consumers may be deceived into thinking a product is more environmentally friendly than it actually is. The asset class is defined loosely, and anyone can state that their investment vehicle follows ESG guidelines, so investors should perform ongoing due diligence to confirm that you get what you want and expect. Some ESG funds and ETFs are mislabeled for marketing purposes or include financial instruments that are not "green." Some of these funds are very similar in makeup to a broad index like the S&P 500 or are heavily weighted toward technology. It is important to perform due diligence on funds claiming to be

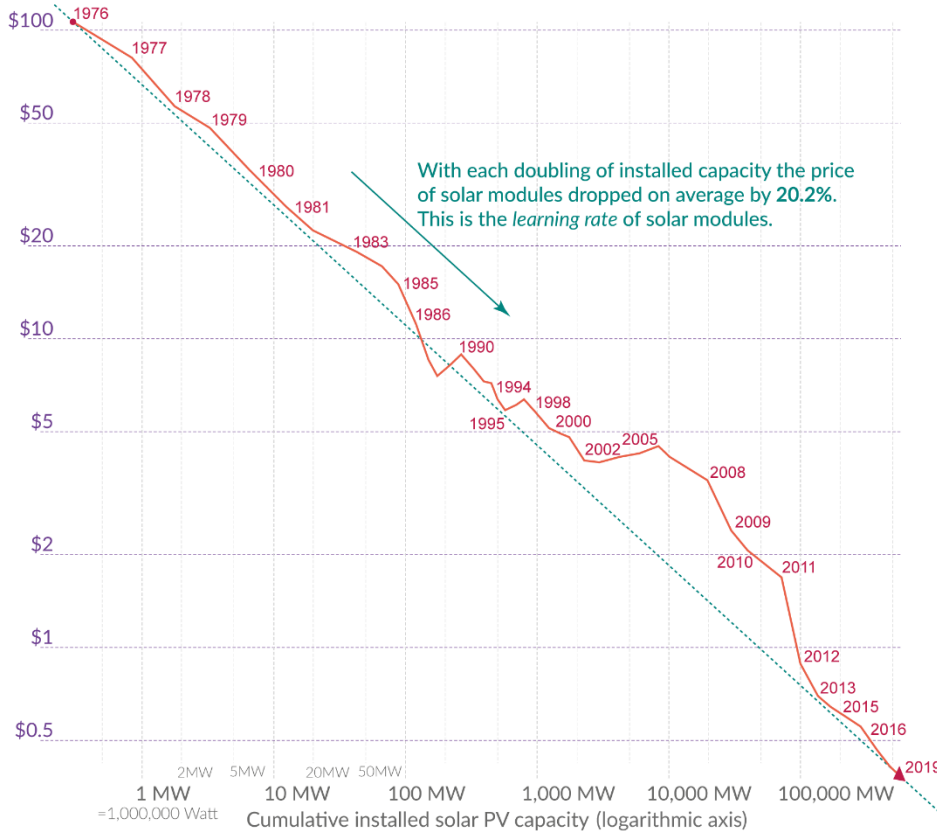
strong proponents of ESG. In 2021 U.S. regulators investigated a Deutsche Bank asset manager for overstating their sustainability claims.²⁹ More cases are likely to follow.

The investor who buys a fund product that becomes tainted will likely endure capital losses. Buyer beware! As an example, renewable energy companies have often started small, as generally happens with new industries. Where profitable they have often relied on subsidies. As has been seen with batteries and other electric vehicle components, the cost per unit is rapidly dropping and there is enough competition that the consumer is getting most of the benefit. What this means for companies is that, even with high growth rates in the number of components sold, revenues and profits grow at much slower rates. There may be little pricing power. As an example, the price of solar modules has steadily declined as shown in the Our World in Data chart reproduced as Figure 2.³⁰ Similar results have occurred throughout the renewable energy industry, reminding one of Moore’s Law, where the number of transistors on an integrated circuit doubles over a relatively short time cycle.

FIGURE 2

The price of solar modules declined by 99.6% since 1976 Our World in Data

Price per Watt of solar photovoltaics (PV) modules (logarithmic axis)
The prices are adjusted for inflation and presented in 2019 US-\$.
OurWorldinData.org



Data: Lafond et al. (2017) and IRENA Database; the reported learning rate is an average over several studies reported by de La Tour et al (2013) in Energy. The rate has remained very similar since then.
OurWorldinData.org – Research and data to make progress against the world’s largest problems. Licensed under CC-BY by the author Max Roser

²⁹ Wall Street Journal. *Regulators Watch Sustainable Investing*. Heard on the Street. August 27, 2021. Page B10. https://www.wsj.com/articles/the-regulators-are-coming-after-sustainable-investing-11629994233?mod=searchresults_pos2&page=1

³⁰ Roser, Max. *Why did renewables become so cheap so fast?* Our World in Data. December 1, 2020. <https://ourworldindata.org/cheap-renewables-growth>

Another opportunity for investors is to build green infrastructure using private capital. Proactive investments can provide solid returns but also reduce future costs to society, leaving everyone better off as renewable energy sources and flood walls become part of planned infrastructure upgrades. Note that some areas may need to be abandoned, creating new cities to become legends like the lost city of Atlantis.

Interactions between existing investments and climate change may have unintended and surprising consequences. As Arctic Sea ice melts, shipping lanes will remain open longer to transport goods through the areas north of North America and Eurasia. Shippers would then have the option to avoid the longer and more time-consuming routes through the Panama Canal or Suez Canal (the recent blockage at Suez highlighted the risks associated with the route) with repercussions for shippers (positive), Canada and Russia (positive except for the ecological damage to coastal regions) and existing shipping lanes (negative).³¹

Investor conundrum

While institutional investors and high net worth individuals can hire consultants to help them divest from fossil fuels, and there are some websites that can help you get started as an individual, current practices vary considerably and make it hard to identify best practices. Some investors are avoiding companies with fossil fuel ties using qualitative means as proxies, for instance using either company reputation, industry sector or specific metrics that identify climate risk investments. Many investors are insisting on numerical rankings and quantitative analysis that may not be credible. Common sense and qualitative analysis may work as an initial filter.

There may be unintended consequences when trying to avoid companies with large carbon footprints. If investors avoid all the companies that have weak environmental practices/scores, especially for new debt issuance, it remains to be seen how regional power generation will proceed. For example, utilities with coal fired plants will need to access capital markets to convert to renewable energy sources and transition away from fossil fuels. Sending a message that these are untouchable investments may cause difficulties and delays. To illustrate, watch for investor reactions to a fossil fuel extractor that buys a renewable energy company. Other industries with so-called sin stocks have similar concerns. For example, asthma drug maker Vectura may become a subsidiary of Philip Morris International, a cigarette maker. Will ESG proponents then drop their Vectura stock or will they encounter other obstacles in their normal business operations?³²

Utilities often have incumbent debt and sunk costs from increasingly uncompetitive coal plants (due to either original or upgraded plants). This discourages utilities from decommissioning the plants and replacing them with renewable sources. This debt could be purchased as part of QE by the Federal Reserve, paid off or reduced through tax or green program incentives.

A potential side effect of avoiding carbon investments would be that no stakeholders would retain share ownership to encourage better ESG practices (e.g., no one would be left to support board proposals that deal with climate issues).

A better way to think of ESG investing is on a continuum. An investor could rank potential investments on an ESG scale and then allocate assets from the most sustainable end of the options until a portfolio has been invested. No

³¹ Piecyk, Adrian. *A Bridge Across Two Oceans: The Arctic Challenge to Panama Canal Shipping*. The Arctic Institute. January 7, 2021.

<https://www.thearcticinstitute.org/bridge-across-two-oceans-arctic-challenge-panama-canal-shipping/>

³² Ryan, Carol. *Philip Morris Gives Investors a Nicotine Test*. Wall Street Journal Heard on the Street. August 13, 2021. <https://www.wsj.com/articles/philip-morris-gives-investors-a-nicotine-test-11628859851>

investment is perfect, and the investor still has a fiduciary responsibility to employer and clients to meet their return objectives.

There is reason to think that a future war will prove particularly harmful to the environment, mainly due to unconstrained use of fossil fuels to conduct fighting and logistical operations. If militaries have not converted to electric vehicles by that time, fossil fuels will become a patriotic investment. This is a very challenging discussion for investors, especially since environmental tipping points are near, but the ability to use long time horizons to consider a variety of positive and negative scenarios can encourage decisions today that will improve results tomorrow.

Disclosures

As climate change becomes ever more certain, information about a company's exposure to climate risks is important for investors to consider. But how can it be done consistently as a systemic change impacting all companies, between companies and within a single company over time? A rules-based approach allows comparisons, but this method has historically been shown to be inadequate in view of many investors for reporting due to creativity of the financial profession. A principles-based approach leaves it to the ethics of the internal financial team, but this has also proven challenging as companies have a continuum of responses to consider, from conservative to aggressive, along with correlations between each pair of assumptions. In general, insolvent companies are hard to identify in advance from an external viewpoint. Many actuaries already know this from traditional practice area work. A helpful feature of the principles-based approach is transparency of methodology, including the choice of scenarios, and assumptions.

Each of the methods described below have both positive and negative features. While not exhaustive, these are the primary protocols currently being discussed by finance professionals. One of the problems with this list is that new entities are being added to it all the time. Each group with a disclosure framework is incented to favor their own platform rather than merge with others. It is hard to keep up, and makes it difficult for companies to comply with everything. There may eventually need to be a consolidation of methods, balancing cost against information gained, for disclosure requirements to be effective.

TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES (TCFD)

The TCFD was created by the Financial Stability Board (FSB), a group of international government regulators with a mandate to promote financial stability.³³ The TCFD recommendations are a voluntary set of disclosures designed to apply peer pressure to companies seeking to use the investment and insurance markets. By providing consistency and transparency, the TCFD appears to choose principles over rules, but letting the market decide means it is easier to update to current practices.

INSURANCE COMPANIES

One group the TCFD hopes will seek out climate risk disclosure is property insurers. If all insurers scan consistent information from those looking to insure a property this will provide an incentive for other companies to align with this voluntary regulation.

³³ Rudolph, Max. *What is the Task Force on Climate-related financial disclosures?* The Actuary magazine. October 2020. <https://theactuarymagazine.org/what-is-the-task-force-on-climate-related-financial-disclosures/>

Both insurers writing all types of business and pension plans are coming under additional pressure as institutional investors to deny access to capital markets for fossil fuel based companies as well as other firms that are not judged to be environmentally friendly. In a period of low economic growth prospects and low interest rates, with significant environmental risks, this shrinks the number of potential investments and makes meeting return objectives more challenging. This represents a balancing act for all investors ; those putting pressure on insurers to stop investing in bonds by oil firms rarely understand the impact it could have on their personal pension plan.

INSTITUTIONAL INVESTORS AND FINANCIAL INSTITUTIONS

Companies interested in accessing the public/private debt or equity markets can disclose their carbon footprint in a transparent fashion using TCFD. If investors refrain from financing companies that do not participate this will make it difficult for those companies to access the capital markets.

TRANSPARENCY AND CONSISTENCY

It is very difficult for analysts, regulators and quasi-regulators like ratings agencies to obtain the big picture for risk without comparable results to consider from each entity. For the same reason some regulators require specific deterministic scenarios to be modeled, here specific information about practices is used for ESG investors to identify good practices. A slightly different view is captured by the Transparency 100 Index, with certain sectors avoided and including companies that have adopted transparency standards.³⁴

DECISION MAKING

Key decision makers, both internal and external to a company, can use TCFD disclosures as part of their process. A financial institution may find TCFD reporting useful for examples like the following.³⁵

- A risk officer may review the impact of a carbon tax on the credit risk of their loan portfolio
- An investment officer may seek to align internal climate risk goals by trending risk exposures
- A portfolio manager can screen for climate risk in potential investments
- An investor relations manager can publish a TCFD report to publicly assess internal risk exposures to climate risk
- A sustainability manager can quantitatively assess its carbon footprint
- A purchasing manager can assess physical climate risk in its supply chain
- A finance director can perform a risk assessment of proposed carbon regulations

TASK FORCE ON NATURE-RELATED FINANCIAL DISCLOSURES (TNFD)³⁶

Still in its formative stage at the time this was written, the TNFD framework plans to focus on biodiversity and plans to work with existing standards bodies to avoid redundancy. It is backed by a consortium of companies, governments, non-government organizations (NGO), and is supported by the United Nations Environment Programme Finance Initiative. It expects recommendations consistent with existing frameworks and standards, including GRI (Global Reporting Initiative, used in the Climate Disclosure Standards Board (CDSB) Framework), SASB (Sustainability Accounting Standards Board) and the IFRS (International Financial Reporting Standards) Sustainability Board.

³⁴ https://transparencyinvest.com/transparency-index/?modtag=djemBestOfTheWeb&mod=djem_b_Feature_912021%2064841%20AM

³⁵ SPG Global. *Seven Ways to Inform Better Decisions with TCFD Reporting*. September 2020.

<https://www.spglobal.com/marketintelligence/en/documents/sp-tcf-use-cases-final.pdf>

³⁶ Task Force on Nature-related Financial Disclosures. <https://tnfd.info/>

UN PRINCIPLES FOR RESPONSIBLE INVESTMENT (PRI)³⁷

While the regulatory based groups discussed earlier utilize mostly voluntary measures (at least for now), PRI relies on a framework that an investor signs up for (with a cost) and is tested against. Once an investor becomes a signatory their results become transparent to the public, so there is an incentive to follow through on pledges.

OTHER GROUPS

There are a number of other groups that may be worth monitoring for future sustainability standards. They include:

- NGFS (Network of Central Banks and Supervisors for Greening the Financial System): this group makes recommendations to regulators (The New York Department of Financial Services is a member)
- SIF (Sustainable Insurance Forum): a group of insurance supervisors concerned with climate risks.
- CFRF (Climate Financial Risk Forum): associated with the Bank of England
- Group Net-Zero Insurance Alliance: part of the UN Environment Programme Finance Initiative's Principles for Sustainable Insurance, with a goal to transition underwriting portfolios to net-zero greenhouse gas emissions by 2050
- Net-Zero Asset Owner Alliance: a group of institutional investors concerned with climate risks.
- CDP (formerly the Carbon Disclosure Project): annual questionnaire.

At least one group, the Value Reporting Foundation's Integrated Reporting Framework, has a goal of aligning financial reporting through transparency and consistency between countries to support all of these other initiatives.

REGULATORY

Regulators seem hopeful that other bodies will develop frameworks they can align with, but many have initiated their own task forces in case those efforts come up short. For institutional investors and insurers these groups include the International Association of Insurance Supervisors (IAIS), Sustainable Insurance Forum (SIF), the Bank of England, National Association of Insurance Commissioners (NAIC), the Office of the Superintendent of Financial Institutions (OSFI) and the European Insurance and Occupational Pension Authorities (EIOPA). As this is a fast-moving topic, it is best to monitor your specific regulatory regime for climate-related initiatives. One recent synopsis of international perspectives on climate risk assessment was developed by the Geneva Association and is a nice summary.³⁸ The Securities and Exchange Commission in the United States, along with provincial securities commissions in Canada and counterparts globally, have also expressed interest in sustainability disclosures.

NEW YORK

In North America the state of New York, through its Department of Financial Services, provides a good example of where U.S. regulation may go.³⁹ They issued a circular letter (#15) in 2020 that provides background as well as a

³⁷ <https://www.unpri.org/>

³⁸ The Geneva Association. *Insurance Industry Perspectives on Regulatory Approaches to Climate Risk Assessment*. June 2021.

<https://www.genevaassociation.org/research-topics/climate-change-and-emerging-environmental-topics/insurance-industry-perspectives-regulatory>

³⁹ Financial Risks from Climate Change. New York State Department of Financial Services. www.Dfs.ny.gov/industry_guidance/climate_change

resource list. Note that this occurred during the period when the U.S. had declared its intention to withdraw from the 2015 Paris Agreement, so coordination with federal climate risk management may have changed since then.

New York notes that company climate efforts should consider effects on disadvantaged communities, which greatly broadens a disclosure initiative. They continue to solicit feedback and are expected to provide more extensive methodology going forward.

NATIONAL ASSOCIATION OF INSURANCE COMMISSIONERS (NAIC)

The NAIC Climate Risk Disclosure Survey has been required for some insurers since 2011 when California began a recurring survey. It provides standardized responses from companies that can be compared over time, but remains a series of self-reported metrics. Recently the NAIC has allowed companies to submit a TCFD report instead, and several companies have chosen to do so.

Bureaucracy Concerns

As TCFD and other initiatives become informal requirements, companies are likely to push back if the information provided is not aligned and becomes a bureaucratic checklist.

As an example, at the 2021 (virtual) shareholder meeting for Berkshire Hathaway, Warren Buffett was asked about climate risk. While not known as a climate friendly company, Berkshire Hathaway is a conglomerate that has made strides in many of its subsidiaries to become more climate friendly. For example, it has publicly discussed that it is developing electric vehicle (EV) locomotives, is involved with EV shuttle buses,⁴⁰ and its utilities have invested in renewables and are well on their way to building an updated electric grid to carry energy created by renewables to urban centers at an expected cost of \$18 billion. Absent any disclosure requirements, according to Buffett, this information has been publicly available for those who invested the time to look for it. Buffett expressed concern that additional disclosure requirements were being added and analysts had not seemed to look very hard for material that was already publicly available.

Scenarios

While stochastic simulations of climate risk can be useful for some purposes, the mathematics and computer intensity are too difficult, and firms lack in-house expertise, at this time for individual companies. However, relevant deterministic scenarios can be identified and used to approximate possible outcomes.⁴¹ The most commonly used scenario set was developed by the International Panel on Climate Change (IPCC),⁴² now nearing the end of its sixth cycle. During the fifth cycle (ending in 2014) four scenarios, covering a broad range of results, were provided. In the current cycle an economic narrative has been added, along with a fifth scenario.⁴³ The scenarios used in the fifth

⁴⁰ Morris, Charles. *Lightning eMotors and Forest River partner to deploy up to 7,500 electric shuttle buses*. Charged: Electric Vehicles Magazine. August 17, 2021. <https://chargedevs.com/newswire/lightning-emotors-and-forest-river-partner-to-deploy-up-to-7500-electric-shuttle-buses/>

⁴¹ Canadian Institute of Actuaries. *Public Statement: Time to Act: Facing the Risks of a Changing Climate*. September 2019. <https://www.cia-ica.ca/docs/default-source/2019/219104e.pdf>

⁴² <https://www.ipcc.ch>

⁴³ IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press. August 2021. <https://www.ipcc.ch/report/ar6/wg1/>

cycle are described in an earlier paper from this series.⁴⁴ For many individual assets the scenarios can be “personalized.” For example, a property purchased near Miami, Florida can access sea level estimates by year under each scenario for the life of the asset and also consider expected conditions for temperature (daytime highs and night-time lows), expected public services (will drinking water be contaminated) and other risks that vary with the climate. What should you pay for a vacation home that is expected to have no value in 2100? Would you provide a 30-year mortgage on the property?

Complexity – it’s not easy being green⁴⁵

Investments can take many forms. The analysis can be complicated, as many seemingly unrelated factors may interact in unexpected ways. For example, an individual may currently be considering the purchase of an electric vehicle. The analysis isn’t as straightforward as a typical cost-benefit analysis when including the environmental impact. A new car needs to be built, so the climate impact decision might differ if this is an additional vehicle for your family or a replacement for a gasoline powered car sold in the secondary market. The new car may be heavier than the old one, due to the large battery, so roads may need to be upgraded. Cement production is one of the worst emitters of GHG emissions. Other considerations include how electricity in your area is generated (coal bad, renewable good), along with the source of elements like cobalt, lithium and rare earths used in the vehicle. Those interested in specific comparisons of new vehicles, both GHG emissions and expected monthly cost, can utilize a tool developed by the MIT Trancik Lab found at <https://www.carboncounter.com/#!/explore>. Decisions are complex, but knowledge of the issues makes a better consumer.

Conclusion

Climate risk may be the most important consideration for both investment and long duration liability strategy over the next 50 years. It is imperative that investors understand how that fits into their tool kit, especially as certainty of assumptions moves to shorter time horizons. By modifying product designs, increasing discount rates, adding charges or extracting fees, an investor can develop techniques that account for the additional risk or opportunity and improve decision making.

In view of the many climate change impacts stated in the report, the reader could conclude that our time-honored myopic and siloed habits and pursuit of economic growth must be revisited to ensure future prosperity. The debit-credit accounting methodology ignores indirect costs and benefits, assessing no charge for resource depletion or environmental impacts. GDP growth rates have surged since the beginning of the industrial revolution. This resource exploitation has created a debt that needs to be repaid. This will make it challenging for investors going forward, but there are growth opportunities in infrastructure and services that are part of the solution. Transparent disclosures and consistent reporting will help. A transition is inevitable, but an alert investor with a long time horizon will improve relative performance.

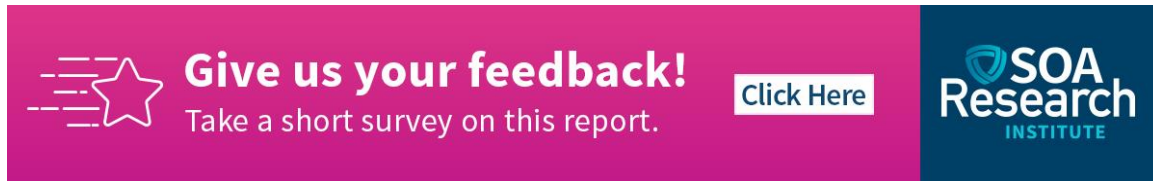
Resources spent on short term results and growth are not available for real long-term value creation from financial and ESG perspectives. Investors should invest in financial instruments and companies that create long term social benefits, rather than focusing on financial engineering and other methods that focus primarily on short term results.


⁴⁴ Rudolph, Max J. *Integrated Assessment Models*. Society of Actuaries. June 2021. www.soa.org/globalassets/assets/files/resources/research-report/2021/integrated-assessment.pdf

⁴⁵ With apologies to Kermit the Frog and Sesame Street


Many risks are changing, and they all interact. Climate change is a threat multiplier. Investors must maintain their focus on long time horizons and scan for emerging risks. Ignoring this plea will result in non-optimal decision making and perhaps have solvency implications.

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