Climate Risk and Investments

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Introduction

With emerging regulations and evolving investor requirements, financial institutions such as insurers are increasingly expected to identify, measure, assess and manage climate risks. These expectations apply not only to an insurer's liabilities and products, but also to its assets – the investment portfolio. Actuaries have a vital role to play in this process, whether it be for modeling asset cash flows in certain climate scenarios, assessing risks posed by climate change or optimizing portfolios to be resilient to climate risks.

This article will discuss how financial professionals can identify climate risks in the investment portfolio. We will discuss methods to measure and assess climate risks in the investment portfolio, for both transition and physical risks. We will also discuss how climate risks can be integrated into the investment process to mitigate and manage potential financial impacts. Lastly, we will touch on decarbonization programs, such as Net Zero, and their challenges.

Background

Climate risks can be broadly categorized into two main types: **physical risks** and **transition risks**.

Physical risks arise from direct environmental changes, such as extreme weather events, rising sea levels, and shifts in precipitation patterns. These risks can lead to asset damage, supply chain disruptions, and increased operational costs for businesses. For instance, hurricanes and floods can devastate infrastructure, while prolonged droughts threaten agricultural productivity.

Transition risks, on the other hand, stem from the economic and policy shifts required to transition to a low-carbon economy. A "low carbon economy" refers to an economic system that aims to significantly reduce greenhouse gas emissions, primarily by transitioning to cleaner energy sources like renewables, while still maintaining economic growth, essentially decoupling economic activity from carbon emissions. The risks associated with the transition include changes in policy and regulations (political risks), technological advancements, and market preferences. Governments worldwide are implementing policies to reduce greenhouse gas emissions, such as carbon pricing, renewable energy incentives, and stricter emissions standards.

Another category of climate risks, which are not covered in this article, are climate liability risks, which are legal risks that arise when companies are sued for contributing to climate change. People and businesses can sue companies for damages caused by climate change, such as flooding or wildfires. These risks can affect a company's reputation and finances.

Physical Risks

Physical risks, driven by climate change and natural disasters, pose significant challenges to investment portfolios. These risks arise from acute events like hurricanes and floods, as well as chronic changes such as rising sea levels and increasing temperatures. Identifying, measuring, and assessing physical risks is crucial for investors to safeguard portfolio value and enhance resilience.

BACKGROUND

Physical risks refer to the direct impacts of environmental changes on assets and operations. These risks can be categorized into acute and chronic types:

1. **Acute Risks**: Sudden and severe events such as **hurricanes, floods, wildfires, and heatwaves**. These events can cause immediate damage to properties and infrastructure, disrupt business operations, and lead to significant financial losses.
2. **Chronic Risks**: Gradual changes in climate, including **rising temperatures, sea-level rise**, and prolonged **droughts**. These changes can reduce the long-term viability of assets, particularly in vulnerable regions.

The financial sector is increasingly exposed to physical risks through various channels:

1. **Real Estate and Infrastructure**: Properties and assets in high climate risk areas are at risk of devaluation. Infrastructure assets, such as roads, bridges, and power plants, may require costly repairs or replacements due to climate impacts.
2. **Supply Chains**: Extreme weather events can disrupt global supply chains, leading to production delays and increased costs for businesses. For example, flooding can damage transportation networks, while droughts can impact agricultural yields.

3. **Business Interruption**: Companies directly impacted by physical risks may experience reduced revenues, increased operating costs, and reputational damage. This can negatively affect stock prices and investor returns.
4. **Insurance Industry**: Insurers face rising claims from natural disasters, necessitating adjustments in premiums and coverage terms. This can affect the affordability and availability of insurance for businesses and individuals.

RISK IDENTIFICATION

The first step in managing physical risks is to identify their potential sources and impacts. It is generally understood that acute physical risks that exist today will become more volatile with climate change[1]. To understand where the vulnerabilities may exist for acute physical risks, **historical data analysis** is valuable. By reviewing past events, such as hurricanes or droughts, and their impacts on businesses and assets, investors can gauge potential future vulnerabilities. For example, when evaluating a real estate investment, an investor can assess potential flood risks by analyzing historical occurrences and damages from these events to inform go-forward probabilities and financial impacts. Additionally, industry-specific risk assessments help identify how specific physical risks impact particular sectors, such as agriculture's vulnerability to drought or real estate's exposure to flooding.

In understanding physical risks, an essential component of analysis is **geographic exposure mapping**. By analyzing the geographic locations of assets, investors can identify areas prone to natural disasters such as coastal zones, floodplains, or wildfire-prone regions. Tools like Geographic Information Systems (GIS) are particularly useful for overlaying asset locations with hazard maps, enabling precise risk identification. For example, investors can visually assess the proximity of an asset to nearby water systems to gauge flood risks or unmanaged forests to assess wildfire risks.

RISK MEASUREMENT

Once risks are identified, quantifying their potential impact is essential. **Quantitative modeling** is a key technique that estimates financial impacts of physical risks on portfolio returns. For example, models can simulate the cost of damages or the effect of disrupted supply chains due to extreme weather. **Climate data analytics** plays a vital role in this process. By leveraging meteorological and climate datasets, investors can assess historical and projected risks. For instance, analyzing temperature trends can reveal potential heatwave impacts, while rainfall patterns can indicate flood risks.[2]

Another essential tool is **scenario analysis**, which involves using plausible climate or disaster scenarios to anticipate risks[3]. For instance, investors can leverage scenarios from the Intergovernmental Panel on Climate Change (IPCC) to evaluate the likelihood and impact of extreme weather events[4]. Scenario analysis is useful not only for estimating the degree of increase in acute physical risks over time, but also in modelling impacts from chronic physical risks which may not have relevant historical data. A commonly used scenario is the RCP[5] 8.5, which simulates unabated growth in emissions and resulting climate conditions that is 4.3ºC degrees warmer by 2100[6]. Under these conditions,

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[1] IPCC Sixth Assessment Report (2021)
[2] NOAA (National Oceanic and Atmospheric Administration). (2024). *Heat stress datasets and documentation*
[3] Many academic, non-governmental and inter-governmental organizations have proposed various climate scenarios that can be leveraged by investors.
[4] IPCC Sixth Assessment Report (2021)
[5] One set of commonly used climate scenarios has been developed by the Intergovernmental Panel on Climate Change (IPCC), each of which reflects a different set of scenario-specific factors, including population growth, mean and extreme temperatures, precipitation, wind speeds, and sea level rise. They developed four primary Representative Concentration Pathways (RCPs), RCP8.5, 6.0, 4.5, and 2.6, corresponding to 3.4ºC, 2.8ºC, 2.4ºC, and 2.0ºC above preindustrial global temperature levels.
[6] IPCC Sixth Assessment Report (2021)

extreme weather events, such as hurricanes and floods, increase in frequency and intensity, resulting in commensurate financial impacts. Practitioners often aggregate the financial impacts from scenario analysis into a single potential loss metric called Climate-Value-at-Risk, or CVaR[7].

An emerging area of scenario analysis is to assess the impact to **insurance costs**. This approach allows investors to examine whether companies or assets can continue to have adequate insurance coverage for physical risks, as well as their impacts to expected returns.

RISK ASSESSMENT

Assessing physical risks involves understanding their broader implications for the portfolio. **Portfolio-wide aggregation** analyzes how individual risks accumulate across the portfolio, revealing systemic vulnerabilities. For example, concentrated exposure to coastal real estate may significantly amplify overall portfolio risk.

Stress testing is a critical method to assess resilience. By simulating extreme but plausible events, such as a category 5 hurricane, investors can evaluate how portfolios would perform under high-stress conditions[8]. **Sectoral and regional assessments** further refine this analysis by highlighting risks specific to industries or geographic areas.

An important aspect to consider in risk assessment is time horizon. Physical risks, or the expected financial impacts due to climate change are expected to be more pronounced over the longer-term time horizon. Although we can witness or experience extreme weather events today, as we always have, the increase in the impact due to climate change is increasing gradually, across multiple decades. Therefore, the assessment of risks should consider the holding period of the assets in question. For example, a one-year treasury bond will likely not be impacted by climate change, while a real estate or infrastructure asset that is expected to be held for 20 years should be closely analyzed for potential climate risk impacts.

RISK MITIGATION AND MANAGEMENT

To manage physical risks effectively, investors can adopt various mitigation and adaptation strategies. One key approach is **diversification**, which reduces concentrated exposure to risk-prone areas or industries. For example, balancing investments across regions with varying climate vulnerabilities can enhance resilience[9].

Insurance optimization ensures that companies or assets have sufficient coverage against physical risks. Investors can purchase comprehensive insurance coverage to mitigate financial losses from physical risks. This includes property insurance, business interruption insurance, and catastrophe bonds.

Investors can also encourage portfolio companies to adopt comprehensive **climate resilience and adaptation** measures, such as flood defenses or heat-resistant infrastructure.[10]

Lastly, **hedging strategies** provide financial protection against physical risks. Instruments like catastrophe bonds or weather derivatives can offset potential losses.

[7] We should take care to differentiate CVaR, which is a deterministic metric, from Conditional Value at Risk (CVaR) or Value at Risk (VaR), which are stochastic measures of potential loss.
[8] Bank of England's Climate Biennial Exploratory Scenario (CBES)
[9] World Bank, Enabling Private Investment in Climate Adaptation and Resilience, 2022
[10] Munich Re, https://www.munichre.com/en/risks/climate-change.html

Transition Risks

Transition risks, arising from the global shift toward a low-carbon economy, represent critical factors for investors to consider in managing their portfolios. These risks stem from regulatory changes, technological advancements, evolving market trends, and reputational challenges. Identifying, measuring, and assessing these risks are essential to protect portfolio value and align investments with sustainability goals. This article outlines key techniques to address transition risks effectively.

BACKGROUND

The global energy landscape is undergoing a transformative shift as the world transitions from fossil fuels to sustainable energy sources[11]. This transition is not always smooth, as policy uncertainties and geopolitical dynamics introduce volatility in its progress. The energy transition, driven by environmental concerns, technological advancements, and policy imperatives, presents both challenges and opportunities for investors.

Several interrelated factors are propelling the energy transition:

1. Climate Change and Environmental Concerns: Rising greenhouse gas (GHG) emissions have heightened global awareness of climate change and its impacts. Governments, organizations, and consumers are increasingly demanding clean energy solutions to mitigate global warming and environmental degradation.
2. Technological Advancements: Breakthroughs in renewable energy technologies, energy storage, and grid modernization have made clean energy sources more efficient and cost-competitive. Solar photovoltaics, wind turbines, and battery storage systems are prime examples of innovations driving the transition.
3. Policy and Regulation: International agreements, such as the Paris Agreement, have set ambitious targets for reducing carbon emissions. National policies, including subsidies for renewables, carbon pricing, and incentives for electric vehicles, further support the transition.
4. Market Dynamics and Consumer Demand: Growing consumer awareness and demand for sustainable products can shift market preferences toward renewable energy and energy-efficient solutions. However, consumers may still opt for cheaper products at the end of the day, regardless of their carbon footprint. Corporate commitments to net-zero goals are also reshaping energy demand.

The energy transition can have significant implications for investment strategies, as it reshapes traditional energy markets and creates new opportunities in emerging sectors. Under idealized transition scenarios, fossil fuel-based industries, such as coal and oil, are expected to face declining demand, while renewable energy sectors experience exponential growth.

RISK IDENTIFICATION

The first step in managing transition risks is to identify their potential sources and implications. One essential technique is policy and regulation analysis, which involves monitoring evolving climate policies such as carbon pricing, emissions reduction targets, and energy efficiency standards. This analysis helps investors determine industries and assets most exposed to regulatory shifts, such as energy, transportation, and heavy industry. A recent example is the European Union enacting the Carbon Boarder Adjustment Mechanism (“CBAM”), a policy that taxes imported goods based on their carbon emissions. In effect, companies exporting goods to Europe are essentially

[11] International Renewable Energy Agency (2020). Global renewables outlook: Energy transformation 2050.

penalized for the carbon footprint of their production processes, and this impact was particularly acute for emerging market countries where fossil fuels dominate as a source of energy.

Another important approach is evaluating **market trends and consumer behavior**. Changing consumer preferences for sustainable products and services—such as electric vehicles or renewable energy—can significantly impact demand patterns, affecting company revenues and growth prospects[12]. Additionally, **technological advancements** must be examined to assess potential disruptions from emerging low-carbon technologies, such as green hydrogen and battery storage, which may challenge existing business models[13].

Industry and sector risk profiling is another crucial method. This approach identifies industries vulnerable to shifts in demand or increased costs due to transition risks, such as fossil fuel-dependent sectors or high-emission manufacturing industries. Many energy-intensive industries, such as steel production, mining, and electric utilities, are subject to these types of risks, although careful analysis of regulatory protections and supply/demand dynamics must be considered before reaching any conclusions.

Finally, investors must consider **reputation and social license risks**, which arise from stakeholder expectations and public sentiment around sustainability. Negative perceptions can harm company brands and reduce access to financing. But, again, perceptions can be arbitrary and inconsistent. Many consumers may continue to put price and availability ahead of climate impact in a company's business practices.

RISK MEASUREMENT

Measuring transition risks requires quantitative and qualitative methods to estimate their financial impact. One key metric is **carbon intensity**, which measures the carbon footprint of portfolio holdings, including Scope 1, 2, and 3 emissions relative to the size of the business[14]. This analysis identifies high-emission assets that may face higher transition-related costs. To walk through an example, consider a coal power plant that generates 3.5 billion kilowatt-hours of electricity per year, which translates to about $600M in annual revenue. To generate this amount of energy, the power plant will burn 7.6M tons of coal, generating 15.2M tons of CO_2. By dividing the asset's annual carbon emissions by its revenue (per $1M), the revenue-based carbon intensity of the coal power plant is around 25,000. In other words, this asset generates 25,000 tons of CO_2 for every $1M of revenue generated. This metric can be used to compare against other assets that may be more or less efficient in how much carbon is emitted to generate a dollar of revenue.

Scenario analysis is another powerful tool. By using models, such as the International Energy Agency's Net-Zero Emissions Scenario (NZE) or IPCC pathways, investors can estimate financial impacts under various transition scenarios, such as rapid decarbonization or delayed policy action[15]. Typically, many investors apply scenario analysis in conjunction with understanding a company's **exposure to carbon pricing.** This analysis evaluates how carbon taxes or emissions trading schemes might affect operating costs and profit margins if any of the climate scenarios were to be realized. Using the example from above, an investor can simulate how much in carbon taxes the coal power plant would need to pay if the government were to impose a tax of $10 for each ton of carbon emitted. The total carbon tax would be equal to $10 times 15.2M tons, which is $150M per annum. Against a revenue of $600M, the result of the scenario analysis would suggest the power plant's revenues net of tax would be $450M per annum and, depending on other fixed and input costs, this may render the asset unviable.

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[12] McKinsey, *Consumers care about sustainability—and back it up with their wallets*, February 2023
[13] International Renewable Energy Agency (IRENA)
[14] Greenhouse Gas Protocol
[15] IEA World Energy Outlook

Similar to the use case with physical risks, the financial impacts under climate scenarios can be summarized into a metric called **Climate Value-at-Risk (CVaR)**.

RISK ASSESSMENT

Once risks are measured, assessing their broader implications is crucial. **Portfolio-wide exposure assessment** analyzes the percentage of portfolio assets exposed to high transition risks, such as fossil fuel companies or heavy emitters[16]. This assessment can be complemented by **sector and geography analyses**, which evaluates transition risks at both sectoral and regional levels, recognizing that different regions face varying policy and economic pressures.

A key element of risk assessment for transition risks is to be mindful of the **probabilities** associated with the scenarios. While the types of risk measurements described above can provide insight to the potential financial impact under various climate transition scenarios, investors need to be mindful of the likelihood that these scenarios will be realized. It is the consensus among practitioners that there is a very low likelihood of the world reaching zero carbon emissions by 2050.

Another important aspect of assessing transition risk is the business models of companies that may be vulnerable to regulatory changes such as carbon pricing. Many companies can pass on increased costs to their customers, which can mitigate the financial impact.

RISK MITIGATION AND MANAGEMENT

To manage transition risks, investors can adopt various strategies. It is important to note that the task of analyzing transition risk overlaps with the type of work performed by research analysts and portfolio managers in active investment portfolios. Analyzing elements, such as **policy, regulation, market trends, consumer behavior, and technology,** and incorporating views about each into financial modelling is what investment practitioners call **fundamental analysis**. This type of research is the backbone of the active management industry, including the management of insurance company balance sheets.

Another approach to managing transition risks is **portfolio decarbonization**, which involves gradually shifting investments toward lower-emission or carbon-neutral assets, such as renewable energy and green bonds. In many instances, portfolio-rebalancing programs towards lower carbons are called **Net Zero investing**, which refers to the practice of structuring investments to achieve a balance between the greenhouse gases emitted and those removed from the atmosphere, ultimately contributing to global carbon neutrality by mid-century.

An important note: the discussion of climate risks in this paper has been framed under "single materiality," which is to focus on the risks that may impact the value of the portfolio. However, some investors may have the license (through government directive, regulations or stakeholder approval) to approach the topic under "double materiality," where investors seek to manage the risks generated by the investments to the broader society and the environment. Most Net Zero programs around the world are framed under double materiality, and their primary objective is to mitigate the impact the investment portfolio has on the climate. If an investor were to pursue decarbonization or Net Zero to manage investment risks stemming from transition risks, it should be accompanied by an investment view that the world is on a trajectory towards a lower carbon economy.

[16] PACTA (Paris Agreement Capital Transition Assessment) reports

Investors willing to take additional risks by taking a stronger view on the energy transition can invest in sectors that are likely to benefit positively in a lower-carbon economy:

1. **Renewable Energy**: Solar, wind, hydroelectric, and geothermal energy are at the forefront of the transition. These technologies benefit from declining costs, technological improvements, and supportive policies. Renewable energy projects also provide stable, long-term returns, making them attractive to institutional investors[17].
2. **Energy Storage**: Advanced battery technologies, such as lithium-ion and solid-state batteries, are critical for addressing the intermittency of renewables. Investments in energy storage enable grid stability and facilitate the integration of clean energy sources.
3. **Electric Mobility**: The electrification of transportation is a major component of the energy transition. Investments in EV manufacturers, charging infrastructure, and battery supply chains are growing rapidly, driven by consumer adoption and government mandates[18].
4. **Green Hydrogen**: As a versatile and low-carbon energy carrier, green hydrogen has significant potential in industries like heavy transportation, steel production, and energy storage. Although still in its nascent stages, green hydrogen is attracting substantial investment.
5. **Energy Efficiency and Smart Grids**: Improving energy efficiency in buildings, industrial processes, and appliances is a cost-effective way to reduce emissions. Smart grid technologies, including digital monitoring and demand response systems, enhance the reliability and efficiency of energy networks.

Despite the opportunities, investing thematically in these sectors can present challenges.

1. **Policy Uncertainty**: Inconsistent or unclear policies, or political risks generally, can hinder investment in clean energy projects.
2. **Capital Intensity**: Many renewable energy and infrastructure projects require substantial upfront investment. Mobilizing sufficient capital, particularly in emerging markets, remains a challenge.
3. **Technological Risks**: Rapid innovation in the energy sector can render certain technologies obsolete, posing risks to early-stage investments.
4. **Market Volatility**: Fluctuations in energy prices, driven by geopolitical tensions or market dynamics, can positively impact the profitability of incumbent energy sectors. Changes, and even reversals in government policy, can also lead to market volatility.

Summary

Climate change poses one of the most significant challenges of the 21st century, affecting ecosystems, societies, and economies globally. For investors, the financial implications of climate change are multifaceted, presenting both risks and opportunities. As climate risks intensify, investment strategies must adapt to account for physical risks, transition risks, and regulatory shifts.

[17] Lazard. (2022). *Levelized cost of energy analysis 2022.* Retrieved from https://www.lazard.com
[18] International Energy Agency. (2021). Global EV outlook 2021.

About The Society of Actuaries Research Institute

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