ROBECO
The Investment Engineers

ROBECO INSTITUTIONAL ASSET MANAGEMENT

Navigating the climate transition:

Forward-looking climate analytics and scenario stress testing (part 2)

December 2023

Navigating the climate transition

Part 2: Climate scenario stress testing

Foreword

There is robust scientific evidence that the global climate has been changing due to human activity, primarily through the usage of fossil fuels and land-use changes. Global warming, if unmitigated, will have unacceptable impacts on society and the global economy. It is clear that society has to act now, as the costs and impact of inaction increase by the year.

Robeco acknowledges the responsibility of the asset management industry to manage climate change risks, opportunities and impacts. Climate change poses material risks and opportunities for our clients' investment portfolios, and it is our fiduciary duty to identify and manage these. Working in partnership with our clients, Robeco aspires to take a leading role in contributing towards a net zero economy. We firmly believe this will create opportunities to enhance long-term risk-adjusted returns.

As investment engineers, Robeco seeks to continuously innovate its investment approach, integrating new research and data as it becomes available. This holds true in particular for climate analytics. To navigate the transition to net zero by 2050, we need forward-looking models to help make well-informed investment decisions which incorporate not only historical performance but also transition plans, risks and opportunities.

Furthermore, the impacts from climate risks are yet uncertain, complex, and subjective. To tackle these challenges, Robeco applies qualitative assessment on top of quantitative techniques to minimize the gap between model results and real-world outcomes. This Part 2 document outlines our approach to tackle these challenges in climate scenario stress-testing and we share our insights into the implications for different sectors and asset classes.

In Part 1, published separately, we explain the different metrics used in forward-looking climate analytics and how they complement each other for making a comprehensive assessment of climate transition risks, opportunities, and impacts.

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For more information on our approach to climate change for countries please see our Country Sustainability Ranking and Country Sustainability Development Goals (SDG) frameworks.

Contents

1. Introduction

Climate risk poses a significant threat to physical assets and transition shifts and therefore can have implications for financial returns. While transition risks are significant in the short-to-medium term, it is the cumulative effects of physical risks that pose the most substantial threat.

As global warming accelerates, the physical impacts from climate change, such as rising sea levels, extreme weather events, and changing precipitation patterns, are becoming increasingly severe both in terms of frequency and intensity. Therefore, understanding and effectively mitigating climate risk is crucial to ensuring sustainable and resilient financial returns.

Despite the fact climate risk is no longer a novelty, its impacts are yet unclear. This is why we use a combination of climate analytics tools and processes in our risk management framework. Combined, they provide a well-rounded view of how climate change may impact companies, portfolios, and entities. In practice, there are five tools available to manage climate risks at Robeco:

- Reduction of carbon footprint versus a benchmark and base year
- Forward-looking analysis of transition-readiness of companies
- Company engagement and voting policy
- Climate risk scenarios and temperature alignment tools
- Proprietary transition climate score model at company level

Climate risk scenarios are one of the best tools for assessing potential losses of portfolios. The complexity around the topic requires organizations to use both top-down and bottom-up approaches because even within the most sustainable sectors, company selection is important to mitigate climate risks and benefit from opportunities.

To avoid tunnel vision and dependency on only one model or metric, Robeco uses several climate scenario models with different assumptions. Furthermore, they should not be the only tool to assess risks and impacts. The results should be used in combination with qualitative assessments and other metrics such as ESG ratings, carbon emissions data and forward-looking climate analytics.

Due to its unprecedented nature, knowledge about climate change must continue to evolve. Currently, it is surrounded by a high degree of uncertainty involving multiple layers of assumptions and a wide variety of underlying data. Additionally, physical risks have a long-term impact. For this reason the scenarios are continuously calibrated with qualitative inputs to minimize estimation errors and reflect the latest research findings and available model improvements.

In this paper, we explain how Robeco tackles the challenges around climate risk identification, measurement, and monitoring.

2. Climate risk

Climate risk is defined as the range of negative or positive consequences, responses, or impacts on society, businesses, economies, and nature, resulting from global warming. It can be split into two groups: (1) risks and opportunities associated with the transition to a lower-carbon economy and (2) risks linked to the physical impacts of global warming.

Transition risks arise from shifts in policies, market dynamics, and consumer preferences as societies move towards more sustainable practices. Some examples of transition risks are policy, legal risks, market and reputational risks. There are also opportunities from the transition towards green activities, for example, gains from resource efficiency and cost savings, low emission energy sources and development of new products and services.

However, one of the main challenges we face is to precisely quantify the financial benefits of companies that adeptly navigate the opportunities in a climate transition pathway. The time horizons for transition risks and opportunities are mostly short-to-medium term as the world needs to take action today to limit the long term impact of climate change. The EU, for example, has the ambition to cut GHG by at least 55% by 2030. Therefore, transition risks and opportunities depend on aspects such as the current and expected carbon profile of a company/ sector, government policies, technological advancement, consumer preferences, liabilities sensitive to climate risk and so on.

Physical risks, driven by climate change and important drivers of ecosystem and natural resource changes, manifest mostly as long-term effects and can be categorized into chronic and acute risks. Chronic risks are gradual, such as slow changes in weather patterns, and mostly affect land and labor productivity. Acute risks are associated with immediate extreme weather events such as cyclones and floods, that cause significant damage to properties. Furthermore, while physical risks may not yet be material for a wide universe of companies, their cumulative financial impact is remarkably larger than that of transition risks. Climate stress testing plays an important role in uncovering the uncertainties around the subject.

With the use of climate stress testing tools, we test our portfolios' sensitivity to climate risks and compare how transition and physical risks alter asset valuations differently. These differences can arise from regional or sectoral exposure and the political and social environment in which companies operate. While climate risks, particularly physical risks, may have a long-term horizon, acting now to mitigate impact across short-, medium- and long-term timeframes is crucial.

3. Robeco's approach to sustainability risk management

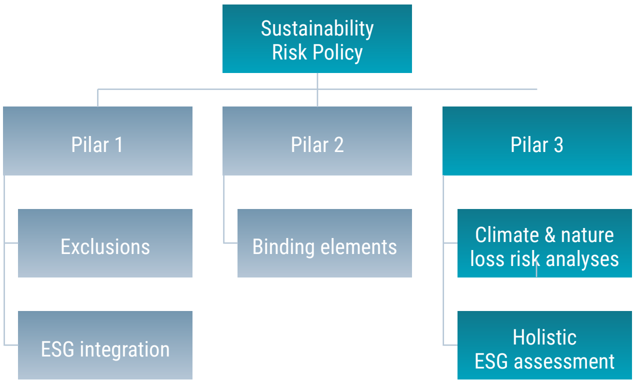
Robeco integrates the consideration of sustainability risks into investment strategies and solutions offered to clients. This includes sustainability investment analyses and decisions, risk management, product governance and client suitability assessment.

The Risk Management (RM) team independently monitors whether the portfolio manager fulfils this promise to investors. Hence, the prime focus of RM is to ensure that Robeco adheres to the sustainability goals and objectives as stated in our strategy.

Our sustainability risk framework is aligned with the EU Sustainable Finance Disclosure Regulation (SFDR)[1], while our reports are aligned with the Task Force on Climate-related Financial Disclosures (TCFD)[2].

Our Sustainability Risk Policy is based on three pillars. The first two pillars focus on investment compliance with the sustainability investment guidelines and regulations. Adherence to thresholds and limits is assessed within these two pillars. The third pillar focuses on financial risks, in which sustainability risk and exposures are translated into potential financial losses. In this pillar we apply our analytics toolkit to assess how climate and nature-loss risks affect our investments through the lens of stress test scenarios. This is the key focus of this paper.

Figure 1 | Robeco's Sustainability Risk Policy



Source: Robeco

1. For more information on SFDR, visit the Sustainable Investing Glossary on the Robeco website.
2. For more information on TCFD, visit the Sustainable Investing Glossary on the Robeco website.

3.1 Scenario models

Scenario models help estimate potential future outcomes and provide insight into the possible impact of climate and nature loss. Given the unprecedented risk associated with climate and nature loss, the outcome of these models is surrounded by uncertainty. Therefore, they are mostly used for directional and relative risk estimation. Furthermore, the results probabilities and their distribution are an important component of the assessment – focusing only on the average and median impacts reveals only part of the problem.

Model outputs can be as granular as asset-level, such as building and infrastructure projects, and these outputs are typically useful for physical risk estimation. But they can also pertain to different levels, including individual companies, industry sectors and countries. They often consider factors such as local weather patterns, topography, and land use, and provide more specific information on the potential impacts on specific communities, industries, and ecosystems.

When it comes to a modelling approach, both top-down and bottom-up approaches are useful. A top-down approach involves assessing systemic risks at a broader level, such as GDP, inflation, and policy frameworks to understand their potential impacts on investments and portfolios. A bottom-up approach focuses on examining individual assets, companies, or sectors to obtain an aggregated impact on countries as well as globally.

Although climate risk is considered systemic, the most granular levels of risk are important in climate risk analyses. For example, there are companies with innovative solutions and low-carbon products that more than offset negative transition risks. In Chapter 4 we provide an example of how transition opportunities are crucial for assessing companies' overall risk profile.

Scenario models present a lot of divergence in modelling assumptions, inputs and climate pathway directions. This is dependent on countless variables such as policy setting, human behavior and emerging scientific findings. Therefore, at Robeco we use various stress test scenarios to prevent tunnel vision.

Scenarios overview

In Table 1, we provide a summary of the existing scenarios, including a nature loss risk sensitivity model that is still in its early stages of development due to data limitations.

Table 1 | Climate and nature loss stress test scenarios

Name	Risk type	Internal/ External	Time horizon	Frequency of shocks	Output	Model type	How it is used
DNB	Climate transition	External	5 years	One-time shock	Equity and corporate loans	Sector-specific	Risk management
Stranded assets	Climate transition	Internal	5 years	One-time shock	Interest rates, credit spreads and equity	Company-specific	Risk management
MSCI	Climate transition and physical	External	Until 2050 (transition) and 2100 (physical)	One-time shock	Equity and credits	Company-specific	Risk management and reporting
NGFS	Climate transition and physical	External	2050	5 years	Macro and financial variables	Sector-specific	Risk management
EIOPA[3] (NGFS)	Climate transition	External[4]	2030-2032	One-time shock	Equity and credit, interest rates and commodities	Company-specific	Risk management
Nature loss	Nature loss sensi-tivity risk	Internal	N/A	N/A	Nature loss sensitivi-ty risk	Sector-specific	Risk management

Source: Robeco

De Nederlandsche Bank (DNB)[5] scenarios

The DNB has developed a climate stress test model, that mainly focuses on the energy transition to a low-carbon economy. The DNB has developed four different scenarios:

1. Confidence shock: Corporations and households postpone investment and consumption due to uncertainty around policy measures and technology. This scenario leads only to a shock to equi-ties.
2. Policy shock: Carbon prices rise by USD 100 per ton due to additional policy measures.
3. Technology shock: The share of renewable energy in the energy mix doubles due to a technologi-cal breakthrough.
4. Double shock: Carbon prices rise by USD 100 per ton due to additional policy measures. The share of renewable energy in the energy mix doubles due to a technological breakthrough.

The report was issued in 2018 and is still used as reference model across Dutch financial institutions. The model provides annual economic impacts on sectors with a five-year time frame, which is then translated into a one-year climate risk scenario. These scenarios are used as model inputs for other studies in this area, including our internal climate stress test, stranded assets (described below).

Stranded assets – internal scenarios

The stranded assets scenarios are two separate pathways based on a literature review of academic research on climate stress testing. The first one follows a gradual long-term scenario (orderly scenario) and another (disorderly scenario) that assumes an abrupt and late response to transition. The scenarios are a combination of top-down and bottom-up evaluation of risks. A sector approach, combined with a transition alignment score for companies in each sector leads to an expected loss. These scenarios inform about transition risks and Paris Climate Agreement alignment in our portfolios.

MSCI Climate Value-at-Risk[6] (CVaR)

Climate VaR aims to assess the potential financial sensitivity to

3. https://www.eiopa.europa.eu/browse/financial-stability/occupational-pensions-stress-test/climate-stress-test-occupational-pensions-sector-2022_en#supporting-documents
4. Company-specific shocks internally applied.
5. https://www.dnb.nl/media/pdnpdalc/201810_nr-_7_-2018-_an_energy_transition_risk_stress_test_for_the_financial_system_of_the_netherlands.pdf
6. https://www.msci.com/documents/1296102/16985724/MSCI-ClimateVaR-Introduction-Feb2020.pdf

climate risks and opportunities, by estimating net present value impact of climate change related to transition and the physical risks to company, equity, and debt values on entities.

We deliver TCFD[7]-aligned reports for each portfolio every quarter. The transition (technology opportunities and policy) and the physical risk models are used as signals of climate risk at the company level. Policy risk is mainly driven by estimated carbon prices, company emissions and their respective budgets. Technology opportunity is estimated based on expected 'green' revenues in the next 15 years.

Physical risk is the most complex component of climate risk. It requires an enormous amount of asset level data on facilities location across the globe and significantly complex models combining climate science and financial models. None of the mainstream scenarios have a sufficient focus on the translation of physical risks into financial asset valuation changes. Therefore, we prefer to rely on an external provider (MSCI currently) rather than replicating this in house.

The Network for Greening the Financial System (NGFS) climate scenarios[8][9]

The NGFS scenarios provide a framework to assess and manage the future financial and economic risks related to climate. They provide a coherent set of transition pathways, climate impact projections, and economic indicators at country-level until 2050, taking into account different assumptions. It is a well-known model that is widely used in the financial industry, however, it lacks the necessary granularity of outputs (e.g. sector shock rather than company-specific). Therefore, we use NGFS climate scenarios as inputs to model other stress tests. The NGFS Disorderly Delayed Transition scenario is used as a reference in the EIOPA climate stress test scenario described below.

The European Insurance and Occupational Pensions Authority (EIOPA) climate stress test[10]

In cooperation with the European Systemic Risk Board (ESRB), EIOPA has developed an EU-wide stress test to assess the resilience for Institutions for Occupational Retirement Provision (IORPs). In 2022 EIOPA focused on climate risk and together with the European Central Bank (ECB) and the ESRB, they developed the narrative of a late-action climate scenario. This is used by pension funds to quantify adverse developments from climate transition. In the case of Robeco, this assessment is focused on transition impacts on assets (rather than also liabilities).

The underlying assumptions of the model are based on the Disorderly Delayed Transition scenario from NGFS, that is sector-specific. We have taken an additional step by using an internal climate transition alignment framework (Climate Score[11]) and applied company-specific shocks. Companies with positive climate scores are impacted less negatively than companies with negative scores within the same sector. The sector's overall impact remains the same.

This climate scenario considers the first three years (from 2030 until 2032), which assumes a sudden carbon price rise to over 300 EUR. Given the shortened time frame, the subsequent economic recovery and the benefits of the transition are not considered.

While the carbon prices in the NGFS Disorderly Delayed Transition scenario increase over a three-year period (2030-32), the stress test scenario assumes that this increase takes place instantaneously (e.g. year 1).

This stress test has a more comprehensive approach using correlations across variables which explicitly accounts for transition impact on interest rates. As explained above, it also applies company-specific shocks aligned with the Climate Score framework that is also used as input to the investment process.

Nature loss scenarios

Due to the limited availability of data, quantifying the financial impact from a potential partial ecosystem collapse is not yet possible. RM, together with Robeco's Biodiversity Committee, searches for data providers with sufficiently accurate information.

In the meantime, we have been working on risk sensitivity analyses based on companies' nature loss footprint. Although footprint metrics should not be the sole source of data, this marks the starting point of a long journey.

7. https://www.fsb-tcfd.org/
8. https://www.ngfs.net/ngfs-scenarios-portal/
9. https://www.ngfs.net/sites/default/files/ngfs_climate_scenario_technical_documentation_final.pdf
10. https://www.eiopa.europa.eu/climate-stress-test-occupational-pensions-sector-2022_en
11. For details about Climate Score see paper part 1 of this joint publication

3.2 Model calibration

As science and new findings emerge, the set of scenarios needs continuous calibration. Calibration can be defined as adjusting input data, parameters and assumptions used to ensure they reflect current developments.

Calibration involves setting values for variables, such as economic indicators, market conditions, climate-alignment scores, and other relevant drivers of stress test scenarios. The goal is to ensure that the outcomes incorporate nuances models do not capture. This is not limited to judgment from research analysts, but also adjustments in model assumptions.

For example, some models such as the EIOPA/NGFS Disorderly Delayed Transition scenario originally apply shocks on sector level. Although companies within the same sector may be affected similarly, they most likely have different responses to climate change and vice versa. Therefore, we enhance model results by applying company-specific shocks using qualitative assessment of our climate alignment tool (Climate Score). This improvement ensures that companies are affected according to the latest climate transition alignment status.

4. Key insights

Climate risk analysis is a fundamental pillar of our sustainability risk policy. In this section we show two cases: a fixed income climate risk hotspot assessment using the Bloomberg Barclays Global Aggregate Bond Index and another case on how different scenarios have different impacts on the RobecoSAM Smart Energy Equities strategy (vs MSCI World Equity Index). For both cases, we explain why it is important not to use only one scenario/methodology.

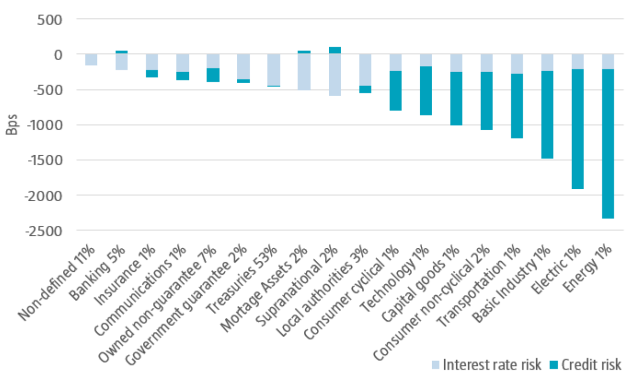
4.1 Fixed income

We ran the NGFS/EIOPA Disorderly Delayed Transition stress test scenario[12] described above on the broadly diversified Bloomberg Barclays Global Aggregate Index and normalized the outcomes (actual impact divided by weight). This method ignores the weight the index has on regions/sectors/asset types, which partially eliminates tilt. This calculation assumes 100% investment in certain countries, regions or sectors.

The results of the stress test show that the biggest loss would be from index interest rate risk (-355 bps value loss) vs the index's credit risk (-120 bps value loss). However, this result is mostly driven by the large exposure (53%) to Treasuries. Unlike most other sectors, government-owned securities have a relatively low carbon footprint and are mostly affected by interest rate risk, rather than credit risk. This is not per se an indication that sovereigns' credit worthiness would not be affected by transition risks, but rather an indication of the existing challenges in estimating the financial impacts of government carbon emissions.

As expected, if we ignore sector weights, as observed in Figure 2, credit risk is the most impactful component in this climate transition scenario (right-hand side of the chart). This is because corporates are affected by abrupt (in this scenario) policy changes and have relatively lower sensitivity to interest rate risk. Such increase in spreads may be driven by either sector-expected default losses or credit risk premium, and in some circumstances both. In this late-action scenario, an immediate shock occurs after strong policies have taken place, and this has the potential to trigger a sentiment effect on the market. However, there may also be permanent repricing in the case of changes in expected default losses. Nonetheless, in this scenario, an immediate mark-to-market adjustment occurs and expected returns may also be important going forward.

Figure 2 | Normalized climate risk attribution per sector – BB Global Aggregate Index*



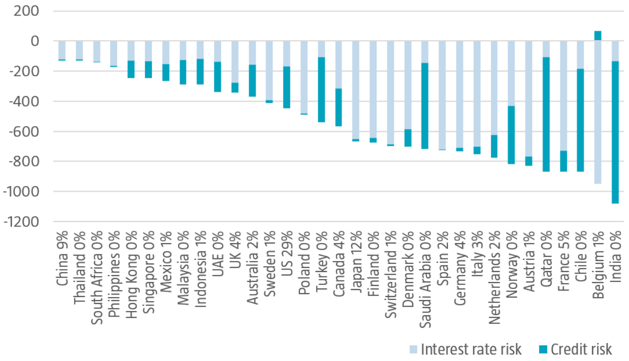
Source: RiskMetrics, 26 June 2023

*11% of holdings are unspecified; % weight after sector name

When transition risk is segregated by country, interest rate risk is dominant. As reflected in Figure 3 below, this is true for most countries except for those in the index with high exposure to carbon intensive corporate bonds such as India, Qatar, Saudi Arabia, US and Canada. The latter two, alongside Norway and UK, are exceptions in DM region.

12. By the time of the analysis (26/06/2023), the model type was on sector-level rather than company-level. Results may look different after taking into account companies' Climate Score.

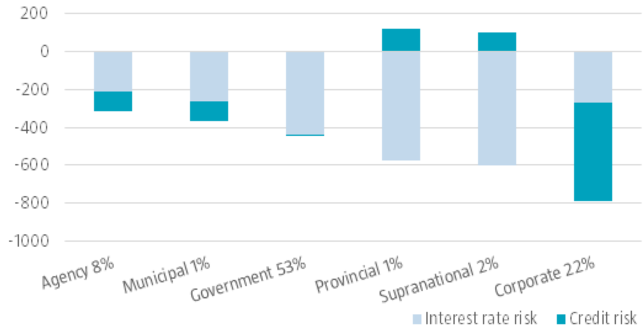
Figure 3 | Transition risk sensitivity per region – BB Global Aggregate Index*



Source: RiskMetrics, 26 June 2023

*11% of holdings are unspecified; % weight after region name; Belgium positive impact is a noise in the model and has no relevant meaning.

Figure 4 | Climate risk sensitivity per asset type – BB Global Aggregate Index*



Source: RiskMetrics, 26 June 2023

*11% of holdings are unspecified; % weight after asset type name

Most developed countries have more sensitivity to interest rates. This is partly explained by their larger proportion of government bonds. In general, developed markets are more exposed to interest rate factors, while emerging countries and carbon-intensive producers have relatively higher credit risks.

When considering total risk, it is remarkable that countries such as Spain, France and Switzerland, with relatively low carbon emissions show relatively high sensitivity to climate transition risks. One of the reasons for this sensitivity may be that transition costs are driven by climate policy-implementation. Countries with strong climate policies have more stringent carbon policies and therefore could be more sensitive to transition risks.

In Figure 4 we segregate sub-asset classes within the BB Global Aggregate Bond Index to show how global sensitivity to climate transition is distributed across asset types. This confirms the previous statement that the index is tilted towards sovereigns.

Aggregated analyses at sector, regional, and asset levels provide useful complementary insights on where climate risks exist. However, averages do not provide a complete picture of a company's climate risks. For example, a company with better-than-average investment in renewables in its energy mix and/or more concrete plans to decarbonize its operations should have a better transition risk profile than its sector as a result of these mitigating factors. This explains why we also look for company-specific factors such as transition plans, carbon reduction patterns and disruptive technologies.

This analysis is not only important for climate risk management, but also for engagement[13] and policy making. Credit risk is typically more aligned with companies' operational and strategic decision-making while interest rates are impacted by macroeconomic decisions and are usually influenced by governments.

Understanding how much credit risk lies in specific sectors and companies allows us to manage such risks in our portfolios, inform engagement strategies and help steer policy.

13. Sovereign engagements follow specific focus areas, aligned with Robeco's sustainable investment strategy and are set up and executed in close consultation with our SI country experts and global macro investment team.

Nuances and limitations

It is important to note that climate risk models are complex and are not able to predict the future accurately, therefore, there are several nuances and limitations we should consider. Below, we describe some nuances that have implications for this case:

- Model assumptions:
  - Business sentiment shock: The NGFS/EIOPA[14] Disorderly Delayed Transition is a scenario that assumes late action (by 2030), in which carbon prices rise above 300 EUR. Due to its sudden nature, price shocks are influenced by an additional business sentiment shock that is unrelated to economic fundamentals.
  - Recovery time from shocks is partially included: The NGFS Disorderly Delayed Transition scenario is constructed to simulate no actions until 2030. After that time, the scenario foresees implementation of a carbon price trajectory in line with long-term targets, including a slow recovery to steady-state conditions. As mentioned, the workaround from the EIOPA assumes a one-time shock of the cumulative impact from 2030-2032, only, ignoring future market adjustments.
- Significance of portfolio duration: The duration of bonds in a portfolio is a critical factor when assessing the impact of climate risks on fixed income assets because climate risks often have long-term implications. In the case of a smooth transition and physical risks, the impacts can manifest gradually over time. Long-duration bonds could be more exposed to these long-term risks, as their cash flows are spread over many years.
- Model vs real-world complexity: Climate models assume perfect foresight and optimal behavior. However, some studies[15] suggest otherwise. There is a consensus that the implementation of carbon taxes affect (even if minor) macroeconomic variables such as GDP, inflation, and interest rates. However, many climate models use general equilibrium models that assume a steady world with stable geopolitical relations and economic conditions. It also assumes that carbon taxes are efficiently channeled back into the economy. However, the reality is different.
- Index concentration: Although the Bloomberg Barclays Aggregate Bond Index is a diversified fixed income index, the granular dissection of this analysis (e.g. by country and by sector) may distort some conclusions. A country or sector with no bonds in the index is assumed to have no impact from climate risks. Alternatively, in cases where a country or sector has only a few companies in the index, results may not represent the true impact.

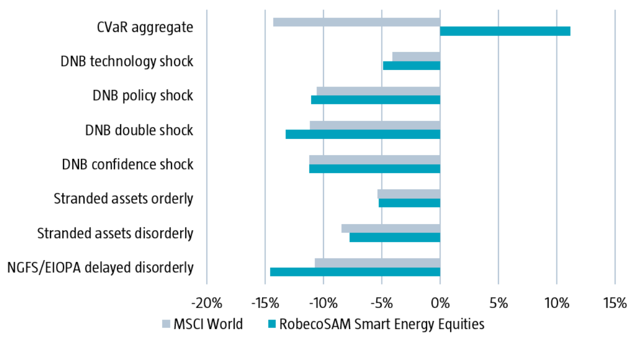
As reflected above, model results do not perfectly translate into the real world. Therefore, general conclusions regarding transition risks should be accompanied by further company fundamental analysis.

4.2 Equity

In the section above we looked at fixed income assets and suggested that climate risk analysis should focus on company-specific risks. In this section we switch to equities and demonstrate the importance of understanding these company-specific transition risks (and benefits from the climate transition).

To do this, we analyze the RobecoSAM Smart Energy Equities strategy and compare it with the broad MSCI World Equity Index. In Figure 5 we show the results of the climate models that were previously explained. Although all models assume a successful transition pathway, the results show a large difference in outcomes between the Climate Value-at-Risk (CVaR) model, which explicitly considers technology opportunities, and the other models, that focus on the negative impacts of climate transition. The strategy's aggregate CVaR is substantially positive, suggesting it has a better climate risk profile than the other models. This supports the tilt the strategy has towards cleaner energy which serves as a climate transition mitigating risk factor.

Figure 5 | Climate risk impact comparison across scenarios



Source: RiskMetrics, 25 May 2023

There is a strong relationship between future costs when transitioning towards a 'green' economy and carbon emissions. This is because if a transition scenario materializes, companies will be punished/compensated for exceeding/not exceeding their allocated carbon budget. Most models assume that this happens mainly via carbon taxes or similar instrument.

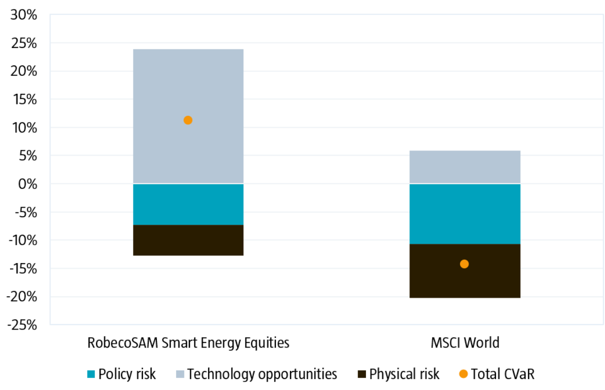
14. https://www.eiopa.europa.eu/climate-stress-test-occupational-pensions-sector-2022_en
15. See the article 'The energy transition comes with a price tag' on the Robeco website.

The carbon footprint[16] of the portfolio is roughly the same as that of the MSCI World Equity Index. This is in line with what we see in Figure 5 for most models. The portfolio has roughly the same expected costs as that of the broad MSCI World Equity Index as a result of policy changes. However, carbon footprint is a backward-looking metric and should not be used as an indicator of a carbon emissions profile. The RobecoSAM Smart Energy strategy is forward-looking with a focus on companies that can reduce carbon emissions from innovative technologies. This is also linked to the avoided emissions concept, defined by IIGCC[17] as "… the reduction in emissions of a product or service relative to the emissions that would have been generated by a comparable product or service using non-'green' assets, energy or processes."[18]

The relationship between avoided emissions, green technologies and their revenues are key components used to assess climate transition opportunities. The EU taxonomy regulation[19] is an important development that will help investors by providing a clear criteria for defining economic activities that are aligned with a net zero trajectory and what can be considered 'green.' This is why Robeco uses alternative sources of data to measure transition opportunities.

For example, the CVaR model suggests that the portfolio policy risk component is roughly 30% lower than that of the index (-7.3% vs -10.7%), which is mostly driven by the relationship between companies' emissions and carbon reduction requirements allocated to each firm. However, the CVaR model also estimates 'green' revenues that are not explicitly considered by the other models. This improves the risk profile for this portfolio as companies with proper transition plans and innovation investments have large expected 'green' cash flows. In Figure 6 we isolate expected technology opportunities CVaR, which estimates a 24% positive impact on transition risk (vs 6% for the index).

Figure 6 | CVaR aggregate impact attribution – RobecoSAM Smart Energy Equities strategy



Source: RiskMetrics, 25 May 2023

Nuances and limitations

Climate models have different assumptions and often do not offer the same results – at times they are not even close. This mirrors an uncertain topic that is influenced by uncountable factors. We summarize some of these challenges below:

- Model assumptions (as described in the fixed income case).
- Projected vs current carbon emissions: Understanding future carbon emissions is key to quantifying climate risks. Some models do not look at forward-looking carbon trajectories. As mentioned previously, the concept of avoided emissions is crucial when assessing climate risks.
- Data quality is limited, particularly for Scope 3 emissions, avoided emissions and future green revenues (as described above).
- Model vs reality (as described in the fixed income case).
- Timing of climate risks: Transition risks are present in the short-to-medium term, however, the exact timing of the impacts is difficult to predict. According to IPCC "limiting warming to around 1.5 °C (2.7 °F) requires global greenhouse gas emissions to peak before 2025 at the latest, and be reduced by 43% by 2030". Therefore, we believe that if a disorderly 1.5 °C transition scenario is to occur, most of the impact should take place around 2030 with secondary effects afterwards. For orderly transition scenarios, the impact starts now and fades out until 2050.
- Physical risks must not be overlooked: Despite their relative late start, after 10-20 years, in cumulative terms, physical risks are the largest component of climate risk and the most likely to be underestimated. It is challenging to model the impacts of immigration, rising sea levels, tipping points or adaptation costs. These factors are not considered in most climate model outcomes.

16. As of 25 May 2023 for Scopes 1 and 2.
17. IIGCC, Investing in climate solutions: listed equity and corporate fixed income September 2023.
18. More information can be found on the page 'Carbon allowances, carbon credits and carbon offsets' in the Sustainable Investing Glossary on the Robeco website.
19. https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en

The idea of integrating climate change and nature loss stress test scenarios into our risk assessment framework has been thoroughly discussed. The Taskforce on Nature-related Financial Disclosures (TNFD)[20] and other initiatives such as the United Nations Environment Programme Finance Initiative (UNEP-FI)[21] and the Finance for Biodiversity Foundation (FfB), have been vocal about the integration of nature loss and climate risks. As part of our third pillar of the Sustainability Risk Policy[22], RM continues to research and enhance their knowledge of the risks together with internal and external stakeholders.

How we apply the third pillar of our Sustainability Risk Policy

Not limited to only climate risk, the third pillar entails independent sustainability risk identification and measurement by Risk Management. The in-depth analyses are used for reporting to stakeholders and serve as a starting point for interactive sessions with portfolio managers when discussing the sustainability profiles of portfolios. Climate risk scenarios and analyses are periodically and systematically shared with internal stakeholders via:

- The monthly sustainability risk dashboard that monitors all portfolios using several sustainability indi-cators, regardless of whether they are restrictive or not. This summarizes and supports evaluation of portfolios using several metrics that enable comparison. The dashboard also allows Risk Management to identify outliers for analysis. Observations are shared in the report and with relevant individuals.
- The worst performing portfolios on a variety of sustainability indicators, including climate risk, are presented to risk management committees. Risk Management shares the findings that are a cause for concern. In these committees, representatives of the investment department participate and discuss these findings with their direct colleagues.

20. For more information on TCFD, visit the Sustainable Investing Glossary on the Robeco website.
21. https://www.unepfi.org/banking/bankingprinciples/
22. You can find the Sustainability Risk Policy on our website under 'Sustainability policies and positions'

5. Conclusion

In this paper, we have indicated the difficulties uncovering the true implications of ‘climate risk’ because of the uncertainty and complexity that surrounds obtaining accurate information.

On the one hand, there has been an enormous amount of effort to obtain data to help us with this task. On the other hand, not all climate risk factors are explicitly considered in climate models. For example, tipping points, rising sea levels, migration, accurate carbon budgets and adaptation costs are often not included. Therefore, climate scenarios models are characterized by large deviations in outcomes that, on average, are most likely underestimating the impact of climate risks.

This is the reason why climate models should not be viewed as definitive predictors, and decision-makers should be cautious when interpreting their results. We summarize some of the reasons below:

1. Complexity and uncertainty: Predicting the exact timing of an abnormal global natural event such as transition or physical shock becomes even more challenging when there are so many cascading factors to consider. Climate risks involve looking decades (or even centuries) ahead taking into account complex interactions between natural systems, economic activities, and social factors. They result in non-linear unpredictable outcomes and the models have little historical data to work with.
2. Diverse model assumptions: Every model has its peculiarities with differences in assumptions, methodologies and underlying data and the integration of these aspects is layered differently depending on the model. For example some models estimate carbon emissions trajectories using the carbon intensity of companies’ operations. Others may use historical emissions or revenue share approach, etc.
3. Input quality shapes output accuracy: Climate/nature risk data is not yet of high quality. One of the most important drivers of transition costs is the expected (and avoided) carbon emissions. Scope 3 data (particularly downstream) is the largest component of carbon emissions, but data providers are working hard to obtain higher quality for future carbon emissions and potential green revenues. Equally, as seen in the fixed income case, portfolio concentration to a particular region or sector is a significant driver of outcomes.
4. Model versus real-world complexity: Discrepancies between climate models and real world may arise due to model simplifications, which often neglect non-linear behaviors and/or tipping points. General equilibrium models used in climate modelling often make assumptions of steady-state growth and efficient channeling of carbon tax revenues into the economy. However, these assumptions may be diverge from reality. The range of potential mismatches between model assumptions and real-world complexities is extensive.

The level of detail, accuracy and quality of data and tools can vary. We use multiple relevant sources of data and methodologies to obtain a comprehensive understanding of the potential risks and opportunities from climate change. Also, as developments and understanding of climate change evolves, we continuously monitor and review inputs, methodologies, and strategies employed in our scenarios.

We acknowledge that there is a very dynamic field on climate and (even more for) nature loss risks. Therefore, we employ both top-down and bottom-up approaches from different methodologies and assumptions to identify, monitor and manage climate risks. While models provide valuable insights, decision-makers should exercise caution when interpreting their results and incorporate complementary fundamental analysis. Importantly, they should not be viewed as definitive predictions.

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