Managing Climate Risk in Investment Portfolios

A Case Study

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Executive Summary

Investors are increasingly concerned about how climate change and a transition to a low carbon economy could impact the risk and return profile of their portfolios. Financial regulators are also urging investors to measure and report on their portfolios' exposures to climate-related risks.[1] Given the different dimensions of climate change that can impact portfolio returns, there are a variety of measures and approaches to measure and manage portfolio climate risks.

In this case study, we selected a sample portfolio representative of a global actively-managed fund in terms of risk-return characteristics and used the MSCI Climate Value-at-Risk ("Climate VaR") model to examine the different dimensions of climate-related risks. We show how Climate VaR can be used to measure climate risks for the portfolio as a whole, as well as further explore which sectors, countries and securities were driving these risks in the portfolio.

We also considered some approaches which a portfolio manager might follow in order to manage these risks. Specifically, we tested four simple exclusion strategies based on the worst-performing decile of the portfolio on the following measures:

- **A.** Aggregated Climate VaR
- **B.** Transition Risks and Opportunities Climate VaR
- **C.** Physical Risks and Opportunities Climate VaR
- **D.** Carbon intensity

For each exclusion strategy, we investigated the impact on climate risks as well as on the risk and return characteristics of the sample portfolio, including sector, country and style exposures. We show that while these exclusion strategies had substantial impacts on the measures of climate risks for the sample portfolio, they had minimal impact on the sample portfolio's conventional risk, return and market exposures. For example, exclusion strategy A reduced the portfolio's overall Aggregated Climate VaR by 74%, but had a 5-year simulated return in line with that of the sample portfolio (10.47% versus 10.71%), with a tracking error of 0.96% and broadly similar country, sector and style exposures to the original portfolio. Exclusion strategies B through D yielded similar results.

We conclude that, in the case of the sample portfolio chosen, it was possible to substantially reduce the portfolio's climate risk exposures without significantly altering

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[1] See, for example: Bank of England 2019, "Discussion Paper: The 2021 biennial exploratory scenario on the financial risks from climate change", or Task Force on Climate-related Financial Disclosures 2017, "Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures".

the portfolio's conventional risk and return characteristics or its market exposures, such as to sectors, countries and styles.

Climate Risks

The notion that there are "climate risks" in financial portfolios has been gaining momentum with investors over the last decade. So, what are climate risks? In short, the idea is that climate change impacts the financial performance of companies and therefore also the risk-return profile of the securities they issue. Climate risks are typically categorized along two dimensions:[2, 3]

- **Transition risks**: the risks associated with transitioning to a low-carbon economy – for instance, shifts in policy, technology or supply and demand in certain sectors; and
- **Physical risks**: the risks associated with the physical impacts of climate change on companies' operations, resulting from, for instance, extreme temperatures, floods, storms or wildfires.

There are various ways to assess climate change risks to a portfolio. In this case study, we illustrate one approach by applying MSCI's Climate Value-at-Risk ("Climate VaR") model to a sample portfolio and examining the different dimensions of climate risks to which the portfolio companies could be exposed. We then considered approaches a portfolio manager might follow in order to manage this risk and investigated the impact that such approaches could have had on the risk and performance characteristics of the portfolio.

Climate VaR

The Climate VaR model developed by MSCI aims to measure the potential impact of different climate scenarios on individual securities' valuations. Climate VaR indicates, in percentage points, what could be the potential impact on a security's market value as a result of the effects of climate change.

The model incorporates three types of climate change impacts:

[2] For a further description, see Task Force on Climate-related Financial Disclosures 2017, "Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures", section B 1. (pages 5-6).

[3] Note that, although we usually refer to climate "risks", there can also be upside exposure ("opportunities") resulting from climate change as we will see in subsequent sections of this paper.

- **Policy Risks**: how much a company may need to reduce its greenhouse gas emissions in the future as a result of climate policy. We perform this analysis by reference to detailed quantitative analysis of existing climate policies, as well as several climate scenarios developed by global climate research institutes;
- **Technology Opportunities**: how much a company may benefit from the transition to a low carbon economy through offering new low-carbon products and services. For this analysis, we use unique datasets of current low-carbon revenues as well as low-carbon patents held by companies; and
- **Physical Risks and Opportunities**: how much a company may suffer an increase (risk) or decrease (opportunity) in business interruptions or asset damages from the physical manifestations of climate change. The model incorporates both chronic hazards (gradual changes in temperatures, precipitation, snowfall and wind) and acute hazards (coastal flooding and tropical cyclones) and takes into account the specific locations of companies' facilities.

For all three types of impacts, the model computes scenario- and company-specific estimates of future cost and revenue impacts, and then applies financial modelling to derive security-level valuation impacts. The Appendix provides further details on the Climate VaR methodology.

Portfolio Climate Risk Assessment

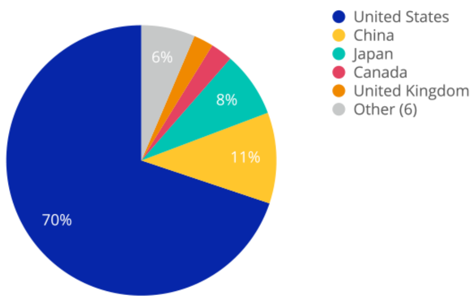
SAMPLE PORTFOLIO

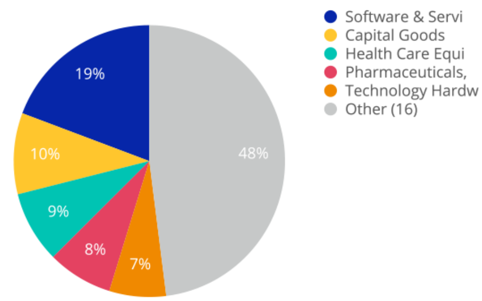
We selected a sample portfolio from the Lipper database of mutual funds focusing on the peer group of global developed market funds.[4] The goal of the selection process was to have a "typical" fund in the sense of having five-year active performance relative to the fund's own benchmark that was close to the median fund active performance in that peer group. We also aimed for a fund with more than 50 holdings to limit concentration. The "typical" fund selected was representative of a global actively-managed fund in terms of risk-return characteristics: its five-year return (10.71%) and volatility (12.76%) were in line with the median of global actively-managed funds in the database as of December 2019.

[4] We started with all global funds available in the Lipper database and selected all the funds that had at least 75% weight invested in equity, then filtered out funds with assets under management below USD 1 million or above USD 500 billion. We also filtered out funds with larger than 15% exposure to emerging markets. Finally, we excluded 5% of funds with largest and smallest tracking error and funds with reference to index tracking in their name.

Exhibit 1 shows the country and Global Industry Classification Standard (GICS®[5]) Industry Group breakdowns of the sample portfolio. The sample portfolio was North America-centric, with nearly three quarters invested in companies domiciled in the US and Canada. The sectoral allocation was more heavily weighted towards the technology, health care and capital goods sectors.

Exhibit 1: Sample Portfolio Country and GICS Industry Group Breakdowns





Source: MSCI ESG Research LLC.

The sample portfolio also had important style tilts (Exhibit 2): towards small/mid cap stocks, towards better quality stocks (as measured by profitability, investment quality or earnings quality); towards value stocks (as measured by earnings yield); and a smaller exposure to momentum stocks. These tilts collectively contributed 62 bps to the annualized outperformance of the sample portfolio over the MSCI World Index as of year-end 2019.

Exhibit 2: Sample Portfolio Active Style Exposures (Benchmark: MSCI World Index)

Style	Active exposure	Contribution to active return
Size	-0.60	-0.13%
Book-to-Price	-0.05	0.01%
Beta	-0.02	-0.23%
Leverage	0.02	-0.06%
Residual Volatility	0.03	0.12%
Dividend Yield	0.04	0.06%
Earnings Variability	0.09	-0.14%
Earnings Quality	0.10	0.05%
Long-Term Reversal	0.11	-0.10%
Growth	0.11	0.12%
Momentum	0.13	0.60%
Investment Quality	0.24	0.25%
Liquidity	0.26	-0.18%
Earnings Yield	0.27	-0.19%
Mid Capitalization	0.35	0.17%
Profitability	0.35	0.27%

Benchmark: MSCI World Index.

Source: MSCI ESG Research LLC.

[5] GICS, the global industry classification standard jointly developed by MSCI and Standard & Poor's.

PORTFOLIO-LEVEL CLIMATE VAR

Exhibit 3 displays a Climate VaR report snapshot for the sample portfolio. The Climate VaR contribution is the calculated percentage impact on the portfolio's valuation from each type of risk or opportunity. The monetary risk contribution represents the value in USD if we assume USD 100 million invested in the sample portfolio.

Exhibit 3: Climate VaR Portfolio Report Snapshot

Scenario	Climate VaR Contribution	Monetary Risk Contribution
Low Carbon Transition Risk Scenarios *Selected Model: 2°C | AIM CGE*	**-0.59%**	**-0.59 USD million**
Policy Risk (2°C)	-4.43%	-4.43 USD million
Technology Opportunities (2°C)	+3.84%	3.84 USD million
Physical Climate Scenarios *Selected Model: Aggressive*	**-7.16%**	**-7.16 USD million**
Extreme Cold	+0.22%	0.22 USD million
Extreme Heat	-1.44%	-1.44 USD million
Precipitation	+0.15%	0.15 USD million
Extreme Snowfall	+0.02%	0.02 USD million
Extreme Wind	-0.03%	-0.03 USD million
Coastal Flooding	-6.15%	-6.15 USD million
Tropical Cyclones	-0.12%	-0.12 USD million
Aggregated Climate VaR	**-7.75%**	**-7.75 USD million**

Source: MSCI ESG Research LLC.

The Aggregated Climate VaR is -7.75%, resulting in a USD 7.75 million monetary risk contribution for a USD 100 million investment.[6] This means that, under the scenarios

[6] We have based this case study on a hypothetical USD 100 million investment. The monetary contribution is calculated as the product of the Climate VaR contribution and the portfolio value.

considered, climate risk and opportunities were estimated to represent a downside valuation impact of 7.75% of the portfolio.

This risk can be further broken between Transition Risks and Opportunities and Physical Risks and Opportunities.

Under the 2-degree Celsius (2°C) scenario considered,[7] Transition Risks and Opportunities amounted to a downside valuation impact of -0.59%. This number is in fact comprised of two effects: -4.43% downside coming from Policy Risks, and +3.84% upside stemming from Technology Opportunities.

On Physical Risks and Opportunities, the overall risk of -7.16% was largely driven by Coastal Flooding (-6.15%) and Extreme Heat (-1.44%). While the large impact of Coastal Flooding will be intuitive for many, it may be surprising to some that Extreme Heat features as one of the major physical risks. However, Extreme Heat is in fact one of the most impactful effects of climate change. Heatwaves have a substantial impact on people's health and are responsible for more deaths than any other extreme weather events, including storms and floods.[8] For businesses' operations, Extreme Heat may materialize in the form of business interruptions – for instance, reduced labor productivity (especially for outside labor) or reduced efficiency of industrial processes relying on heating/cooling cycles.

We also observe that some of the Physical Risks and Opportunities Climate VaRs were positive – i.e. representing an upside. This was the case for Extreme Cold (+0.22%) and in this case stems from the fact that, in the scenario considered, in many locations around the globe the number of days with temperatures reaching below 0°C are likely to decrease, resulting in fewer business interruptions.

For a more robust climate risk assessment, it is useful to look beyond the portfolio risk measures and into what drives them – be it at the level of sectors, countries or individual securities.

SECTORS

The three GICS Industry Groups in the sample portfolio with the highest Transition Risks were real estate, materials and food & staples retailing (Exhibit 4) – although we note that the risk in real estate here was inflated by the fact that Swire Pacific Limited, classified in the real estate GICS Industry Group, owns an airline (Cathay Pacific).

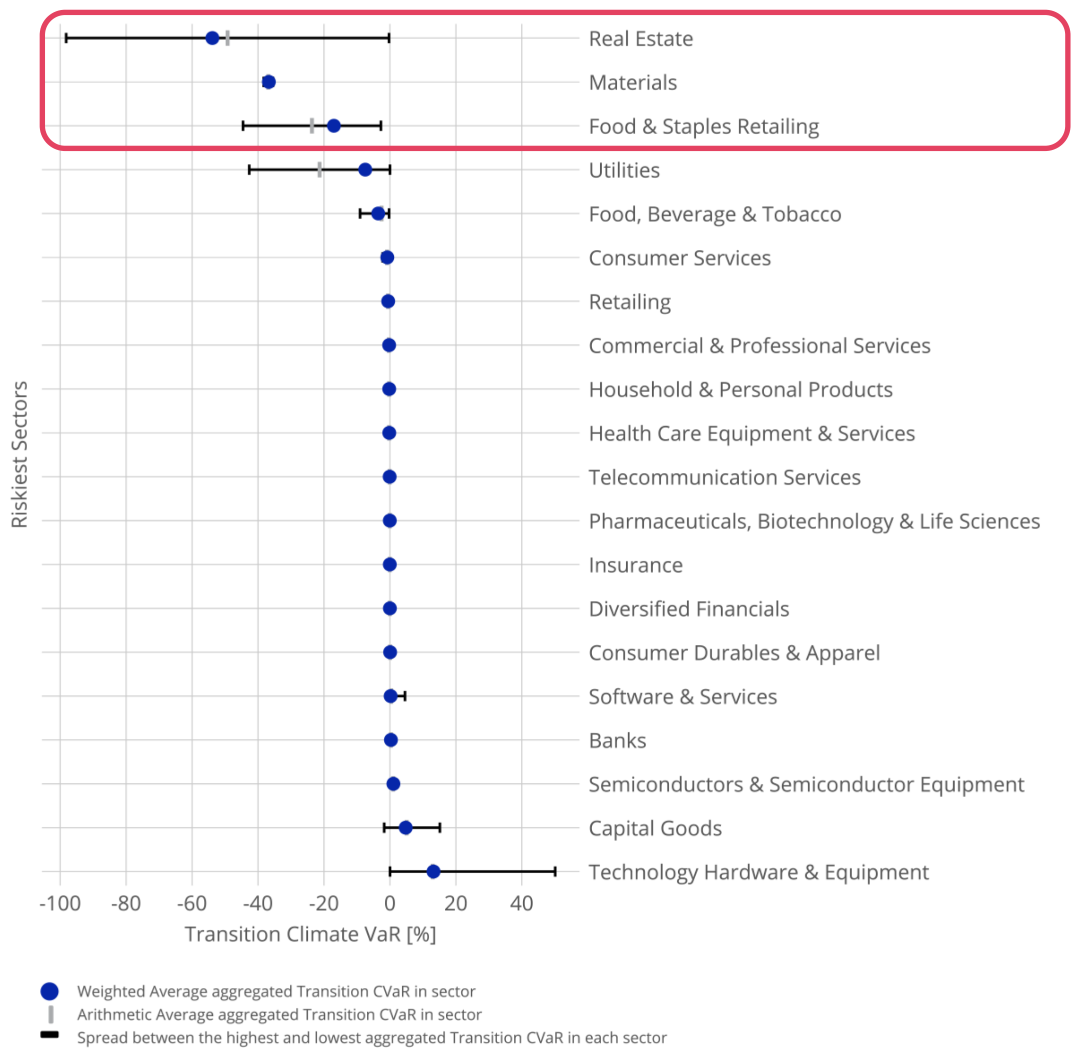
[7] MSCI Climate VaR takes as input a range of different transition scenarios, which are differentiated by, among others, temperature targets and the "pathways" to achieve such temperature targets. We also use scenarios from different Integrated Assessment Models to include a diversity of approaches and assumptions. In this example, we use a 2°C scenario produced by the AIM/CGE 2.0 Integrated Assessment Model that is characterized by mitigation action starting in 2020.

[8] See Center for Climate and Energy Solutions 2017, "Resilience Strategies for Extreme Heat".

The weighted average Transition Risks and Opportunities Climate VaR of utilities stocks in the sample portfolio, at -7.49%, showed a little less risk than usual; by comparison, the utilities stocks in the MSCI World Index carried an average Transition Risks and Opportunities Climate VaR of approximately -25%. The lower transition risk for utilities in this sample portfolio is explained by the fact that both holdings in this Industry Group (Portland General Electric Company and Northland Power Inc) have, in our model, substantial opportunities in clean technologies.

Looking at Transition Opportunities, we found that the upside of the low-carbon transition came from the stocks in the sample portfolio in technology hardware & equipment and capital goods – activities with comparatively lower direct greenhouse gas emissions or with a focus on developing new technologies.

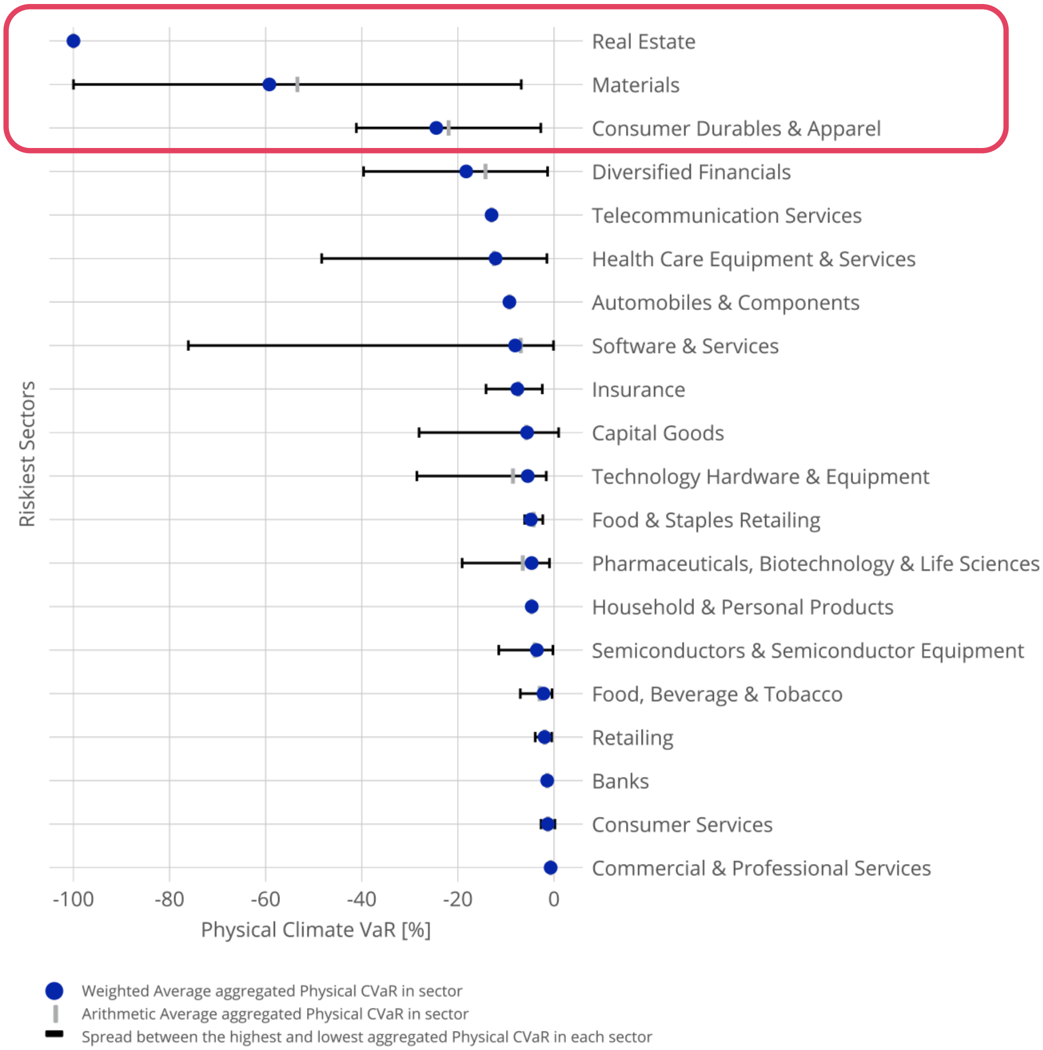
Exhibit 4: Climate VaR by GICS Industry Group – Transition Risks and Opportunities



Source: MSCI ESG Research LLC.

Turning to Physical Risks and Opportunities (Exhibit 5), the three highest risk sectors were real estate, materials, and consumer durables & apparel.

Exhibit 5: Climate VaR by GICS Industry Group – Physical Risks and Opportunities



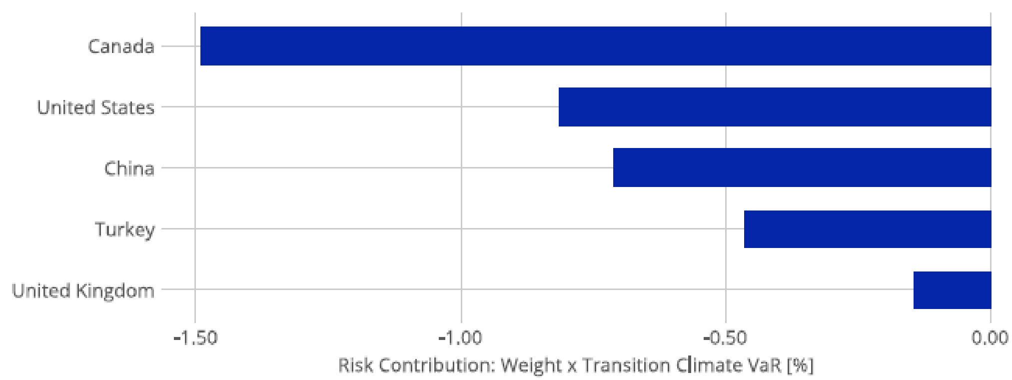
Source: MSCI ESG Research LLC.

COUNTRIES

We then investigated the countries showing the highest level of climate risks in the sample portfolio. For this analysis, the Climate VaR model looks through to a company's activities, identifying the different countries in which a company operates. Doing so is necessary, as transition and physical risks (e.g., climate policy, extreme weather events) are likely to have local impacts on companies' international operations.

The country with the highest Transition Risks was Canada (Exhibit 6), accounting for over a third of the sample portfolio's Policy Risks (-1.49% out of -4.43%). The United States and China were also among the highest contributors to Transition Risks, which is an intuitive result considering the large portfolio weights the two countries represent (70% and 11%, respectively) and the importance of those markets in the global economy, meaning that many companies incorporated elsewhere also tend to have operations there.

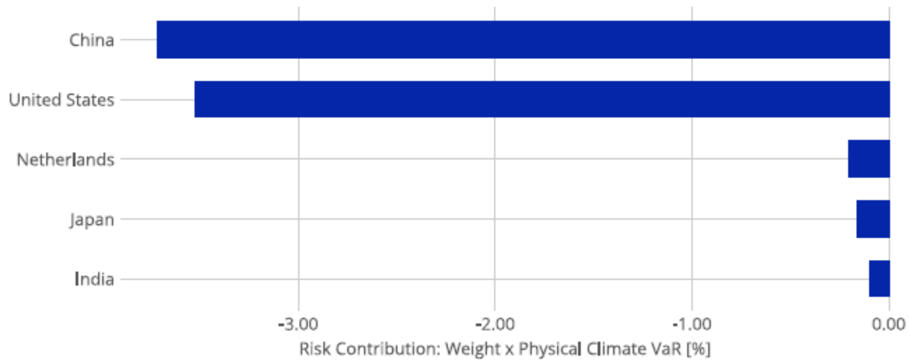
Exhibit 6: Countries Representing the Most Transition Risks



Source: MSCI ESG Research LLC.

China and the United States also contributed substantially to the portfolio's Physical Risks and Opportunities (Exhibit 7), with the two countries representing by far the largest contributions. The top five was completed by the Netherlands, Japan and India.

Exhibit 7: Countries Representing the Most Physical Risks



Source: MSCI ESG Research LLC.

To understand what drives Physical Risks and Opportunities inside a country, it is useful to look further down into the specific company facilities. Exhibit 8 shows that in China, for instance, the five facilities with the highest Physical Risks were affected by Coastal Flooding, Extreme Heat and Extreme Cold – and did not all belong to Chinese companies.

Exhibit 8: Highest Risk Facilities in the People's Republic of China

#	Location	Company Name	ISIN	Risk Type
1	Shenzhen City, PRC	ANHUI CONCH CEMENT COMPANY LIMITED	CNE0000019V8	↑ Coastal Flooding
2	Tianjin Binhai Intl. Airport, PRC	Airbus SE	NL0000235190	↑ Coastal Flooding
3	Changning, PRC	JOHNSON CONTROLS INTERNATIONAL PUBLIC LIMITED COMPANY	IE00BY7QL619	↑ Coastal Flooding
4	Wuhan City, PRC	LENOVO GROUP LIMITED	HK0992009065	↑ Extreme Heat
5	Tuanjie Xincun Subdistrict, PRC	LENOVO GROUP LIMITED	HK0992009065	↑ Extreme Cold

Source: MSCI ESG Research LLC.

Portfolio Climate Risk Management

Having used Climate VaR to review the climate risks of the sample portfolio, we then considered the approaches a portfolio manager might take to manage these risks and investigated the impact that these would have had on the risk and return characteristics of the sample portfolio.

One approach to managing climate risks is to exclude the portfolio constituents that contribute the most to the risks. We performed this exercise four times with different variations, each time excluding the “worst” decile (eight stocks) on the following criteria:[9]

- **A.** Aggregated Climate VaR
- **B.** Transition Risks and Opportunities Climate VaR
- **C.** Physical Risks and Opportunities Climate VaR
- **D.** Carbon intensity

Doing so, we obtained four new hypothetical portfolios (A through D), which we could compare with the original sample portfolio (“Original”).

IMPACTS ON CLIMATE RISKS

Exhibit 9 displays the impact that the four exclusion strategies would have had on climate risks.

Exhibit 9: Climate Risk Impacts of the Different Exclusion Strategies

	Original	A (Aggregated)	B (Transition)	C (Physical)	D (S12 Intensity)
Aggregated Climate VaR	-7.75%	-2.04%	-4.32%	-2.83%	-4.40%
Transition Climate VaR	-0.59%	1.79%	2.03%	-0.35%	1.34%
Physical Climate VaR	-7.16%	-3.83%	-6.34%	-2.48%	-5.74%
WACI* (tCO2e / USD million)	185.87	44.07	43.78	82.34	20.67

*Weighted Average Carbon Intensity

Data as of 31 December 2019.

Source: MSCI ESG Research LLC.

All exclusions tended to improve Climate VaR and reduce the portfolio’s carbon intensity, albeit to varying degrees: exclusion strategies A through C improved Climate VaR the most, and exclusion strategy D reduced the carbon intensity the most. This is,

[9] For Climate VaR, “worst” performers were those with the lowest Climate VaR (which in many cases means the most negative Climate VaR). For carbon intensity “worst” performers were those with the highest carbon intensity. Carbon intensity is defined in this analysis as the amount of Scope 1 and 2 greenhouse gas emissions, in tons of CO2 equivalent (tCO2e) per USD million of sales.

of course, by design – but it is worth noting that the reductions achieved by the exclusions were substantial: strategy A reduced the Aggregated Climate VaR by 74% (from -7.75% to -2.04%); strategy B changed the sign of Transition Risks and Opportunities Climate VaR (from -0.59% to +2.03%); strategy C reduced the Physical Risks and Opportunities Climate VaR by 65% (from -7.16% to -2.48%); and strategy D reduced the Weighted Average Carbon Intensity ("WACI") of Scopes 1 and 2 ("S12") by 89% (from 185.87 to 20.67 tCO2e/USD million of sales).

The four strategies had different impacts:

- **Strategy A** improved not just the Aggregated Climate VaR but also both the sub-components of Climate VaR and the carbon intensity;
- On the other hand, excluding on the basis of a single component of Climate VaR seemed to act on that component alone in this sample portfolio: **strategy B** improved Transition Risks and Opportunities Climate VaR, but did not have much impact on the Physical Risks and Opportunities Climate VaR, (a small improvement from -7.16% to -6.34%). The opposite is true for **strategy C**;
- In **strategy D**, exclusions on the basis of carbon intensity not only reduced the WACI but also improved the Transition Risks and Opportunities Climate VaR. This result is intuitive, considering that the transition is likely to compel companies to reduce their carbon emissions – hence, companies with higher carbon intensities would, on average, face more transition risks. For the same reason we can also see that strategies A and B, which substantially improved the Transition Risks and Opportunities Climate VaR, also substantially reduced the carbon intensity. However, these results also highlight that carbon intensity and transition risks are not one and the same, as the exclusions in strategies A, B and D were not identical; for example, Northland Power Inc. was excluded in strategy D on account of its carbon intensity (1,294 tCO2e/USD million of sales), but it was not excluded from strategy A or B because it had a relatively small Transition Risks and Opportunities Climate VaR, thanks to having 59.1% of its total revenue generated in alternative energy.

IMPACTS ON TRADITIONAL RISK / RETURN PROFILE

The above analysis showed that it was possible to reduce the climate risks in the sample portfolio, as measured by four different criteria. Of course, this is only one part of the story; a portfolio manager would also want to know the impact each exclusion approach might have on the sample portfolio's risk/return characteristics.

We investigated this question and show the results in Exhibit 10, which compared the five-year simulated performance of the strategies.[10] Interestingly, although exclusion strategies A through D substantially improved the various measures of climate risks, the traditional risk/return characteristics remained largely similar to the original strategy: all strategies had five-year simulated returns in the mid to high 10% range (compared to 10.71% in the original strategy), and volatilities in the mid 12% range (compared to 12.76% in the original strategy). All but the exclusion based on the Aggregated Climate VaR (strategy A) led to a very small outperformance. The tracking errors of strategies A through D to the original strategy were all approximately 1%.

Exhibit 10: Risk/Return Impacts of the Different Exclusion Strategies

	Original	A (Aggregated)	B (Transition)	C (Physical)	D (S12 Intensity)
Return	10.71%	10.47%	10.74%	10.87%	10.89%
Volatility	12.76%	12.59%	12.59%	12.55%	12.58%
Active return vs Original	-	-0.25%	0.03%	0.16%	0.18%
Tracking error	-	0.96%	0.93%	0.95%	1.07%
Information ratio	-	-0.26	0.03	0.17	0.17

Simulation period: Dec 31, 2014 - Dec 31, 2019, figures are annualized.

Source: MSCI ESG Research LLC.

We also investigated the impact that these exclusions had on the sector, country, style and other exposures of the strategy using MSCI's Global Total Equity Market Factor model. The high-level contributions from the factor groups are shown in Exhibit 11.

Exhibit 11: High-Level Contributions from Factor Groups

Source of return	A (Aggregated)	B (Transition)	C (Physical)	D (S12 Intensity)
Styles	0.15%	0.20%	-0.04%	0.02%
Industries	0.00%	0.21%	0.09%	0.32%
Countries	-0.12%	0.05%	-0.17%	0.11%
Currencies	-0.09%	-0.08%	-0.05%	-0.05%
Stock-specific	-0.19%	-0.36%	0.32%	-0.21%
Total active return vs Original	**-0.25%**	**0.03%**	**0.16%**	**0.18%**

Simulation period: Dec 31, 2014 - Dec 31, 2019, figures are annualized.

Source: MSCI ESG Research LLC.

[10] We use a 5-year simulation period based on the availability of historical data.

This report may contain analysis of historical data, which may include hypothetical, backtested or simulated performance results. There are frequently material differences between backtested or simulated performance results and actual results subsequently achieved by any investment strategy.

The analysis and observations in this report are limited solely to the period of the relevant historical data, backtest or simulation. Past performance — whether actual, backtested or simulated — is no indication or guarantee of future performance. None of the information or analysis herein is intended to constitute investment advice or a recommendation to make (or refrain from making) any kind of investment decision or asset allocation and should not be relied on as such.

In general, the factor profile of the original strategy was only slightly modified by the exclusion strategies. Industry factors and stock-specific returns tended to have a higher impact than styles, countries and currencies, but overall the contributions of all five sources of return remained very small when compared to the overall simulated returns of these strategies:

- **Strategy A** was the only strategy showing a small underperformance (-25 bps) when compared to the original strategy. This underperformance was driven by stock-specific, country and currency effects (-19 bps, -12 bps and -9 bps, respectively) partly compensated by a positive style effect (15 bps);
- **In strategy B**, positive style, industry and country effects (20 bps, 21 bps and 5 bps) were partly compensated by a negative stock-specific and currency effect (-36 bps and -8 bps) resulting in a very small outperformance of 3 bps;
- Slightly larger outperformances were achieved by the exclusions based on Physical Risks and Opportunities Climate VaR (16 bps) and carbon intensity (18 bps). In the case of **strategy C**, this result was largely driven by stock-specific and industry effects (32 bps and 9 bps, respectively), in part compensated by a negative country effect (-17 bps). The exclusion based on carbon intensity (**strategy D**) had a larger effect on industry contributions (32 bps) due to a small underweight in the energy, utilities and materials GICS Industry Groups, which was expected given that the largest carbon emission intensity companies are members of those industry groups. At the same time, country contributions increased (10 bps) due to a small underweight in South Korea and Hong Kong, and an even smaller overweight in Brazil. This type of exclusion, however, decreased stock-specific contributions by 21 bps.

Conclusion

In this case study, we used a sample portfolio representative of a “typical” actively-managed global fund in order to illustrate how Climate VaR can be used to assess climate risks. We then considered some approaches that a manager might follow to mitigate these climate risks and simulated the impact that such approaches could have on the risk and return characteristics of the sample portfolio.

We have shown, through four exclusion strategies, that simple steps could have a very substantial impact on climate risks: for example, excluding the worst-performing decile by Aggregated Climate VaR led to a reduction of 74% in the sample portfolio’s overall Aggregate Climate VaR. We have also shown that, for the sample portfolio selected, the impact of those exclusions on the traditional measures of risks, returns and market exposures were comparatively small: the tracking error between the exclusion strategies and the original strategy was around 1%, and the five-year simulated returns and volatilities remained substantially similar (in the mid to high 10% and mid 12% ranges, respectively); the impact on the high-level contributions from factor groups was small when compared to the overall return, too.

These results suggest that a portfolio manager could, in the context of this sample portfolio, substantially reduce their climate risk exposures without altering significantly the portfolio’s conventional risk and return characteristics or its market exposures.

Appendix - Climate VaR Methodology Overview

AN INTEGRATED AND TRANSPARENT APPROACH

With the MSCI Climate Value-at-Risk (Climate VaR) model provided by MSCI ESG Research LLC we aim to empower financial institutions with the tools to identify assets vulnerable to the worst effects resulting from climate change and also help identify new innovative low carbon investment opportunities.

TRANSITION AND PHYSICAL SCENARIOS

Climate change impacts can be placed into two broad categories commonly used in market practice for how environmental threats, and efforts to address them, can create financial impacts:

Transition risks and opportunities

Risks and opportunities which arise from efforts to address environmental change, including but not limited to abrupt or disorderly introduction of public policies, technological changes, shifts in consumer demand, investor sentiment, and disruptive business model innovation.

Physical risks and opportunities

Risks and opportunities which arise from the impact of climatic events, such as extreme weather, or widespread changes in eco-system equilibria, such as soil quality or marine ecology. Physical changes can be event-driven ('acute') or longer-term in nature ('chronic').

Source: MSCI ESG Research LLC.

POLICY TRANSITION SCENARIOS

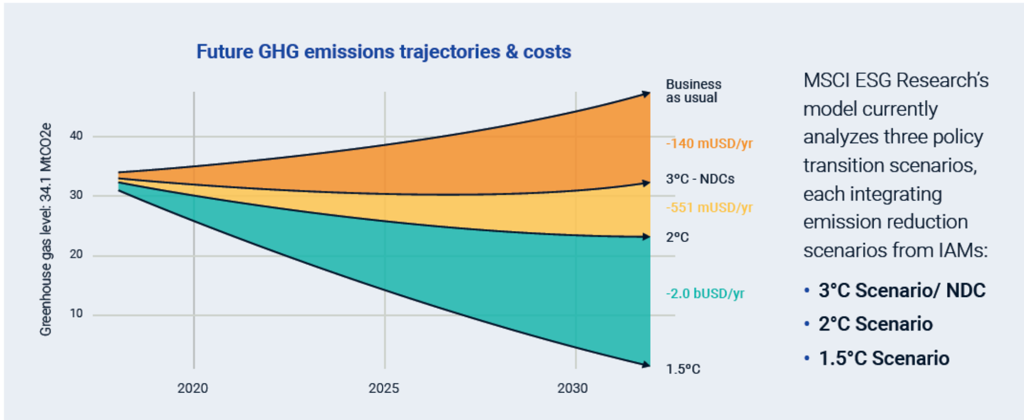
POLICY RISKS

MSCI employs a top-down and bottom-up hybrid methodology to calculate risks from future policies aimed at addressing climate change. The modeling begins with the quantification of country level greenhouse gas (GHG) emission reduction targets embedded within policies that have been proposed within the Nationally Determined Contributions (NDCs) of the Paris Agreement. Country emission reduction targets are then broken down into sector level targets based on details within the NDCs as well as recently proposed national level climate regulations. Using a combination of MSCI ESG Research's production facilities database for intra-sector company comparison, sector emission reduction targets are then assigned to each company production facility, giving MSCI ESG Research insights into the emission reduction requirements for facilities owned and operated by thousands of companies.

COST CALCULATION

To calculate the costs associated with reaching emission reduction requirements, MSCI ESG Research uses technology and policy based price estimates available from Integrated Assessment Models (IAMs). MSCI ESG Research's formula for calculating the costs associated with reaching an emission reduction requirement is straight-forward:

Total Cost = Required GHG Reduction Amount * Price per tCO2e.



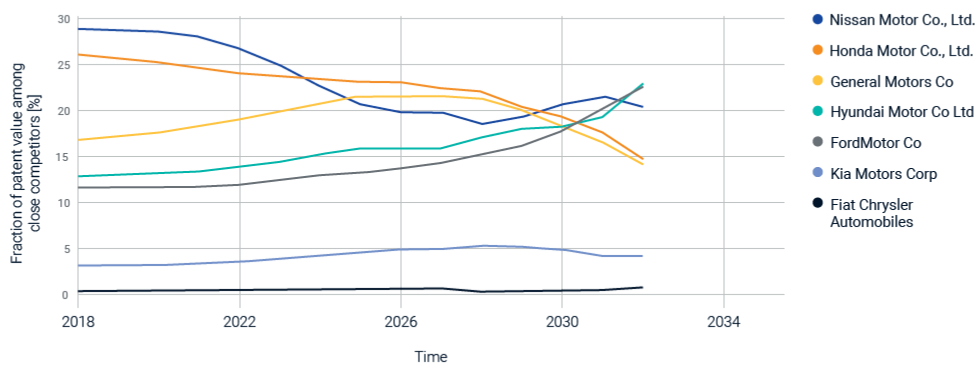
Source: MSCI ESG Research LLC.

INNOVATION TRANSITION SCENARIOS

TECHNOLOGY OPPORTUNITIES

The transition to a low-carbon economy may present untapped growth potential for investors. The growth of the solar industry is one of many examples over the past decade where growth was massively underestimated. Looking into the future, the question is: which companies may emerge as future innovators and take advantage of these high growth opportunities via the successful development or growth of key low-carbon technologies? MSCI ESG Research's low-carbon technology model is based on current green revenues as well as company-specific patent data. Recently published patent databases allow an evidence-based, view into the strategic R&D investments of companies, which may complement the policy risk analysis on GHG reduction requirements. MSCI ESG Research's model currently assesses millions of unique low carbon patents that have been granted from 40 patent authorities worldwide. Using current green revenues and patent analysis as a proxy for low carbon innovative capacity, we simulate which companies may benefit if/when 3ºC, 2ºC or 1.5ºC policies are implemented on a global level. The graph below shows the low carbon patent score of seven selected automotive companies until 2032.

Relative low carbon patent value over time for the automotive sector



Source: MSCI ESG Research LLC.

MSCI ESG Research takes a multifaceted approach to establishing the future value of each patent. Using the current green revenues as a starting point, patent valuation is then used to estimate the level of "future green revenue" that each company could attain from the establishment and sale of low carbon technologies. To establish a value for each patent and compare them within the patent database, MSCI ESG Research looks at the following characteristics of patents:

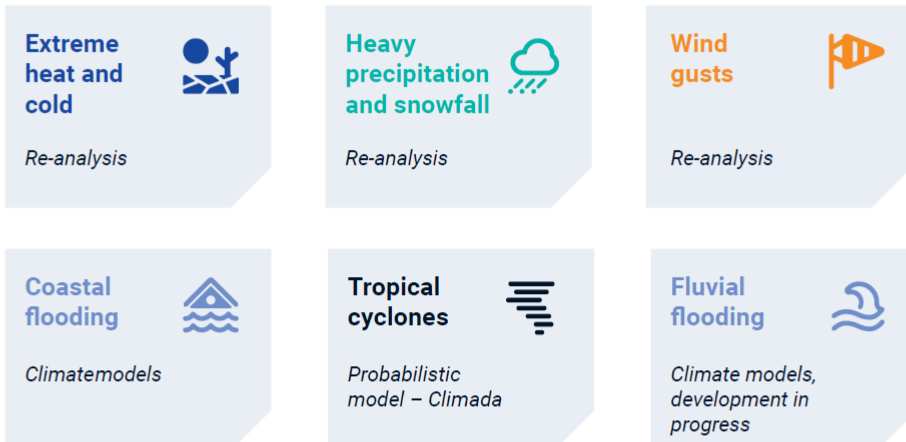
- **Backward citations**
- **Forward citations**
- **Number and economic size of countries where patent coverage has been filed**
- **Number of different industries applicable to each patent**

To get the power of the patent portfolio for one company, an average weighted sum of these four factors is calculated for all patents belonging to a company. This sum is designed to deliver a deep understanding of the potential valuation of a company's patent portfolio, which is used in conjunction with the current green revenues to estimate future green revenues. MSCI ESG Research's green revenue forecast for each company can be used to assess the investment exposure for certain technologies under a 3°C, 2°C, or 1.5°C transition scenario.

PHYSICAL RISKS AND OPPORTUNITIES

RISKS AND OPPORTUNITIES OF EXTREME WEATHER

Physical climate scenarios define possible climate consequences resulting from increased concentration of GHG emissions. They describe changes in global temperatures, precipitation levels, extreme weather events such as storms, snowfall, wildfires, etc. Using the past 35 years of observed extreme weather to set a historical base-line, MSCI ESG Research brings current and future extreme weather developments into perspective for the coming 15 years. Current physical climate scenarios modeled by MSCI ESG Research include costs of extreme weather events relating to temperature changes (extreme heat and cold), extreme precipitation, extreme snowfall and wind patterns. Recent additions to the model have been datasets on tropical cyclones and coastal flooding (from sea level rise).



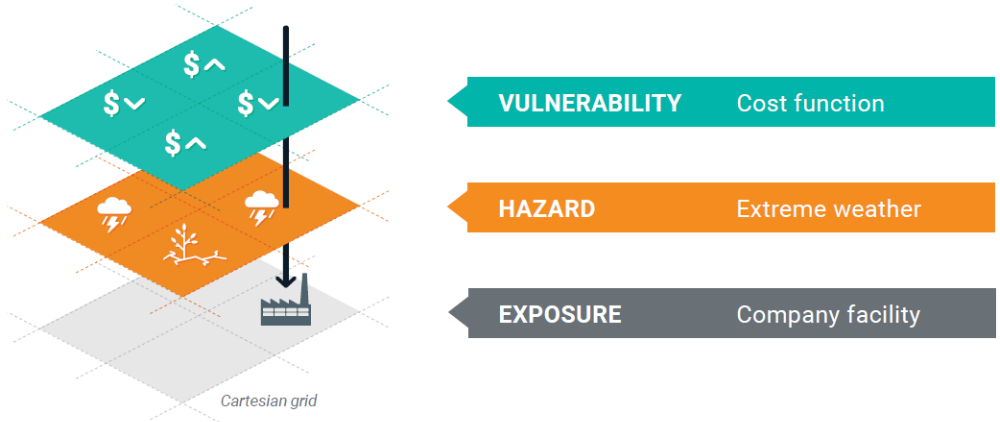
Physical climate impacts vary greatly depending on geographical positioning. This is why MSCI ESG Research employs global gridded data for assessing physical impacts. To model high-resolution spatial distributions of extreme weather impacts across the globe, MSCI ESG Research has produced a 0.5° x 0.5° Cartesian grid whereby hazard data is overlaid. The coverage is global, reaching across all land covered area, and the grid cell width in mid-latitudes is around 15km, which reasonably resolves most cities.

MSCI works closely with the Potsdam Institute for Climate Impact Research (PIK) to define the hazard datasets and vulnerability functions used in the Climate VaR model.

COST CALCULATION

To quantify physical risks and opportunities, MSCI applies a formula used in most hazard models in the insurance industry, which can be represented as follows:

Expected cost = vulnerability * hazard * exposure.



MSCI ESG Research's physical climate methodology is not only applicable for extreme weather scenario modelling, as outlined above. Additional climate datasets will be added to the Climate VaR model in 2020, computing other physical impacts. MSCI ESG Research and PIK are currently refining and calibrating a wealth of physical climate change data together.

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