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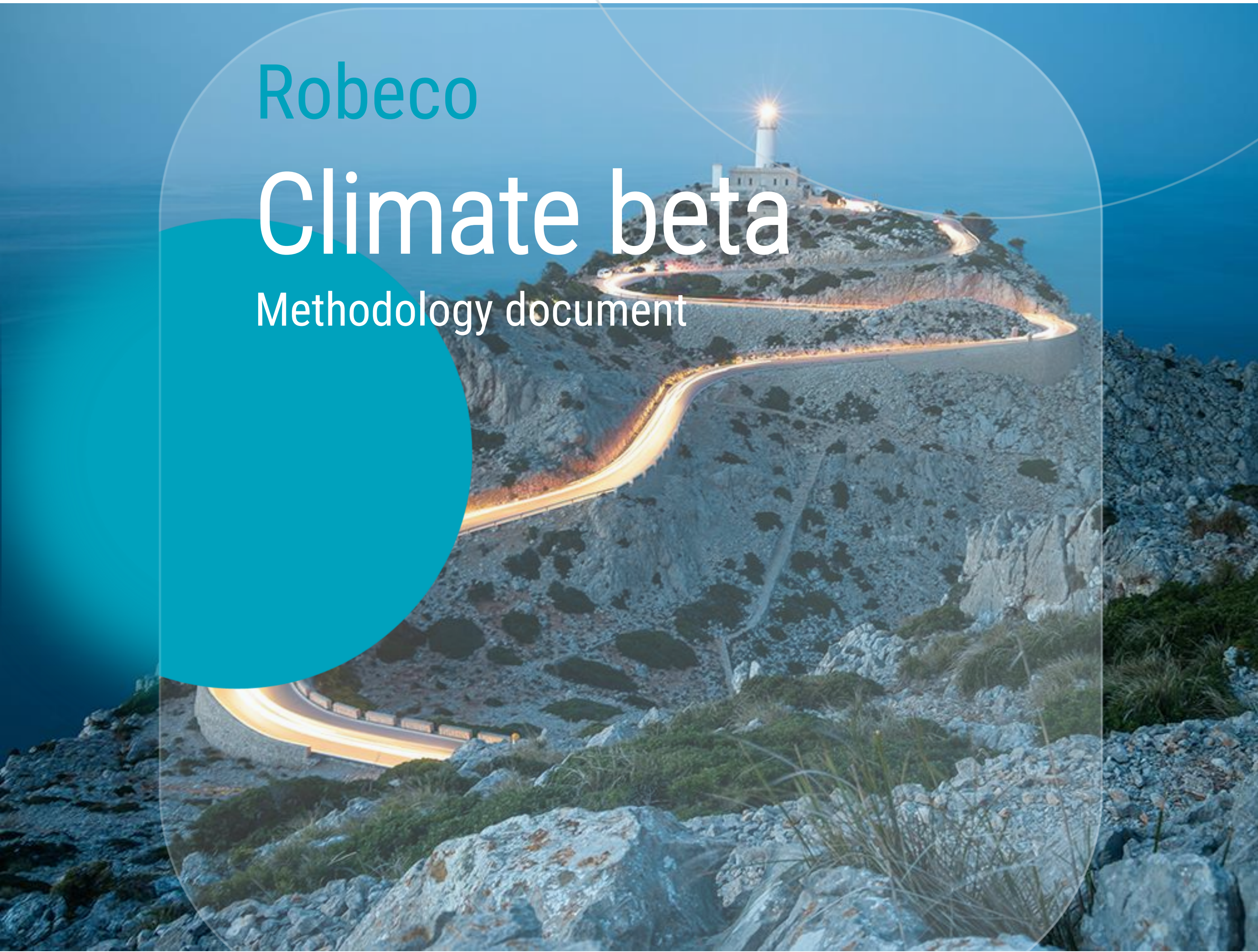

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Climate beta

Methodology document

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Contents

Climate beta: Novel measure of stock sensitivity to climate transition risk 3

The climate risk factor 4

Regression approach 5

Climate beta in practice 6

Climate beta in the academic literature 7

Climate beta in Robeco Indices 7

Conclusion 8

METHODOLOGY DOCUMENT – DECEMBER 2024

Investment research for professional investors

Robeco Indices Team

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Climate beta: Novel measure of stock sensitivity to climate transition risk

Robeco's climate beta is a forward-looking measure that captures climate transition risk above and beyond traditional carbon emissions data. Climate beta is based on the correlation of a stock with the climate risk factor and reflects the anticipated positive or negative reaction of the stock price to climate events. Because climate beta is based on publicly available information, it provides a novel, objective perspective on climate transition risk.

While climate transition risk has become a critical concern for most investors, addressing it presents inherent challenges, many of which are data related. Carbon emissions data, although valuable, is not specifically designed to measure climate transition risk. Even though the quality of Scope 1 and Scope 2 emissions data is relatively good and still improving, it has notable limitations. For instance, the data is often backward-looking with potential lags that can exceed two years, which means it does not capture any recent actions companies have taken to reduce emissions.

Moreover, while carbon emissions data typically provides a good indication of companies likely to be negatively affected by a sudden shift to a low-carbon economy, it is less effective at identifying potential 'winners' in such a transition. Another significant drawback is that not all companies report their carbon emissions data. To address this gap, data providers use proprietary models to estimate emissions for non-reporting companies. However, these estimates can vary significantly between providers, raising questions about their reliability.[1]

Climate beta is based on the concept that the market is relatively efficient in pricing transition risk in the near- and medium-term. It relies on the climate risk factor, which measures the return differential between stocks with high climate risk exposure and those with low climate risk exposure. By incorporating current events and market expectations, climate beta is a more timely and forward-looking measure compared to, for example, emissions data. Additionally, the methodology is applicable to a wide range of securities, as market data is available for virtually all listed companies. Such data is highly transparent, because it is not dependent on voluntary disclosures.

Most importantly, climate beta is able to identify companies vulnerable to the low-carbon transition (climate laggards) and those expected to benefit from it (climate leaders). This is crucial information that generic emissions data does not provide.

Estimating climate betas relies on a two-step procedure:

- In step 1, we calculate the return of the climate risk factor that captures the return differential between companies with high climate risk exposure and companies with low climate risk exposure.

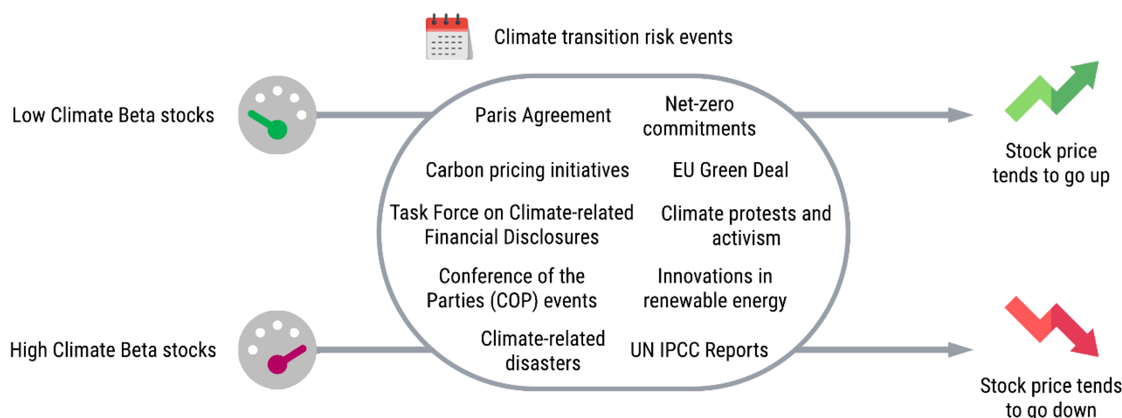
- In step 2, we perform a weighted least squares regression to estimate a stock's return sensitivity to changes in the climate risk factor.

This results in a single number that indicates whether a stock tends to outperform (negative climate beta) or underperform (positive climate beta) when there is a positive shock to the climate risk factor. When the climate beta of a stock is zero, the price of the stock tends to be unresponsive to changes in the climate risk factor and insensitive to climate transition risk. Examples of climate-related events in which climate uncertainty is high are the US presidential elections, Conference of the Parties (COP) events, and natural disasters such as bush fires in Australia.

[1] See for example Busch, Johnson, and Pioch (2020) "Corporate Carbon Performance Data: Quo Vadis?"

Figure 1 illustrates this concept. There are two stocks, a climate leader with a low and negative climate beta (highlighted in green) and a climate laggard with a high and positive climate beta (highlighted in magenta). Note that a high climate beta indicates a tendency to co-move positively with the climate risk factor, which depreciates in times of rising climate concerns. In response to a climate risk event (e.g. introduction of a global carbon price, a cap on emissions, introduction of a low-cost renewable energy source, etc.), the low climate beta stock tends to appreciate in value, while the high climate beta stock tends to depreciate in value. This relationship holds for both positive shocks to climate risk as well as for negative shocks.

Figure 1 – Conceptual illustration of climate beta



Source: Robeco

The climate risk factor

In step 1 we calculate the climate risk factor. The climate risk factor captures return differences between stocks with high climate risk exposure and stocks with low climate risk exposure. Robeco calculates two long-short Climate Risk Factor Indices on a daily basis: the **Robeco Developed Climate Risk LS Factor Index USD Total Return Index** and the **Robeco Emerging Climate Risk LS Factor Index USD Total Return Index**. The returns of these indices represent the return differential between a long basket of stocks with poor climate SDG scores and a short basket of stocks with good climate SDG scores.[2]

"The Robeco Climate Risk Long-Short Factor Indices track the return differentials between a long basket of stocks with poor climate SDG scores and a short basket of stocks with good climate SDG scores

The Robeco Climate Risk Factors are available for reference and can be downloaded via the website of S&P Global[3] and via other data providers such as FactSet.

[2] The Robeco SDG-alignment scores measure a company's contributions to the 17 Sustainable Development Goals (SDGs). The scores range from -3 (strongly misaligned) to +3 (strongly aligned). Companies with a zero score have neutral impacts on the SDGs. Climate-related SDGs are SDG 7 (Renewable and Affordable Energy) and SDG 13 (Climate Action). Robeco's SDG-alignment scores are available for download via the Sustainable Investing Open Access project.

[3] See Robeco Developed Climate Risk LS Factor Index USD Total Return | S&P Dow Jones Indices for developed markets and Robeco Emerging Markets Climate Risk LS Factor Index USD Total Return | S&P Dow Jones Indices for emerging markets.

Figure 2 presents a screenshot of the Robeco Developed Climate Risk LS Factor Index as viewed from S&P Global's web portal. Looking at the long-term performance of the Developed Climate Risk Factor, we can roughly identify three different "regimes". In the years from 2006 to 2012, the Climate Risk Factor gained in value, which implies that stocks with poor climate SDG scores outperformed stocks with good climate SDG scores. This period coincides with increased oil and commodities prices. From 2012 to mid-2020, a long downward trend occurred, indicating that over this period, stocks with good climate SDG scores outperformed their poor climate SDG counterparts. This period coincides with tightening climate policies and a general shift towards sustainable investing. Lastly, starting from 2020, we see low-climate-SDG firms outperforming.

Figure 2 – The Robeco Developed Climate Risk Factor

Source: S&P Global and Robeco Sustainable Index Solutions. The Robeco Climate Risk Factors are available at https://www.spglobal.com/spdji/en/custom-indices/robeco-indices-bv/robeco-developed-climate-risk-ls-factor-index-usd-total-return/#overview

Regression approach

In the second step, we calculate the climate beta of a stock by regressing its return on the climate risk factor while controlling for broad market movements.

Climate betas are estimated using weighted least squares (WLS) regressions.[4] Using WLS instead of ordinary least squares (OLS) leads to regression estimates that assign greater weight on more recent information.[5] We perform the regression as follows:

$$R_t = \alpha + \beta^M MKT_t + \beta^{CB} CRF_t + \varepsilon_t$$

In the above equation, R_t represents the return on the stock month *t* in excess of the risk-free rate, α is the risk-adjusted outperformance, β^M is the exposure to the market factor, MKT_t is the return on the market factor in excess of the risk-free rate, β^{CB} is the climate beta, CRF_t is the return on the climate risk factor, and ε_t is the residual.

To further improve the usefulness of the climate betas, we apply a technique called empirical Bayes shrinkage. This reduces the effects of sampling variation. Specifically, a model that incorporates shrinkage typically performs better in out-of-sample estimation tasks. We apply shrinkage using normal-normal updating with priors defined by

[4]The weighting scheme applied is the exponentially weighted moving average (EWMA). We use a decay parameter λ of 0.97 since it is recommended by RiskMetrics for use with monthly stock returns. The regression is performed with a 60-month (5-year) historical estimation window. We require at least 24 monthly return observations to complete the regression.

[5] Note that the regression can also be conducted using OLS, potentially in combination with a moving regression window, but this will lead to climate beta estimates that adjust more slowly to new information.

GICS industries.[6] In simple terms, this implies that when the estimated climate beta of a stock strongly deviates from the average climate beta in its industry, the coefficient is (slightly) adjusted towards the industry average. The adjustment is performed only to the extent that it corrects for the regression's estimation uncertainty.

Climate beta in practice

In this section, we provide two case studies on climate beta as used in practice. In the first case study, we provide two examples of how climate beta and emission intensities can convey different information. These anonymized examples are highlighted in Table 1.

The first example considers a large company active in serving the oil & gas industry. Note that this company does not directly produce high emissions, but rather is economically exposed to the oil sector and carbon emissions via its operations. While this company scores in the lowest decile for emission intensity, its climate beta ranks among the top 10% of companies with the highest climate betas.

The second example considers a utility firm that is recognized as an industry leader in renewable energy. While its emissions are relatively high, the climate beta of this firm ranks in the bottom decile of companies with the lowest climate betas, which is much more in line with intuition based on the company's business model (see description).

Table 1 –Examples of climate beta vs. emissions

Name	Description	Sector (GICS)	Scope 1+2 emissions	Scope 1+2 intensity	Climate beta
Land Ownership Co.	US land ownership corporation that collects royalties from the extraction of oil and gas from its lands.	Financials	31,679 Low 2nd decile	2 Low 3rd decile	0.96 High 10th decile
Renewable Energy Co.	US energy company, offering business solutions for a path towards decarbonization	Utilities	43 million High 10th decile	199 High 10th decile	-0.45 Low 1st decile

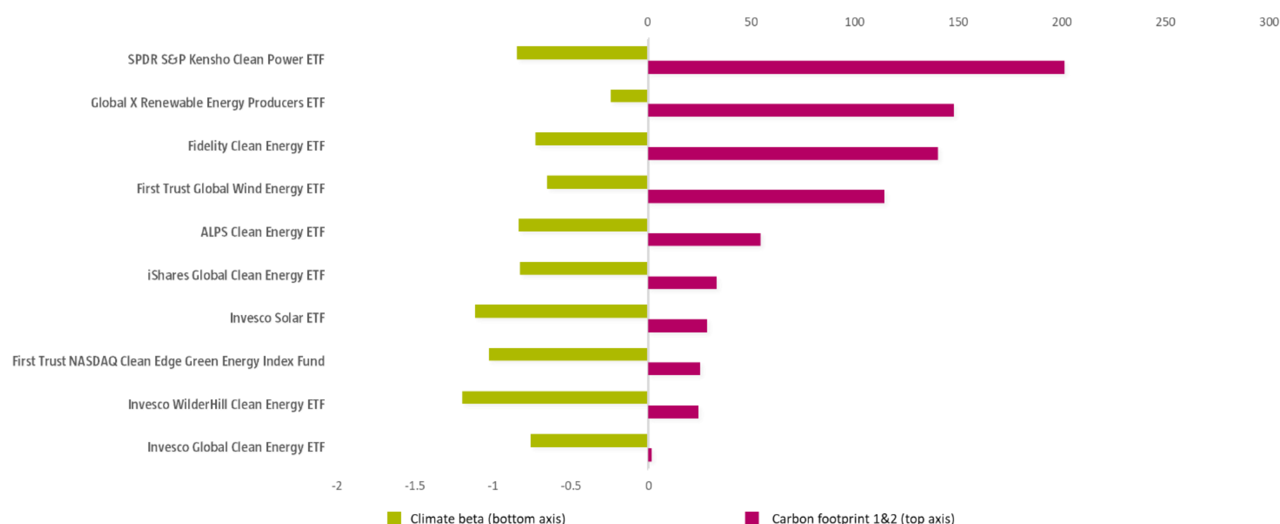
Source: Robeco, Trucost. Emissions are reported in metric tonnes of CO_2-equivalent.The universe used is MSCI World. The analysis is conducted using data as of March 2024.

Our second case study considers the climate beta of a portfolio. This can be estimated in two ways. The first is bottom up, that is, by aggregating the climate betas of the underlying positions that make up the portfolio. Here we highlight the second approach, namely, top down, where climate betas are highlighted for a selection of 10 renewable energy ETFs.

These were estimated directly from the ETFs' returns. The average carbon footprint of the constituents in these ETFs vary, but are high overall. Their climate betas, however, are in all cases significantly negative. Hence, this shows that climate beta provides unique insights into climate transition risk that cannot be derived from generic emissions data. Specifically, the climate betas correctly indicate, in this case, that renewable energy ETFs tend to be less sensitive to climate transition risk and therefore tend to have higher returns when this is high. Focusing on emissions data could therefore potentially lead to sub-optimal decisions regarding these ETFs, or the companies that these ETFs hold, in terms of climate transition risk and the impact climate-related events may have on returns.

[6] In technical terms, the posterior climate beta is calculated using the estimated climate beta and the squared standard error of the climate beta coefficient. For more information regarding this adjustment, contact Robeco Indices.

Figure 3 – Renewable energy ETFs: Carbon footprint vs. climate beta relative to MSCI World



Source: Robeco, Trucost, FactSet, Morningstar. The analysis is conducted using data as of 18 May 2022.

Climate beta in the academic literature

Climate beta builds on concepts that have been theorized and thoroughly tested in decades of academic research on asset pricing and expected stock returns. See for example work by Huij, Laurs, Stork, and Zwinkels (2020). Moreover, a similar concept is applied by Görgen, Jacob, Nerlinger, Riordan, Rohleder, and Wilkens (2017)[7], who study the asset pricing implications of a green-minus-brown factor portfolio and find that an extended factor model that includes such a factor is better able to explain the cross-section of returns.

Engle, Giglio, Kelly, Lee, and Stroebel (2020)[8] use machine learning to construct a hedging strategy that generates high returns when climate news spikes. Huynh and Xia (2020)[9] estimate corporate bond sensitivities to climate change news using a similar approach as the one outlined in this document.

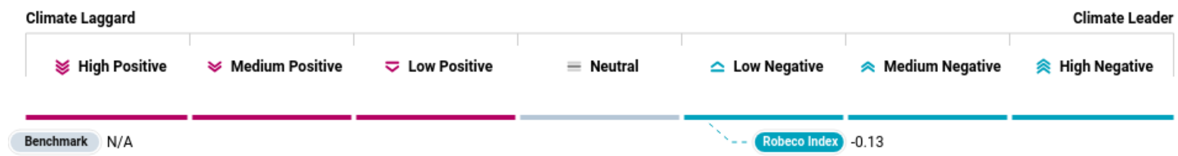
Moreover, climate risk factors provide crucial information in the research by Pástor, Stambaugh, and Taylor (2022),[10] Bolton and Kacperczyk (2021)[11] and Blasberg, Kiesel, and Taschini (2021) who study the additional return generated by brown assets over green assets.[12]

Climate beta in Robeco Indices

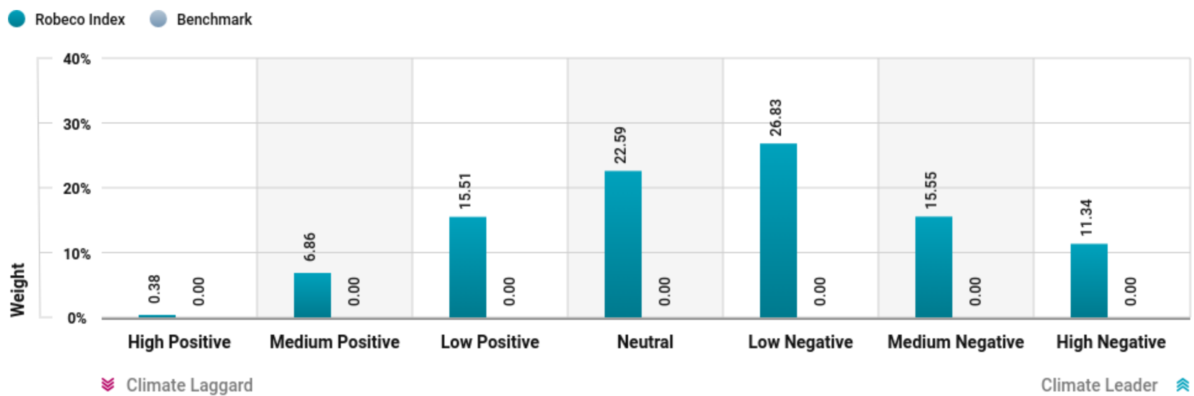
In nearly all of Robeco's Climate, Sustainable and (Multi)-Factor Indices, the climate transition risk is managed by stipulating that the climate beta of our indices must be lower than the (market-cap weighted) benchmark. In certain Climate Indices, e.g. the Robeco Paris-Aligned Climate Leaders Tilt Index, we impose an even more stringent restriction to further lower the climate transition risk profile. Figure 4 shows how such a restriction shifts the index positions away from climate laggards and toward climate leaders.

[7] Carbon Risk, available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2930897
[8] Hedging Climate Change News, available at: https://www.jstor.org/stable/48574183
[9] Climate Change News Risk and Corporate Bond Returns, available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3577321
[10] Dissecting Green Returns, available at: https://www.sciencedirect.com/science/article/abs/pii/S0304405X22001672
[11] Do Investors Care About Carbon Risk?, available at: https://www.sciencedirect.com/science/article/abs/pii/S0304405X21001902
[12] Carbon Default Swap – Disentangling the Exposure to Carbon Risk through CDS, available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3856993

Figure 4 – Distribution across climate leaders and laggards of Robeco Paris-Aligned Climate Leaders Tilt Index vs. benchmark



Distribution across climate beta



Source: Robeco. The benchmark is the S&P Developed LargeMidCap ex Korea and Luxembourg Index. The analysis is conducted using data as of November 2024.

Conclusion

Climate beta provides a forward-looking climate transition risk metric that provides unique insights above and beyond traditional carbon emissions data. By using climate beta, investors can better protect their investments against high climate transition risk and negative climate-related events.

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Additional information for investors with residence or seat in Spain
Robeco Institutional Asset Management B.V., Sucursal en España with identification number W0032687F and having its registered office in Madrid at Calle Serrano 47-14º, is registered with the Spanish Commercial Registry in Madrid, in volume 19.957, page 190, section 8, sheet M-351927 and with the National Securities Market Commission (CNMV) in the Official Register of branches of European investment services companies, under number 24. The investment funds or SICAV mentioned in this document are regulated by the corresponding authorities of their country of origin and are registered in the Special Registry of the CNMV of Foreign Collective Investment Institutions marketed in Spain.
Additional information for investors with residence or seat in South Africa
Robeco Institutional Asset Management B.V. is registered and regulated by the Financial Sector Conduct Authority in South Africa.
Additional information for investors with residence or seat in Switzerland
The Fund(s) are domiciled in Luxembourg. This document is exclusively distributed in Switzerland to qualified investors as defined in the Swiss Collective Investment Schemes Act (CISA). This material is distributed by Robeco Switzerland Ltd, postal address: Josefstrasse 218, 8005 Zurich. ACOLIN Fund Services AG, postal address: Leutschenbachstrasse 50, 8050 Zürich, acts as the Swiss representative of the Fund(s). UBS Switzerland AG, Bahnhofstrasse 45, 8001 Zurich, postal address: Europastrasse 2, P.O. Box, CH-8152 Opfikon, acts as the Swiss paying agent. The prospectus, the Key Information Documents (PRIIP), the articles of association, the annual and semi-annual reports of the Fund(s), as well as the list of the purchases and sales which the Fund(s) has undertaken during the financial year, may be obtained, on simple request and free of charge, at the office of the Swiss representative ACOLIN Fund Services AG. The prospectuses are also available via the website.
Additional information relating to RobecoSAM-branded funds/services
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The Prospectus has not been approved by the Securities and Exchange Commission which takes no responsibility for its contents. No offer to the public to purchase the Shares will be made in Thailand and the Prospectus is intended to be read by the addressee only and must not be passed to, issued to, or shown to the public generally.
Additional information for investors with residence or seat in the United Arab Emirates
Some Funds referred to in this marketing material have been registered with the UAE Securities and Commodities Authority ("the Authority"). Details of all Registered Funds can be found on the Authority's website. The Authority assumes no liability for the accuracy of the information set out in this material/document, nor for the failure of any persons engaged in the investment Fund in performing their duties and responsibilities.
Additional information for investors with residence or seat in the United Kingdom
Robeco is deemed authorized and regulated by the Financial Conduct Authority.
Additional information for investors with residence or seat in Uruguay
The sale of the Fund qualifies as a private placement pursuant to section 2 of Uruguayan law 18,627. The Fund must not be offered or sold to the public in Uruguay, except under circumstances which do not constitute a public offering or distribution under Uruguayan laws and regulations. The Fund is not and will not be registered with the Financial Services Superintendency of the Central Bank of Uruguay. The Fund corresponds to investment funds that are not investment funds regulated by Uruguayan law 16,774 dated 27 September 1996, as amended.

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