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Integrating Climate Risk Into an Insurer's Strategic Asset Allocation

When practitioners apply climate considerations into strategic models such as strategic asset allocation (SAA), they tend to apply climate-impact adjustments at the security level *after* the portfolio optimization is complete.

Neuberger Berman has developed a proprietary framework to estimate the potential impact of climate change at the asset-class level, which can then be used to generate climate-adjusted capital market assumptions to serve as inputs in an SAA. We believe there are considerable advantages to this *ex-ante* adjustment for climate-related effects because SAA determines a meaningful portion of the variation of portfolio returns over time. Substantial variation exists in our estimated climate effects for asset classes, sectors and regions, suggesting the availability of abundant "climate asset-allocation alpha."

In previous work, we showed that this "Climate SAA" process could "recover" some of the estimated return "lost" when climate-related effects are applied *ex post*.

In this paper, we apply the same Climate SAA framework with constraints and objectives, such as solvency capital requirements and asset-liability matching, designed to reflect those of European insurance investors.

Executive Summary

- We use a proprietary framework that incorporates "Climate Value at Risk" (Climate VaR) and an equivalent proprietary sovereign bonds model to estimate the potential impact of climate change on the present value of assets and securities, which we then aggregate up to the benchmark index level to use as inputs into the strategic asset allocation (SAA) process.
- Under a 2°C warming scenario, we subject the optimized asset allocations of a typical UK general insurer and Continental European life insurer to these climate-related adjustments to estimated returns: these *ex-post* adjustments lower the portfolios' estimated returns, revealing them to be sub-optimal.
- We run an optimization for each insurer that integrates climate-related effects into the SAA by subjecting the portfolio constituents to climate-cost adjustments *ex ante.*
  - This "Climate SAA" process "recovers" a large portion of the estimated return "lost" to the *ex-post* adjustment for climate adjustments.
  - The process also lowers the solvency capital requirements (SCR) of the portfolios on the efficient frontier, as it results in allocations away from equities and extended fixed income and toward core fixed income.
- Climate SAA also lowers the financed emissions of the portfolios; introducing financed emissions as a constraint in the Climate SAA optimization can lower them even further, with minimal effect on estimated return and volatility (but with some sacrifice of solvency-capital efficiency).

Traditional ESG analyses have tended to focus on fundamental or "bottom-up" factors. That means climate considerations are generally addressed at the sector and company level only after a portfolio's strategic asset allocation (SAA) has been set. This leaves climate risk exposure unrecognized and unmanaged at the SAA level.

At Neuberger Berman, we believe that this is a significant decision, given that SAA can drive up to 90% of the variation in portfolio returns over time. We believe that fully integrating climate considerations into SAA can identify portfolio-level return potential that is missed when climate-related impact is considered only afterwards, at the issuer level. That belief was reinforced when we applied our climate-related adjustments to the expected returns of our universes of corporate bonds and equities, and found very wide dispersion at the regional, asset-class and sector levels. This suggests to us an abundant availability of top-down "climate asset-allocation alpha."

Neuberger Berman developed its proprietary "Climate SAA" model to test this hypothesis, and set out its findings in its 2022 paper, *Integrating Climate Risk into Strategic Asset Allocation*. We found that, when we adjusted asset-class expected returns for climate-related effects *after* conducting a standard SAA optimization, it lowered the efficient frontier relative to the standard SAA output. When we adjusted asset-class estimated returns *before* conducting the optimization, however, we found that it "recovered" some of that lost estimated return.

In other words, integrating climate-related effects *ex ante* into the SAA optimization process achieved higher levels of estimated return with no additional portfolio volatility, relative to imposing the effects after a standard SAA.[1]

[1] Charles Nguyen, Tully Cheng, et al, Integrating Climate Risk into Strategic Asset Allocation (May 2022), at https://www.nb.com/en/gb/insights/integrating-climate-risk-into-strategic-asset-allocation.

Climate VaR

How do we estimate climate effects and integrate them into an SAA?

We use a "Climate Value at Risk" (Climate VaR) model to estimate the impact of climate change on most equity and corporate bond securities. Climate VaR is defined as the present value of aggregated future policy risk costs, technology opportunity profits, and extreme weather event costs and profits, under a given warming scenario, expressed as a percentage of a security or portfolio's market value. This initial analytical step can be useful in itself, in that it reveals where climate-related risks and opportunities may lie in an existing portfolio or asset allocation. To get the most out of the information, however, we think it is best to bring it into the investment process before the risks are allowed into the portfolio.

To that end, we use a proprietary methodology to convert this present value of costs into a change in return expectation, and then aggregate these security-level Climate VaR return adjustments, using the relevant index's security weights, to create a climate risk-adjusted, index-level estimated return to use in the Climate SAA process.

In this paper, we aim to apply Climate SAA to portfolios typical of insurance investors. European insurance portfolios tend to have meaningful allocations to sovereign bonds, requiring us to apply an "apples-to-apples" equivalent of Climate VaR to those assets. Our estimates of climate impact on sovereign bonds are calculated by taking the same future policy risks, technology opportunities and extreme weather events that go into the Climate VaR model, and applying them to macro-financial factors such as GDP growth, debt-to-GDP ratios and inflation.[2]

As in our previous work, to test the benefit of integrating these climate-related effects into the SAA process, we first apply them *ex-post* to the estimated returns of illustrative UK and Continental European insurance portfolios, before re-optimizing them with the climate effects applied *ex ante.* We can then quantify how much of the "lost" estimated return has been "recovered" by this Climate SAA process.

Climate SAA for a Typical UK General Insurer

In the Appendix, we describe a typical UK insurer's balance sheet and asset allocation, based on what we see in the current market.

While this asset allocation reflects what is typical for the sector, it is not an optimized portfolio. Therefore, to provide a more robust starting point, we optimize for estimated return and surplus volatility (reflecting the illustrative insurer's asset-liability matching), with constraints based on the illustrative insurer's estimated solvency capital requirements (SCR), and on asset weights that would be reasonable for such an insurer to consider.

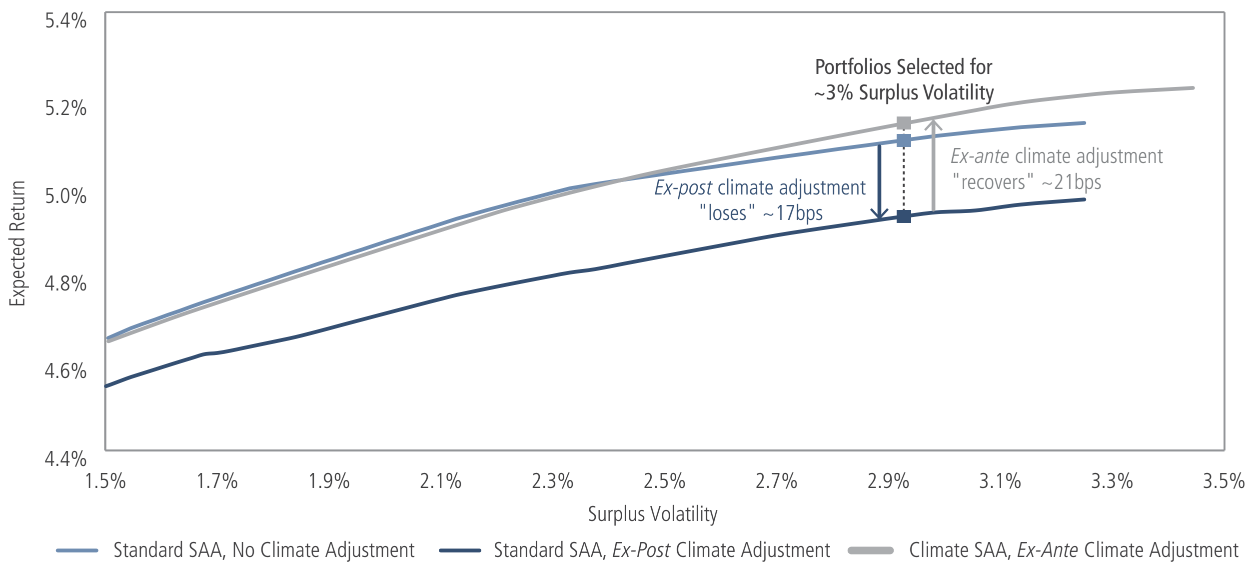
This provides us with an efficient frontier from which we can select the portfolio that has similar surplus volatility to that of our illustrative UK insurer, around 3%. That portfolio has an estimated return of 5.11%.

We then take the standard approach to climate-related costs: applying Climate VaR and its equivalents to the constituents of the portfolio, assuming a 2°C warming scenario, after the optimization is complete. For a surplus volatility level around 3%, the estimated return falls from 5.11% to 4.94%, a loss of 17 basis points. The efficient frontiers for these optimizations are shown light and dark blue in figure 1.

[2] Our illustrative Continental European life insurer asset allocations include private equity and hedge funds. As we are still developing a Climate VaR equivalent for these asset classes, in this paper their estimated returns remain unadjusted for climate effects.

FIGURE 1. CLIMATE EFFECTS CAN BE MITIGATED BY INTEGRATING THEM INTO AN SAA

Standard and Climate SAA efficient frontiers for a typical UK general insurer



Source: Bloomberg, MSCI, JP Morgan, S&P Global, Neuberger Berman. Data as of April 2023. Indices used: Bloomberg-Barclays Indices for Government/Agency Debt, Corporate Bonds, and US Equities; MSCI Indices for UK Equity and Global Equity; JPM EMBI for Emerging Markets Sovereign Debt; JPM CEMBI for Emerging Markets Corporate Bonds; MSCI and S&P Global Indices for Real Estate. **Past performance is no guarantee of future results.** Please note that estimated returns data is based on NB's capital markets assumptions and are provided for information purposes only. There is no guarantee that estimated returns will be realized or achieved nor that an investment strategy will be successful, and may be significantly different than shown here. Investors should keep in mind that the securities markets are volatile and unpredictable. There are no guarantees that historical performance of an investment, portfolio, or asset class will have a direct correlation with its future performance. Net returns will be lower.

How much of this "lost" estimated return can be "recovered" by adjusting for climate-related effects before optimizing the portfolio, rather than afterwards? That is shown by the gray efficient frontier in figure 1. The selected Climate SAA portfolio, with the same level of surplus volatility as the Standard portfolios, has an estimated return of 5.15%. Climate SAA has recovered 21 basis points, more than the 17 basis points lost when we made *ex-post* adjustments for climate-related effects.

This recovered loss represents asset-allocation alpha. But it also represents something even more interesting: "climate asset-allocation alpha." To understand what we mean by that, let's take a closer look at how this Climate SAA process changes both the portfolio's asset allocation and its general risk profile, in figure 2. This shows the profiles of the Standard and Climate portfolios selected from the efficient frontiers for 2.9% surplus volatility.

FIGURE 2. INTEGRATING CLIMATE EFFECTS INTO AN SAA CAN PROFOUNDLY CHANGE A PORTFOLIO'S RETURN-RISK PROFILE

Effect of *ex-ante* Climate SAA at asset class level, and on portfolio risk profile

	Standard SAA, Ex-Post Climate Adj.	Climate SAA	Δ (Climate – Standard)
Sterling Gov/Agency	15.9%	16.4%	0.5%
Sterling IG Corp	32.5%	31.5%	-1.0%
Euro Gov/Agency	8.5%	9.0%	0.5%
Euro IG Corp	13.1%	16.6%	3.5%
US Gov/Agency	8.5%	8.7%	0.2%
US IG Corp	6.5%	6.3%	-0.2%
Core Fixed Income	**85.1%**	**88.5%**	**3.4%**
HY BB	5.0%	5.0%	0.0%
EMD	1.5%	0.0%	-1.5%
Extended Fixed Income	**6.5%**	**5.0%**	**-1.5%**
Real Estate	2.0%	2.0%	0.0%
UK Equity	3.8%	2.6%	-1.1%
US Equity	0.8%	0.5%	-0.2%
Global Equity	1.9%	1.3%	-0.6%
Equity & Alternatives	**8.4%**	**6.5%**	**-1.9%**
Expected Return	4.94%	5.15%	0.21%
Surplus Volatility	2.9%	2.9%	0.0%
Asset Volatility	3.0%	3.0%	0.0%
Asset Duration	2.0	2.0	0.0
Surplus Duration	0.4	0.4	0.0
Carbon Intensity	96	61	-35
Carbon Footprint	52	31	-21
Total SCR	**6.1%**	**5.4%**	**-0.7%**

Asset re-allocation effect of *ex-ante* Climate SAA at industry sector level

	Sterling Core FI	Euro Core FI	US Core FI	Extended FI	Equity
Basic Materials	0.0%	-1.3%	-1.2%	-2.4%	-3.7%
Communications	-1.3%	-2.6%	-2.8%	9.4%	3.1%
Consumer, Cyclical	-6.6%	-4.4%	-4.2%	-22.1%	0.0%
Consumer, Non-cyclical	-5.6%	-0.5%	-2.8%	1.0%	15.8%
Energy	-0.7%	-1.5%	-3.2%	-1.4%	-5.3%
Financial	18.2%	17.0%	24.4%	3.6%	-9.0%
Industrial	-2.1%	-2.6%	-3.9%	-0.1%	-3.4%
Technology	0.0%	-0.9%	-3.7%	0.2%	1.6%
Utilities	-2.0%	-3.3%	-2.7%	11.8%	0.9%

Source: Bloomberg, MSCI, JP Morgan, S&P Global, Neuberger Berman. Data as of April 2023. Indices used: Bloomberg-Barclays Indices for Government/Agency Debt, Corporate Bonds, and US Equities; MSCI Indices for UK Equity and Global Equity; JPM EMBI for Emerging Markets Sovereign Debt; JPM CEMBI for Emerging Markets Corporate Bonds; MSCI and S&P Global Indices for Real Estate. Carbon Intensity and Carbon Footprint data are calculated on Scope 1 and 2 emissions. **Past performance is no guarantee of future results.** Please note that estimated returns data is based on NB's capital markets assumptions and are provided for information purposes only. There is no guarantee that estimated returns will be realized or achieved nor that an investment strategy will be successful, and may be significantly different than shown here. Investors should keep in mind that the securities markets are volatile and unpredictable. There are no guarantees that historical performance of an investment, portfolio, or asset class will have a direct correlation with its future performance. Net returns will be lower.

The first thing to note is the improvement in the portfolio's Scope 1 and 2 carbon intensity and carbon footprint. Carbon intensity is defined as the number of tons of CO_2 equivalents emitted for every million dollars of each constituent company's revenue. The carbon footprint of the portfolio is the absolute apportioned emissions financed by the portfolio itself—that is, the emissions attributed to the portfolio based on its ownership share of an emitter's total invested capital, further normalized by the investment value.

This is an intuitive result, as the optimizer now penalizes the assets whose estimated returns are most affected by climate-related costs, and those assets tend to be issued by entities with relatively large carbon emissions.

More strikingly and counterintuitively, the Climate SAA process reduces the portfolio's solvency capital requirement (SCR) even as it adds 21 basis points of estimated return.

It might be assumed that taking allocation away from equities, high yield bonds and emerging markets debt and giving it to core fixed income, especially EUR-denominated investment grade bonds, would reduce estimated return, not raise it. The fact that it raises estimated return reflects the extent to which the traditionally higher-return asset classes are hit by bigger adjustments for climate-related costs. For example, as we can see in the table in the Appendix, even short-duration US high yield bonds receive a 163-basis-point-per-annum penalty, and UK equities get hit by 77 basis points per annum. With Climate SAA, all of these adjustments are fed into the optimizer *ex ante*, in a way they were not with the Standard efficient frontier.

Finally, it is also worth noting that, like any SAA, the Climate SAA process provides no insight into the additional benefits that can be achieved with security selection, below the levels of asset classes, regions and sectors. At Neuberger Berman, we believe that climate risk-awareness and sustainable business practices tend to be rewarded by the market, and therefore can and should inform bottom-up security selection. In our view, ESG-integrated, sustainable and impact investment strategies that build these factors into their processes or objectives have the potential to squeeze further return from each unit of portfolio risk.

Climate SAA for a Typical Continental European Life Insurer

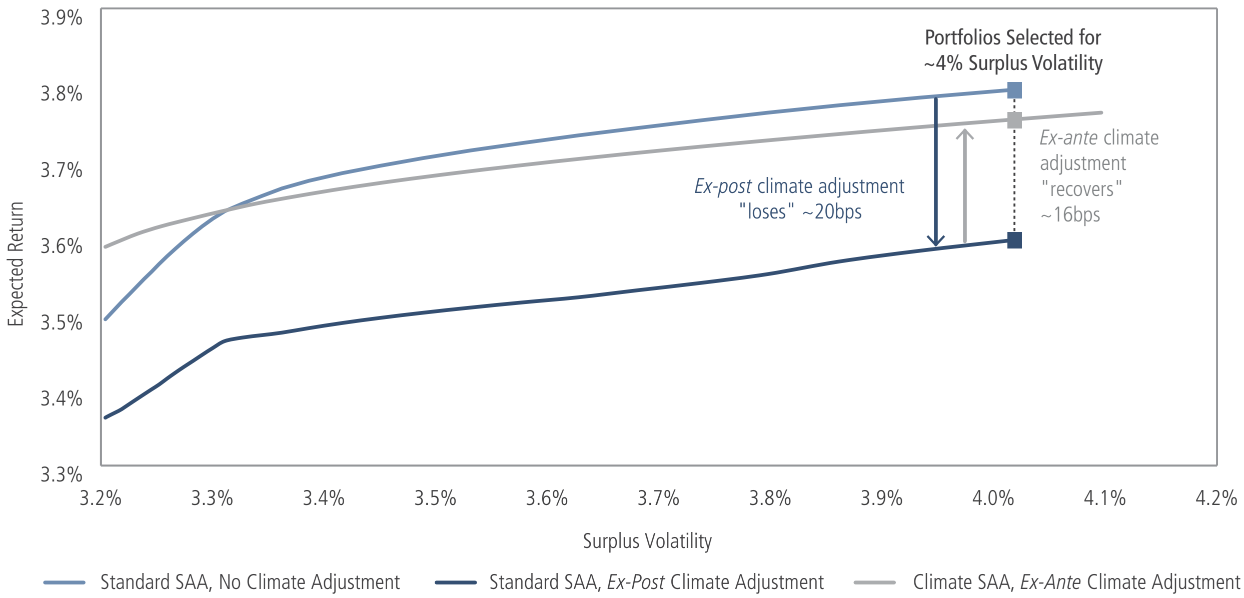
With our Continental European life insurer, we again optimize an efficient frontier with constraints related to the illustrative profile shown in the Appendix. When we select the portfolio that has similar surplus volatility to that of our illustrative asset allocation, around 4%, we find an estimated return of 3.79%.

We apply Climate VaR and its equivalents to the constituents of this efficient frontier and the selected portfolio to find the dark-blue efficient frontier and portfolio shown in figure 3. For a surplus volatility level around 4%, the estimated return falls from 3.79% to 3.59%, a loss of 20 basis points.

A Climate SAA generates the gray efficient frontier. The selected Climate SAA portfolio, with the same level of surplus volatility as the Standard portfolios, has an estimated return of 3.75%, recovering 16 basis points of the total 20 basis points lost by the *ex-post* adjustment for climate-related effects.

FIGURE 3. INTEGRATING CLIMATE EFFECTS INTO AN SAA CAN ENHANCE ESTIMATED RETURN

Standard and Climate SAA efficient frontiers for a typical Continental European life insurer



Source: Bloomberg, MSCI, JP Morgan, S&P Global, Cambridge Associates, HFRI, Neuberger Berman. Data as of April 2023. Indices used: Bloomberg-Barclays Indices for Government/Agency Debt, Corporate Bonds, US Equities and Europe Equities; JPM EMBI for Emerging Markets Sovereign Debt; JPM CEMBI for Emerging Markets Corporate Bonds; Cambridge Associates Indices for Private Equity; HFRI Indices for Hedge Funds; MSCI and S&P Global Indices for Real Estate. **Past performance is no guarantee of future results.** Please note that estimated returns data is based on NB's capital markets assumptions and are provided for information purposes only. There is no guarantee that estimated returns will be realized or achieved nor that an investment strategy will be successful, and may be significantly different than shown here. Investors should keep in mind that the securities markets are volatile and unpredictable. There are no guarantees that historical performance of an investment, portfolio, or asset class will have a direct correlation with its future performance. Net returns will be lower.

Figure 4 confirms, once again, that the Climate SAA process can substantially reduce an insurance portfolio's carbon intensity and carbon footprint while simultaneously lowering its SCR and raising estimated return, due to the *ex-ante* penalization of traditionally higher-return assets.

FIGURE 4. INTEGRATING CLIMATE COSTS INTO AN SAA CAN IMPROVE SOLVENCY CAPITAL EFFICIENCY

Effect of *ex-ante* Climate SAA at asset class level, and on portfolio risk profile

	Standard SAA, Ex-Post Climate Adj.	Climate SAA	Δ (Climate – Standard)
Euro Gov/Agency	20.7%	21.0%	0.3%
Euro IG Corp	60.4%	61.1%	0.6%
US IG Corp	0.0%	0.0%	0.0%
Core Fixed Income	**81.2%**	**82.1%**	**0.9%**
HY BB&B	5.0%	5.0%	0.0%
EMD	5.0%	4.5%	-0.5%
Extended Fixed Income	**10.0%**	**9.5%**	**-0.5%**
US Equity	0.0%	0.0%	0.0%
Europe Equity	5.9%	5.5%	-0.4%
Private Equity	0.5%	0.5%	0.0%
Hedge Funds	0.4%	0.4%	0.0%
Real Estate	2.0%	2.0%	0.0%
Equity & Alternatives	**8.8%**	**8.5%**	**-0.4%**
Expected Return	3.59%	3.75%	0.16%
Surplus Volatility	4.0%	4.0%	0.0%
Asset Volatility	7.1%	7.1%	0.0%
Asset Duration	9.0	9.0	0.0
Surplus Duration	-0.9	-0.9	0.0
Carbon Intensity	170	106	-64
Carbon Footprint	111	67	-43
Total SCR	**13.6%**	**13.4%**	**-0.2%**

Asset re-allocation effect of *ex-ante* Climate SAA at industry sector level

	Euro Core FI	US Core FI	Extended FI	Equity
Basic Materials	-0.4%	-0.1%	-3.3%	-3.1%
Communications	6.2%	2.1%	4.2%	2.2%
Consumer, Cyclical	-0.7%	0.3%	-5.2	-5.2%
Consumer, Non-cyclical	-0.2%	-1.0%	2.7%	15.9%
Energy	0.4%	-1.8%	1.5%	-3.5%
Financial	4.6%	0.3%	9.0%	-0.6%
Industrial	-1.4%	-0.3%	-6.5%	-6.4%
Technology	0.2%	0.1%	1.0%	2.8%
Utilities	-8.7%	0.4%	-3.5%	-2.2%

Source: Bloomberg, MSCI, JP Morgan, S&P Global, Cambridge Associates, HFRI, Neuberger Berman. Data as of April 2023. Indices used: Bloomberg-Barclays Indices for Government/Agency Debt, Corporate Bonds, US Equities and Europe Equities; JPM EMBI for Emerging Markets Sovereign Debt; JPM CEMBI for Emerging Markets Corporate Bonds; Cambridge Associates Indices for Private Equity; HFRI Indices for Hedge Funds; MSCI and S&P Global Indices for Real Estate. Carbon Intensity and Carbon Footprint data are calculated on Scope 1 and 2 emissions. **Past performance is no guarantee of future results.** Please note that estimated returns data is based on NB's capital markets assumptions and are provided for information purposes only. There is no guarantee that estimated returns will be realized or achieved nor that an investment strategy will be successful, and may be significantly different than shown here. Investors should keep in mind that the securities markets are volatile and unpredictable. There are no guarantees that historical performance of an investment, portfolio, or asset class will have a direct correlation with its future performance. Net returns will be lower.

Integrating Financed Emissions into the SAA Process

In both the UK and Continental European insurer case studies, we found that the Climate SAA process substantially reduced carbon intensity and carbon footprint while simultaneously lowering SCR and raising estimated return.

We think this is notable, especially in light of the recent approval, by the European Parliament's Committee on Economic and Monetary Affairs, of draft amendments to Solvency II that would require insurers to publish quantifiable plans for achieving net-zero portfolio emissions by 2050, as well as the processes by which they monitor and address carbon-transition risks.[3]

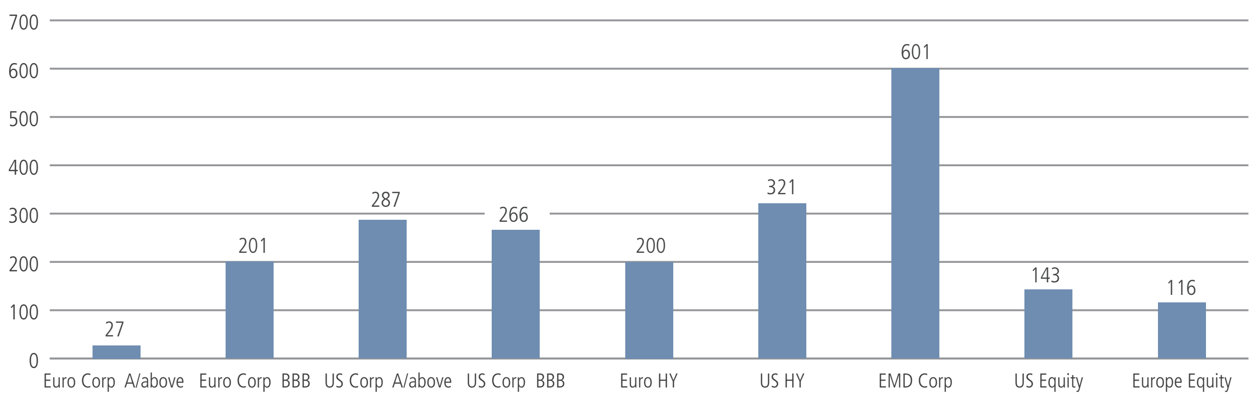
The Climate SAA process reduces financed emissions because they are important inputs into the Climate VaR model and its equivalents that are used to calculate estimated returns. All other things being equal, the Climate SAA therefore prefers assets with lower financed emissions. Investors can choose to "dial-up" the effect of financed emissions, however, by adding them as constraints to the Climate SAA.[4]

As a reminder, carbon intensity is defined as the number of tons of CO_2 equivalents emitted for every million dollars of each constituent company's revenue. The carbon footprint of the portfolio is the absolute apportioned emissions financed by the portfolio itself—that is, the emissions attributed to the portfolio based on its ownership share of an emitter's total invested capital, further normalized by the investment value.

Like the impact of Climate VaR on estimated returns, and for much the same reason, carbon intensity and carbon footprint vary widely at the asset-class level (figure 5). In general, fixed income assets generate more financed emissions than equities, due to their lower sector exposures in technology and higher exposures in utilities and energy; and EUR fixed income generates fewer financed emissions than USD fixed income due to its higher exposure to financials.

FIGURE 5. FINANCED EMISSIONS VARY WIDELY AT BOTH ASSET CLASS AND SECTOR LEVEL

Carbon intensity, tons of CO_2 equivalents per million dollars of issuer revenue, by asset class



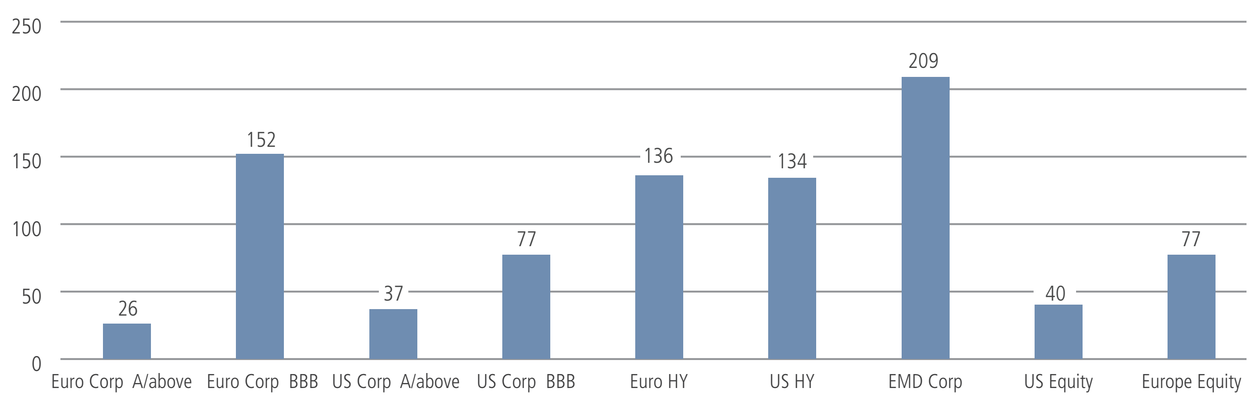
[3] https://emeeting.europarl.europa.eu/emeeting/committee/en/agenda/202307/ECON?meeting=ECON-2023-0718_1&session=07-18-08-00; https://www.europarl.europa.eu/cmsdata/273462/RCVs_18%20July%202023.pdf

[4] While we have used them for simple illustration in this paper, we regard metrics such as carbon intensity and carbon footprint as somewhat blunt instruments for assessing issuer and portfolio emissions, and particularly future emissions. As an example of some of the issues they present, note how, in figure 5, while carbon intensity and carbon footprint are generally positive correlated, EUR BBB corporate bonds and high yield have a higher carbon footprint than their US counterparts, despite exhibiting lower carbon intensity; and the same is the case with European versus US equities. This apparent anomaly occurs because the macroeconomic environment can effect these metrics via both their numerators (carbon output) and, especially, their denominators (revenue or enterprise value), without their being a real change in a company or sector's overall emissions profile. That is one reason why we regard metrics such as these as necessary but not sufficient to determine net-zero alignment, a subject we address in more detail in a recent paper, which also sets out a proprietary Net Zero Alignment Indicator, designed to assign a net-zero alignment score and status to security issuers based on what we believe to be a richer, more forward-looking set of data and metrics. See Jonathan Bailey, Sarah Peasey and Laura Kunstler-Brooks, *Net-Zero Alignment: Beyond the Numbers (July 2023)*, at https://www.nb.com/en/link?type=article&name=whitepaper-net-zero-alignment-beyond-the-numbers.

Carbon intensity, tons of CO_2 equivalents per million dollars of issuer revenue, by sector

	Euro Corp A/above	Euro Corp BBB	US Corp A/ above	US Corp BBB	Euro HY	US HY	EMD Corp	US Equity	Europe Equity
Basic Materials	568	441	713	535	600	677	1136	631	461
Communications	47	29	25	31	25	27	73	18	18
Consumer, Cyclical	25	112	42	76	167	273	387	56	22
Consumer, Non-cyclical	26	44	25	31	45	53	112	24	29
Energy	291	337	369	735	207	691	661	447	273
Financial	4	28	10	30	23	46	13	51	8
Industrial	46	788	192	203	294	194	615	132	206
Technology	9	22	23	23	44	39	152	20	18
Utilities	389	589	2497	1787	1030	3121	3805	2227	627
Index	27	201	287	266	200	321	601	143	116

Carbon footprint, tons of CO_2 equivalents per million dollars of portfolio investment, by asset class



Carbon footprint, tons of CO_2 equivalents per million dollars of portfolio investment, by sector

	Euro Corp A/above	Euro Corp BBB	US Corp A/above	US Corp BBB	Euro HY	US HY	EMD Corp	US Equity	Europe Equity
Basic Materials	202	663	171	353	1478	579	698	191	325
Communications	19	14	7	12	12	11	33	5	8
Consumer, Cyclical	68	107	26	31	114	77	136	23	14
Consumer, Non-cyclical	9	22	11	19	20	34	53	9	9
Energy	271	356	242	266	109	289	314	256	291
Financial	1	2	2	3	2	11	4	13	1
Industrial	22	699	44	72	190	94	264	34	132
Technology	2	11	4	7	21	17	12	3	4
Utilities	12	360	207	278	381	1507	711	375	352
Index	26	152	37	77	136	134	209	40	77

Source: Bloomberg, MSCI, JP Morgan, S&P Global, Neuberger Berman. Data as of April 2023. Indices used: Bloomberg-Barclays Indices for Government/Agency Debt, Corporate Bonds, US Equities and Europe Equities; JPM CEMBI for Emerging Markets Corporate Bonds. Carbon Intensity and Carbon Footprint data are calculated on Scope 1 and 2 emissions.

This variation, both among asset classes and within them, makes it possible to set the constraints on financed emissions with a wide range, which should help to achieve a meaningful additional reduction in carbon intensity and footprint with minimal impairment of estimated risk-adjusted return. That is indeed what we find, as shown for the Continental European life insurer portfolio in figure 6.

It is also worth noting that this Climate SAA lowers financed emissions despite *raising* the allocation to core fixed income, which is made up of asset classes that have generally higher financed emissions. This result is possible due to the wide variation in financed emissions *within* these asset classes, as well as among them, which, once again, give us abundant opportunity to realize asset-allocation alpha.

FIGURE 6. FINANCED EMISSIONS CAN BE REDUCED BY MORE THAN 50% WITHOUT SUBSTANTIAL IMPAIRMENT OF ESTIMATED RETURN

Effect of *ex-ante* Climate SAA on a Continental European life insurer portfolio, with and without financed emissions constraints

	Standard	Climate	Climate with Carbon Footprint Constraints (CF)	Climate with Carbon Intensity Constraints (CI)	Δ (CF – Climate)	Δ (CI – Climate)
Euro Gov/Agency	20.7%	21.0%	21.3%	20.9%	0.3%	-0.1%
Euro IG Corp	60.4%	61.1%	61.8%	60.8%	0.8%	-0.2%
US IG Corp	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Core Fixed Income	**81.2%**	**82.1%**	**83.1%**	**81.7%**	**1.1%**	**-0.3%**
HY BB&B	5.0%	5.0%	5.0%	5.0%	0.0%	0.0%
EMD	5.0%	4.5%	0.0%	0.0%	-4.5%	-4.5%
Extended Fixed Income	**10.0%**	**9.5%**	**5.0%**	**5.0%**	**-4.5%**	**-4.5%**
US Equity	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Europe Equity	5.9%	5.5%	8.9%	10.3%	3.4%	4.8%
Private Equity	0.5%	0.5%	0.5%	0.5%	0.0%	0.0%
Hedge Funds	0.4%	0.4%	0.4%	0.4%	0.0%	0.0%
Real Estate	2.0%	2.0%	2.0%	2.0%	0.0%	0.0%
Equity & Alternatives	**8.8%**	**8.5%**	**11.9%**	**13.3%**	**3.4%**	**4.8%**
Expected Return	3.59%	3.75%	3.74%	3.73%	-0.01%	-0.02%
Surplus Volatility	4.0%	4.0%	4.0%	4.0%	0.0%	0.0%
Asset Volatility	7.1%	7.1%	7.2%	7.2%	0.1%	0.1%
Asset Duration	9.0	9.0	9.0	9.0	0.0	0.0
Surplus Duration	-0.9	-0.9	-0.9	-0.9	0.0	0.0
Carbon Intensity	170	106	78	72	-28	-34
Carbon Footprint	111	67	52	54	-15	-13
Total SCR	**13.6%**	**13.4%**	**13.7%**	**13.8%**	**0.3%**	**0.4%**

Source: Bloomberg, MSCI, JP Morgan, S&P Global, Cambridge Associates, HFRI, Neuberger Berman. Data as of April 2023. Indices used: Bloomberg-Barclays Indices for Government/Agency Debt, Corporate Bonds, US Equities and Europe Equities; JPM EMBI for Emerging Markets Sovereign Debt; JPM CEMBI for Emerging Markets Corporate Bonds; Cambridge Associates Indices for Private Equity; HFRI Indices for Hedge Funds; MSCI and S&P Global Indices for Real Estate. Carbon Intensity and Carbon Footprint data are calculated on Scope 1 and 2 emissions. **Past performance is no guarantee of future results.** Please note that estimated returns data is based on NB's capital markets assumptions and are provided for information purposes only. There is no guarantee that estimated returns will be realized or achieved nor that an investment strategy will be successful, and may be significantly different than shown here. Investors should keep in mind that the securities markets are volatile and unpredictable. There are no guarantees that historical performance of an investment, portfolio, or asset class will have a direct correlation with its future performance. Net returns will be lower.

As we have already seen, a Climate SAA already reduces financed emissions by almost 40%. Adding carbon intensity and carbon footprint as constraints in the Climate SAA reduces them by another 20 – 30%.

The impact on estimated volatility and return is minimal, although there is a small sacrifice in terms of SCR efficiency—this is because the major change in asset allocation is to remove emerging markets debt (which generates high financed emissions but a relatively low SCR) and reallocate most of the proceeds to European equities (which generates low financed emissions despite its relatively high Climate VaR, but has a higher SCR).

Conclusion: Lower Climate Costs, Lower Solvency Costs, Higher Estimated Returns

Investors are increasingly cognizant of the potential impact that climate change, and the measures imposed to mitigate climate change, might have on the value of their portfolios. However, efforts to assess and address these costs and opportunities happen almost exclusively during the bottom-up, issuer-level stages of the investment process. As such, climate-related adjustments to valuations and estimated returns are imposed upon portfolios whose asset-class, region and sector allocations have already been determined.

We believe that integrating climate-related costs into SAA processes—before asset allocation is determined—can "recover" some of the estimated return that gets lost when climate-related adjustments are imposed on existing portfolios. The wide dispersion of climate impact we find between asset classes, regions and sectors provides abundant opportunity to optimize between risk-adjusted estimated return and climate effects.

Moreover, in the context of insurance portfolios, we find that integrating climate-related costs into SAA processes can not only raise estimated return with no additional volatility, but also lower a portfolio's SCR, thereby enhancing solvency capital efficiency.

Finally, we think it is important to underline the flexibility and adaptability of Climate SAA. An investor can introduce or "dial up" the effect of any risk or parameter it chooses by adding it as a constraint to the optimization. As governments, regulators, corporations and investors increasingly adopt Net-Zero and other emissions-reduction targets, the flexibility Climate SAA has to take account of these parameters could become a major advantage.

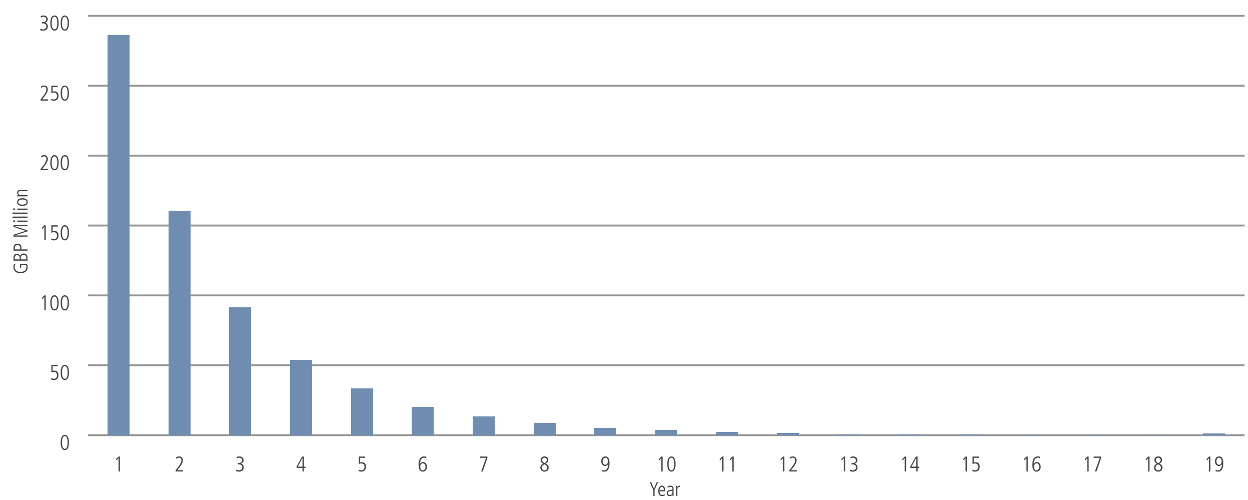
PROFILES OF AN ILLUSTRATIVE UK GENERAL INSURER AND CONTINENTAL EUROPEAN LIFE INSURER

Illustrative UK General Insurer

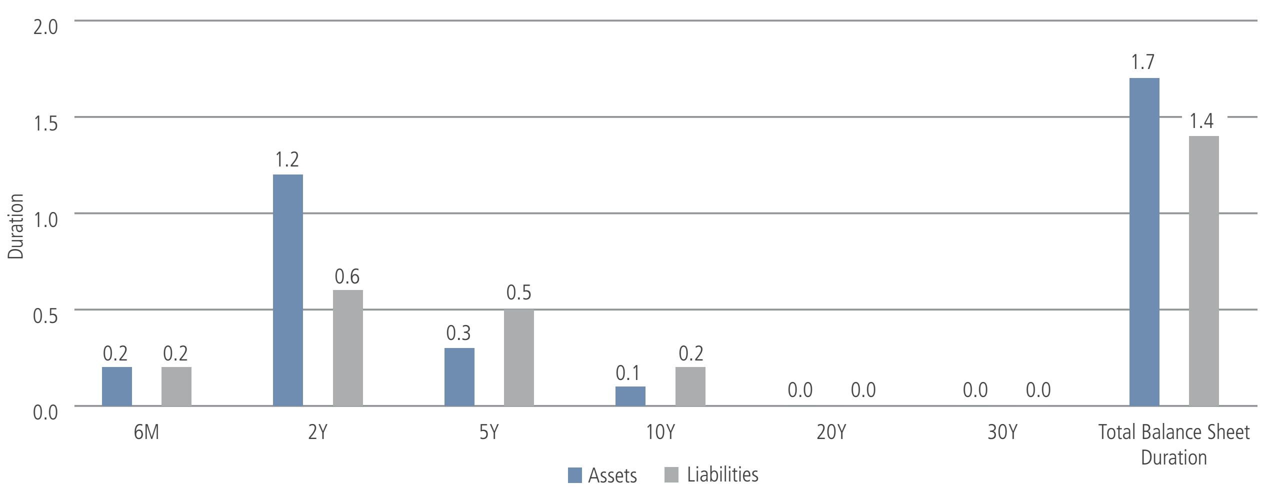
Balance Sheet

	Original		Duration Scaled to Assets	
	Assets	**Liabilities**	**Liabilities**	**Surplus**
Market Value (GBP Million)	1,000	623	623	377
Duration (years)	1.7	2.3	1.4	0.3
DV01 (GBP Million)	17	14	14	3

Illustrative Liability Cash Flows



Key Rate Duration, Assets vs. Liabilities (Years, Scaled to Assets)



Asset Allocation, with Estimated Reduction in Annualized Return from Climate Adjustments

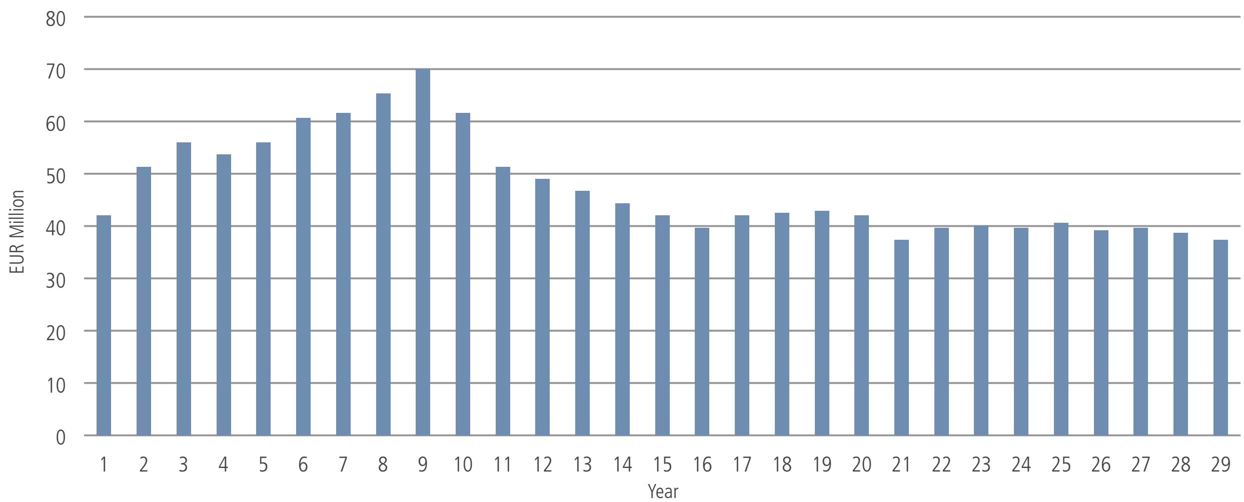
Asset Class	Allocation (%)	Return Reduction (bps)	Portfolio Return Reduction (bps)
Sterling Cash	7	NA	NA
Sterling Gilt 1-3 yrs	13	0	0
Sterling IG Corp 1-3 yrs	23	-12	-3
Euro Treasury 1-3 yrs	6	0	0
Euro IG Corp 1-3 yrs	11	-47	-5
Euro Mortgage Loans	6	NA	NA
US Treasury 1-3 yrs	6	-1	0
US IG Corp 1-3 yrs	11	-14	-2
Sterling HY BB&B 1-3 yrs	2	-56	-1
Euro HY BB&B 1-3 yrs	1	-113	-1
US HY BB&B 1-3 yrs	1	-163	-2
Europe Real Estate	2	NA	NA
UK Equity	5	-77	-4
US Equity	2	-18	0
Global Equity	3	-25	-1
Total	**100**	**NA**	**-19**

Source: Bloomberg, MSCI, JP Morgan, S&P Global, Neuberger Berman. Data as of April 2023. Indices used: Bloomberg-Barclays Indices for Government/Agency Debt, Corporate Bonds, and US Equities; MSCI Indices for UK Equity and Global Equity; JPM EMBI for Emerging Markets Sovereign Debt; JPM CEMBI for Emerging Markets Corporate Bonds; MSCI and S&P Global Indices for Real Estate. Carbon Intensity and Carbon Footprint data are calculated on Scope 1 and 2 emissions. **Past performance is no guarantee of future results.** Please note that estimated returns data is based on NB's capital markets assumptions and are provided for information purposes only. There is no guarantee that estimated returns will be realized or achieved nor that an investment strategy will be successful, and may be significantly different than shown here. Investors should keep in mind that the securities markets are volatile and unpredictable. There are no guarantees that historical performance of an investment, portfolio, or asset class will have a direct correlation with its future performance. Net returns will be lower.

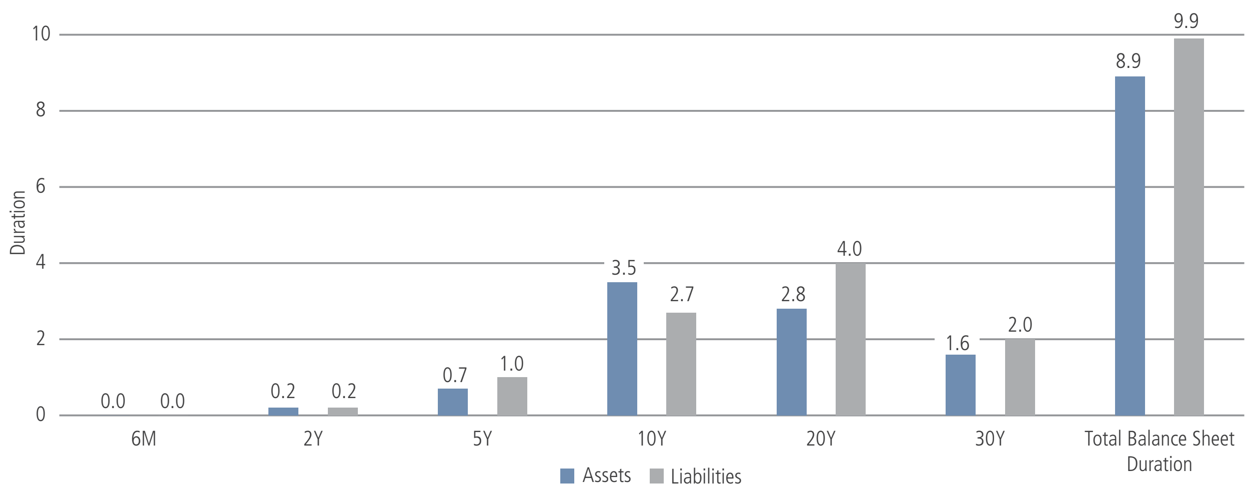
Illustrative Continental European Life Insurer
Balance Sheet

	Original		Duration Scaled to Assets	
	Assets	**Liabilities**	**Liabilities**	**Surplus**
Market Value (EUR Million)	1,200	1,000	1,000	200
Duration (years)	8.9	11.9	9.9	-1.1
Dollar Duration (EUR Million)	106	119	119	-13

Illustrative Liability Cash Flows



Key Rate Duration, Assets vs. Liabilities (Years, Scaled to Assets)



Asset Allocation, with Estimated Reduction in Annualized Return from Climate Costs

Asset Class	Allocation (%)	Return Reduction (bps)	Portfolio Return Reduction (bps)
Euro Cash	3	NA	NA
Euro Gov 1-10 Yr	2	1	0
Euro Gov 10+ Yr	21	3	1
Covered Bonds	12	NA	NA
Euro Corp A/above 1-10 yrs	1	-11	0
Euro Corp A/above 10+ yrs	11	-1	0
Euro Corp BBB 1-10 yrs	2	-66	-2
Euro Corp BBB 10+ yrs	22	-26	-6
Euro Mortgage Loans	9	NA	NA
US Corp A/above 1-10 yrs	0	-1	0
US Corp A/above 10+ yrs	0	-2	0
US Corp BBB 1-10 yrs	0	-21	0
US Corp BBB 10+ yrs	1	-19	0
Euro HY BB&B	3	-89	-3
US HY BB&B	0	-56	0
EM Sovereigns	0	-15	0
EM Corporates	0	-48	0
US Equities	1	-18	0
Europe Equities	7	-55	-4
Private Equity	1	NA	NA
Hedge Funds	0	NA	NA
Europe Real Estate	2	NA	NA
Total	**100**	**NA**	**-14**

Source: Bloomberg, MSCI, JP Morgan, S&P Global, Cambridge Associates, HFRI, Neuberger Berman. Data as of April 2023. Indices used: Bloomberg-Barclays Indices for Government/Agency Debt, Corporate Bonds, US Equities and Europe Equities; JPM EMBI for Emerging Markets Sovereign Debt; JPM CEMBI for Emerging Markets Corporate Bonds; Cambridge Associates Indices for Private Equity; HFRI Indices for Hedge Funds; MSCI and S&P Global Indices for Real Estate. German Government Bonds and Pfandbriefe are used as proxies for Euro Government Bonds and Covered Bonds. Carbon Intensity and Carbon Footprint data are calculated on Scope 1 and 2 emissions. **Past performance is no guarantee of future results.** Please note that estimated returns data is based on NB's capital markets assumptions and are provided for information purposes only. There is no guarantee that estimated returns will be realized or achieved nor that an investment strategy will be successful, and may be significantly different than shown here. Investors should keep in mind that the securities markets are volatile and unpredictable. There are no guarantees that historical performance of an investment, portfolio, or asset class will have a direct correlation with its future performance. Net returns will be lower.

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