Impact of Climate Risk Metrics in Asset Management

Amundi Quantitative Research*
Inès Barahhou, Mohamed Ben Slimane & Thierry Roncalli

*Amundi Asset Management[1], France

Conseil Scientifique de l'AMF, April, 6th 2022

Amundi | Institute
ASSET MANAGEMENT

Amundi | Institute
ASSET MANAGEMENT

[1]The opinions expressed in this presentation are those of the authors and are not meant to represent the opinions or official positions of Amundi Asset Management.

Amundi Research Project

1. Portfolio Construction with Climate Risk Measures, January 2022
2. Net Zero Carbon Metrics, February 2022
3. The Shift from Carbon Emissions to Net Zero Carbon Metrics on Portfolio Construction, March 2022
4. Multi-Period Portfolio Optimization & Application to Portfolio Decarbonization, March 2022
5. The Green Risk Premium & The Performance(s) of ESG Investing, March 2022

https://research-center.amundi.com

Preliminary remarks

- Financial information ⇒ standardization & accounting
- Extra-financial information ⇒ not standardized & heterogenous
- Climate risk metrics
  - Carbon emissions & intensity
    - Scope 1 & 2
    - Scope 3
  - Net zero alignment
    - Net zero decarbonization metrics
    - Net zero transition metrics
  - Green taxonomy

Climate risk metrics reshape the asset management industry

... in a disordered pathway

The puzzle

- Portfolio decarbonization
- Portfolio alignment

Academic findings

- Portfolio decarbonization is easy
- Portfolio alignment is easy
- The cost of portfolio alignment may be low

$\neq$

Asset owners & managers

- Portfolio decarbonization is easy
- Portfolio alignment is difficult
- The cost of portfolio alignment may be high

Asset allocation $\Rightarrow$ Portfolio weights x_i

Asset allocation $\Rightarrow$ { **Capital** allocation / Economy **financing** }

Two visions of asset management

Carbon emissions

The GHG Protocol corporate standard classifies a company's greenhouse gas emissions in three scopes[2]:

- **Scope 1**: Direct GHG emissions (○)
- **Scope 2**: Consumption of purchased energy (○○)
- **Scope 3**: Other indirect GHG emissions (●●)
  - **Scope 3 upstream**: emissions associated to the supply side
    1. First tier direct (●)
    2. Tier 2 and 3 suppliers (●●)
  - **Scope 3 downstream**: emissions associated with the product sold by the entity
    1. Use of the product (●●●)
    2. Waste disposal & recycling (●●●●)

[2] Measurement robustness: from ○○○○ (very high) to ●●●● (very low)

Carbon emissions

Figure: Total absolute scopes per GICS sector in $GtCO_2e$

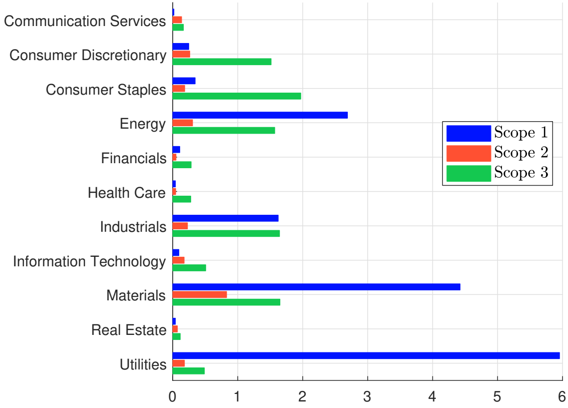
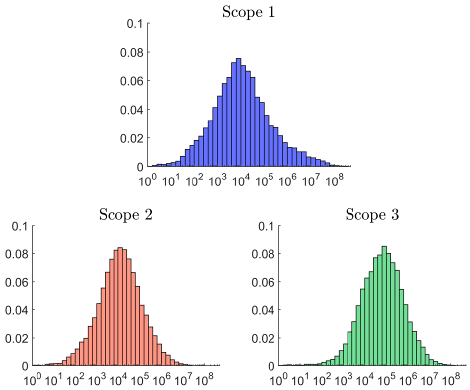


Table: Scope 1 + 2 vs. scope 3

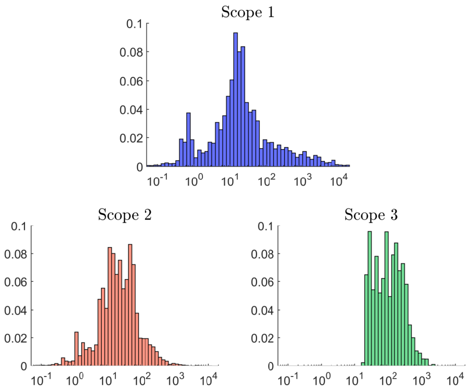
Sector	$\frac{\mathcal{SC}_3}{\mathcal{SC}_{1+2}}$
Communication Services	1.1
Consumer Discretionary	**3.0**
Consumer Staples	**3.7**
Energy	**0.5**
Financials	1.8
Health Care	**3.3**
Industrials	0.9
Information Technology	1.9
Materials	**0.3**
Real Estate	1.0
Utilities	**0.1**

Carbon intensity vs emissions

Emissions (log scale, tCO_2e)



Intensity[a] (log scale, tCO_2e/$ mn)



[a] Carbon intensity = carbon emissions / revenues

Carbon intensity

Table: Examples of carbon emissions and intensity

Company	Emission (in tCO_2e)			Revenue	Intensity (in tCO_2e/$ mn)		
	Scope 1	Scope 2	Scope 3	(in $ mn)	Scope 1	Scope 2	Scope 3
Alphabet	74 462	5 116 949	7 166 240	161 857	0.460	31.614	44.275
Amazon	5 760 000	5 500 000	20 054 722	280 522	20.533	19.606	71.491
Apple	50 463	862 127	27 618 943	260 174	**0.194**	**3.314**	106.156
BP	49 199 999	5 200 000	103 840 194	276 850	**177.714**	18.783	375.077
Danone	722 122	944 877	28 969 780	28 308	**25.509**	**33.378**	**1 023.365**
Enel	69 981,891	5 365 386	8 726 973	86 610	**808.016**	61.949	100.762
Juventus	6 665	15 739	35 842	709	9.401	22.198	50.553
LVMH	67 613	262 609	11 853 749	60 083	**1.125**	**4.371**	**197.291**
Microsoft	113 414	3 556 553	5 977 488	125 843	0.901	28.262	47.500
Nestle	3 291 303	3 206 495	61 262 078	93 153	**35.332**	**34.422**	**657.647**
Netflix	38 481	145 443	1 900 283	20 156	1.909	7.216	94.277
Total	40 909 135	3 596 127	49 831 487	200 316	**204.223**	17.952	248.764
Volkswagen	4 494 066	5 973 894	65 335 372	282 817	15.890	21.123	231.016

Carbon intensity

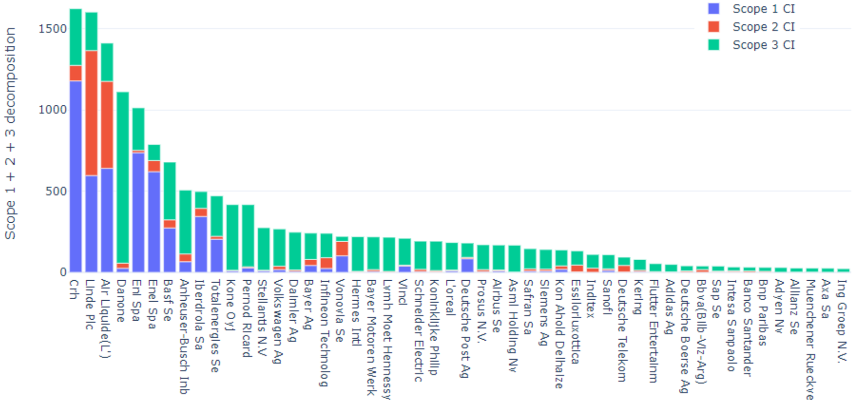
Table: The case of Danone (total emissions breakdown)

Year		2019	2020
Scope 1		2.70%	2.60%
Scope 2		2.20%	1.80%
Scope 3	**Purchase of goods and services: Agriculture - milk**	**35.50%**	**36.90%**
	Purchase of goods and services: Agriculture - dairy ingredients	**15.40%**	**15.10%**
	Purchase of goods and services: Agriculture - other raw materials	**9.00%**	**8.40%**
	Purchase of goods and services: Packaging	10.30%	9.60%
	Purchase of goods and services: Purchase of finished products	5.60%	6.20%
	Upstream transportation and distribution of goods	1.40%	1.20%
	Downstream transportation and distribution of goods	8.10%	6.20%
	Use of sold products	7.10%	7.20%
	End-of-life treatment of sold products	**0.90%**	**3.00%**
	Fuel and energy related activities	1.20%	1.10%
	Waste generated in operations	0.60%	0.60%
Agricultural emissions breakdown			
	Milk	59.20%	61.10%
	Dairy ingredients	25.70%	25.00%
	Other raw materials	15.10%	13.90%

Source: Danone, Exhaustive 2020 Environmental Data.

Impact of the scope 3

Figure: Breakdown of the scope 1+2+3 carbon intensity (Eurostoxx 50 index)



Portfolio decarbonization

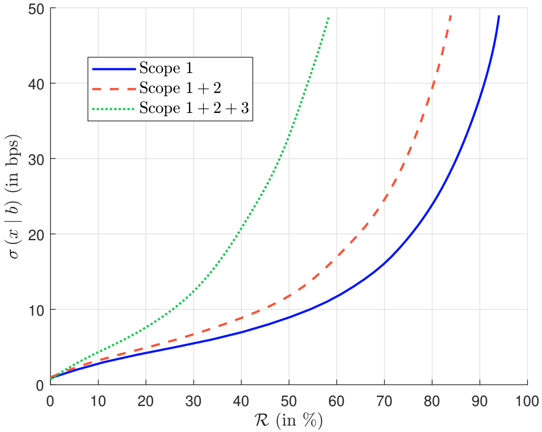
- The optimization problem is:

$$
\begin{aligned}
x^{\star}(\mathcal{R}) &= \arg\min \frac{1}{2}(x-b)^{\top}\Sigma(x-b) \\
\text{s.t.} & \left\{ \begin{array}{l} \mathbf{1}_n^{\top}x = 1 \\ x \geq \mathbf{0}_n \\ \sum_{i=1}^{n} x_i \cdot \mathcal{CI}_i \leq (1-\mathcal{R}) \cdot \mathcal{CI}(b) \end{array} \right.
\end{aligned}
$$

  where x is the portfolio and b is the benchmark portfolio
- $\mathcal{R}$ is the reduction rate of the carbon intensity
- The underlying idea is to obtain a decarbonized portfolio $x^{\star}$ such that the tracking error with respect to the benchmark b is the lowest
- The benchmark b can be a current portfolio (active management) or an index portfolio (passive management)

Portfolio decarbonization

Figure: Impact of the carbon scope on the tracking error volatility (S&P 500 index, October 2021)



Portfolio alignment

Paris-aligned benchmarks

- A year-on-year self-decarbonization of 7% on average per annum, based on **scope 1, 2 and 3 emissions** ⇒ postponed in 2023? 2024? 2025?
- A minimum carbon intensity reduction $\mathcal{R}^-$ compared to the investable universe
- A minimum exposure to sectors highly exposed to climate change:
  1. Narrow measure of HCIS (non official, e.g. $\approx$ 19% of the S&P 500)
  2. Broad measure of HCIS (official, e.g. $\approx$ 55% of the S&P 500)
- Issuer exclusions (controversial weapons and societal norms violators)
- ~~Minimum green share revenue~~

CTB

$$\mathcal{R}^- = 30\%$$

PAB

$$\mathcal{R}^- = 50\%$$

Decarbonization pathway

Figure: Decarbonization pathway of PAB labels (base year = 2020)

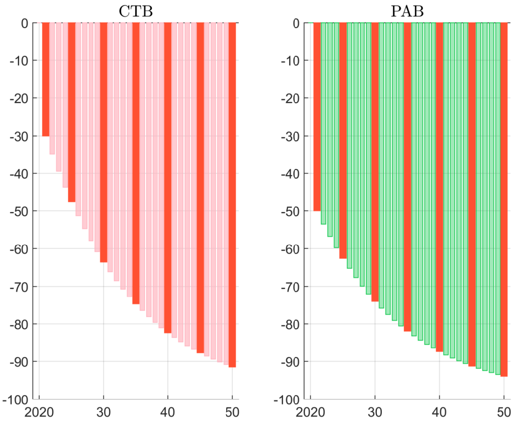


Table: Reduction $\mathcal{R}(2020, t)$

Year	CTB	PAB
2021	30.0%	**50.0%**
2022	34.9%	53.5%
2023	39.5%	56.8%
2024	43.7%	59.8%
2025	47.6%	**62.6%**
2026	51.3%	65.2%
2027	54.7%	67.7%
2028	57.9%	69.9%
2029	60.8%	72.0%
2030	63.6%	**74.0%**
2035	74.7%	81.9%
2040	82.4%	87.4%
2045	87.7%	91.2%
2050	91.5%	93.9%

High climate impact sector (HCIS)

- HCIS sectors are defined with respect to NACE classification
- Official HCIS = 8 NACE classes(*) among 21
- Broad HCIS = 129 GICS sub-industries among 185 ($\approx$ 70%)

Table: The narrow measure of high climate impact sectors

NACE		GICS	
Code	Sector	Code	Sector
A	Agriculture, Forestry & Fishing	302020	Food Products
B	Mining & Quarrying	10 151040	Energy Metals & Mining
C	Manufacturing	20	Industrials
D	Electricity, Gas, Steam & Air Conditioning Supply	55	Utilities
E	Water Supply Sewerage, Waste Management & Remediation Activities		
F	Construction	151020	Construction Materials
G	Wholesale & retail trade Repair of Motor Vehicles & Motorcycles	301010	Food & Staples Retailing
H	Transportation & Storage	2030	Transportation
L	Real Estate Activities	60	Real Estate

(*) A. Agriculture, Forestry, Fishing; B. Mining, Quarrying; C. Manufacturing; D. Electricity, Gas, Steam, Air Conditioning Supply; E. Water Supply; Sewerage, Waste Management, Remediation Activities; F. Construction; G. Wholesale, Retail Trade; Repair of Motor Vehicles and Motorcycles; H. Transportation, Storage; L. Real Estate Activities

High climate impact sector (HCIS)

Table: Weights and carbon intensity (Scope 1 + 2 + 3) of high climate impact sectors (S&P 500 index, October 2021)

Sector	S&P 500		Narrow HCIS		Broad HCIS	
	b_s	$\mathcal{CI}_s$	b_s	$\mathcal{CI}_s$	b_s	$\mathcal{CI}_s$
Communication Services	10.89%	80				
Consumer Discretionary	**13.57%**	190			**10.22%**	**185**
Consumer Staples	6.10%	355	2.73%	348	6.10%	355
Energy	**2.81%**	790	2.81%	790	**2.81%**	**790**
Financials	11.13%	67				
Health Care	**12.74%**	126			**8.56%**	**152**
Industrials	7.97%	330	7.97%	330	6.32%	368
Information Technology	**27.50%**	99			**13.30%**	**139**
Materials	**2.45%**	966	0.44%	850	**2.45%**	**966**
Real Estate	**2.55%**	198	2.55%	198	**2.55%**	**198**
Utilities	**2.30%**	2669	2.30%	2669	**2.30%**	**2669**
Total	100.00%	245	18.79%	681	54.59%	380

Only two sectors (Communication Services & Financials) are not HCIS

Optimization problem (naive approach)

We have:

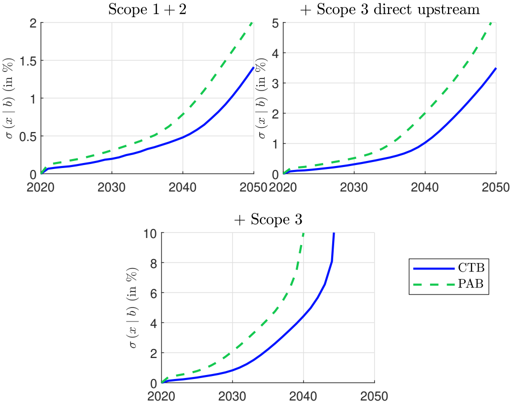
$$
\begin{aligned}
x^{\star}(t) &= \arg\min_{x(t)} \frac{1}{2}\sigma^2(x(t) \mid b(t)) + \lambda \tau(x(t) \mid x^{\star}(t-1)) \\
&\text{s.t.} \quad \left\{ \begin{array}{l}
\mathbf{1}_n^\top x(t) = 1 \\
x(t) \geq \mathbf{0}_n \\
\mathcal{CI}(x(t)) \leq (1 - \mathcal{R}(t_0, t)) \cdot \mathcal{CI}(b(t_0)) \\
\mathbf{HCIS}(x(t)) \geq \varphi \cdot \mathbf{HCIS}(b(t))
\end{array} \right.
\end{aligned}
$$

where $\lambda \geq 0$, $\sigma(x(t) \mid b(t))$ is the tracking error risk and $\tau(x(t) \mid x^{\star}(t-1))$ is the one-way turnover of the portfolio between $t-1$ and t

$\Rightarrow$ Dynamic rebalancing (e.g., every quarter)

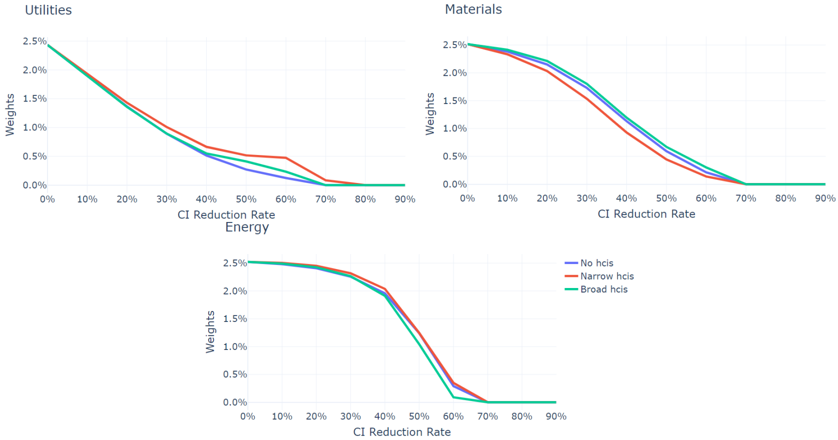
The scope 3 issue (which scope 3?)

Figure: Tracking error of CTB and PAB labels when implementing the broad HCIS constraint (S&P 500 index, October 2021)



Impact of the reduction rate $\mathcal{R}$ on sector allocation

Figure: HCIS constraints do not help to keep strategic sectors in the allocation (MSCI USA index)



Portfolio decarbonization does not imply financing green solutions

Table: Impact of the reduction rate $\mathcal{R}$ on green revenue share

$\mathcal{R}$	SX5E			MSCI EMU			MSCI USA		
	No HCIS	Narrow	Broad	No HCIS	Narrow	Broad	No HCIS	Narrow	Broad
0%	3.4%	3.4%	3.4%	4.8%	4.8%	4.8%	5.9%	5.9%	5.9%
30%	3.5%	3.6%	3.5%	4.7%	5.0%	5.0%	5.8%	5.8%	5.8%
50%	3.4%	3.6%	3.3%	4.5%	5.2%	5.1%	5.6%	5.8%	5.8%
60%	3.0%	3.5%	2.8%	4.0%	5.0%	5.2%	5.6%	5.8%	5.8%
70%	2.4%	2.4%	1.2%	3.4%	4.8%	5.6%	5.4%	5.4%	5.4%
80%	1.9%	1.9%	0.2%	2.8%	4.4%	7.2%	4.3%	4.2%	3.1%

- Green share revenues represent a small part of CW indices (3.4% for the Eurostoxx 50 index, 4.8% for the MSCI EMU index and 5.9% for the MSCI USA index)
- Without the HCIS constraint, the green share revenues decrease with the carbon intensity reduction rate
- Some contradictory results when implementing HCIS: SX5E & MSCI USA vs. MSCI EMU

Impact of the reduction rate $\mathcal{R}$ on diversification

Table: Herfindahl index

$\mathcal{R}$	SX5E				MSCI EMU				MSCI USA			
	Issuer	Sub.	Ind.	Sec.	Issuer	Sub.	Ind.	Sec.	Issuer	Sub.	Ind.	Sec.
0%	32	18	16	7	78	31	25	8	74	36	26	6
30%	31	18	16	7	77	29	24	8	74	35	25	6
50%	30	16	15	6	74	26	22	7	73	33	22	6
60%	27	14	13	6	72	23	19	6	72	31	20	5
70%	24	12	11	5	68	19	16	6	72	29	17	5
80%	18	9	8	3	61	14	10	4	82	21	9	3
Cardinality	50	33	29	11	233	82	53	11	628	126	63	11

$\Rightarrow$ Sector diversification loss $\approx$ 10% if $\mathcal{R} = 50\%$, 25% if $\mathcal{R} = 60\%$, 35% if $\mathcal{R} = 70\%$ and 50% if $\mathcal{R} = 80\%$

How to read these figures? For instance, in the case of the Eurostoxx 50 index, we have 50 stocks in the universe, but the allocation is comparable to a portfolio of 32 equally-weighted stocks, 18 equally-weighted subindustries, 16 equally-weighted industries and 7 equally-weighted sectors

Impact of the reduction rate $\mathcal{R}$ on sector rotation

Table: Sector allocation in %

Sector	MSCI EMU						MSCI USA					
	0%	50%	60%	70%	80%	90%	0%	50%	60%	70%	80%	90%
Communication Services	4.10	5.81	6.99	8.45	9.46	2.90	10.12	11.21	11.79	12.10	6.53	
Consumer Discretionary	17.25	17.76	16.81	13.74	9.45	0.82	12.56	12.63	12.29	10.40	3.93	
Consumer Staples	7.91	6.79	5.6	4.6	3.08	3.73	5.68	3.95	2.88	1.25		
Energy	3.80	2.24	1.77	**0.78**			2.52	1.24	**0.29**			
Financials	14.70	**20.16**	**23.87**	**31.43**	**43.19**	**72.24**	10.51	**13.60**	**15.84**	**22.20**	**40.94**	**100**
Health Care	7.48	8.62	8.85	7.46	4.76		13.14	14.71	14.79	12.31	7.62	
Industrials	15.59	16.73	15.92	13.86	9.94	8.88	7.76	6.21	5.01	3.92	4.05	
Information Technology	14.55	15.80	16.5	17.20	17.61	11.22	29.88	32.23	33.23	34.49	34.83	
Materials	6.96	**1.80**	**0.6**				2.52	**0.59**	**0.21**			
Real Estate	1.41	1.63	1.66	1.57	1.43	0.20	2.88	3.35	3.54	3.32	2.11	
Utilities	6.25	2.65	**1.43**	**0.92**	**1.08**		2.43	**0.27**	**0.12**			

$\Rightarrow$ Portfolio decarbonization is **a long strategy on Financials** and **a short strategy on Energy, Materials and Utilities**

Comparison of CTB, PAB and IEA NZE scenarios

Figure: Utilities (SX5E)

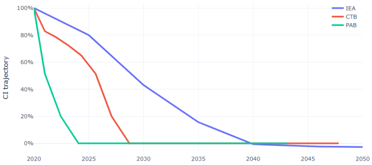


Table: Attrition date

Sector	IEA NZE	SX5E CTB	SX5E PAB	MSCI EMU CTB	MSCI EMU PAB	MSCI USA CTB	MSCI USA PAB
Utilities	2040	2028	**2024**	2032	2032	**2025**	**2021**
Const. Mat.	2050	**2022**	**2021**	**2025**	**2021**	2029	**2021**
Homebuilding	2050					**2025**	2029
Industrials	2050	2042	2037	2050	2050	2038	2033

Naive CTB and PAB approaches may decarbonize[3] faster the strategic sectors than expected by IEA!

$\Rightarrow$ **CTB/PAB methodologies are not all equal**

[3] Decarbonize = remove

The arithmetic of net zero

"Using global mean surface air temperature, as in AR5, gives an estimate of the remaining carbon budget of 580 $GtCO_2e$ for a 50% probability of limiting warming to 1.5°C, and 420 $GtCO_2e$ for a 66% probability (medium confidence)" (IPCC, 2018).

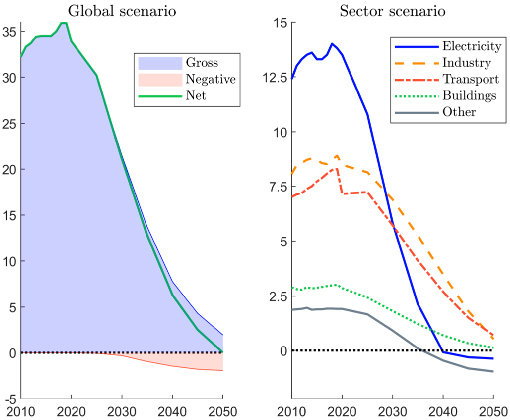
$$\begin{aligned}
\Pr\{\mathcal{T} \leq 1.5^{\circ}\mathrm{C} \mid \mathcal{CB}(2019, 2050) \leq \mathbf{580} \text{ GtCO}_2\text{e}\} &\geq 50\% \\
\Pr\{\mathcal{T} \leq 1.5^{\circ}\mathrm{C} \mid \mathcal{CB}(2019, 2050) \leq 420 \text{ GtCO}_2\text{e}\} &\geq 66\% \\
\Pr\{\mathcal{T} \leq 1.5^{\circ}\mathrm{C} \mid \mathcal{CB}(2019, 2050) \leq 300 \text{ GtCO}_2\text{e}\} &\geq 83\%
\end{aligned}$$

Remark

- Current carbon emissions $\approx$ 36 $GtCO_2e$ per annum
- $580/36 = 16$ years (2035)

The arithmetic of net zero

Figure: CO_2 emissions in the IEA NZE scenario



Carbon budget

$$\mathcal{CB}_i(t_0, t) = \int_{t_0}^{t} \mathcal{CE}_i(s)\, ds$$

NZE scenario

$$\begin{cases} \mathcal{CB}(2019, 2050) \leq 580 \text{ GtCO}_2\text{e} \\ \mathcal{CE}(2050) \approx 0 \text{ GtCO}_2\text{e} \end{cases}$$

The arithmetic of net zero

Table: IEA NZE global scenario (in $GtCO_2e$)

Year	2019	2025	2030	2035	2040	2045	2050
Gross emissions	35.90	30.30	21.50	13.70	7.77	4.30	1.94
CCS	0.00	−0.06	−0.32	−0.96	−1.46	−1.80	−1.94
Net emissions	35.90	30.24	21.18	12.74	6.31	2.50	0.00
Reduction (in %)	0.00	15.60	40.11	61.84	78.36	88.02	94.60

Table: IEA NZE sector scenario (in $GtCO_2e$)

Year	2019	2025	2030	2035	2040	2045	2050
Electricity	13.80	10.80	5.82	2.12	−0.08	−0.31	−0.37
Industry	8.90	8.14	6.89	5.25	3.48	1.80	0.52
Transport	8.29	7.23	5.72	4.11	2.69	1.50	0.69
Buildings	3.01	2.43	1.81	1.21	0.69	0.32	0.12
Other	1.91	1.66	0.91	0.09	−0.46	−0.82	−0.96

By assuming linear interpolation, we find the following values for $\mathcal{CB}_i(2019, 2050)$ in in $GtCO_2e$:

- Global scenario
  - Gross: 512.35
  - CCS: −27.85
  - Net: 484.5
- Sector scenario
  - Electricity: 138.225
  - Industry: 158.99
  - Transport: 133.57
  - Buildings: 42.685
  - Other: 11.185

NZE framework

Net zero emission tools

- **Absolute carbon emissions**
- Carbon target
- Carbon trend
- Carbon budget

Net zero emission metrics

Static NZE metrics

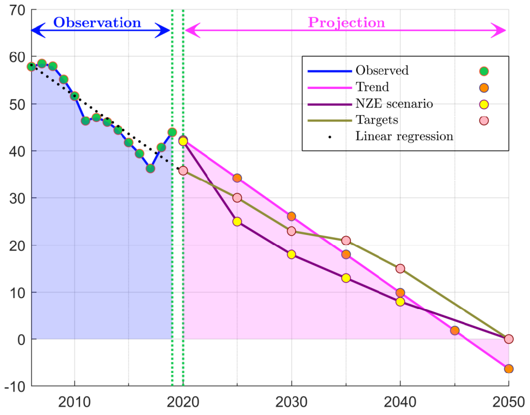
- Gap
- Slope
- Budget
- Duration

Dynamic NZE metrics

- Time contribution
- Velocity
- Zero-velocity & burn-out scenarios

NZE framework

Figure: Comparison of historical emissions, carbon trend, targets and NZE scenario (in $MtCO_2e$)



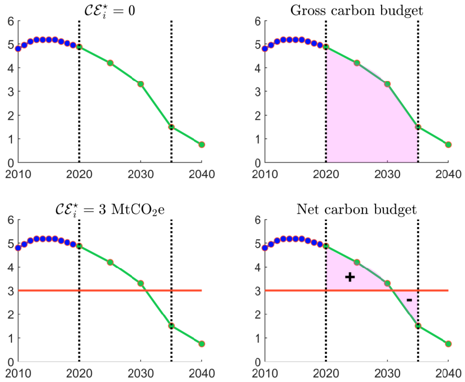
Carbon budget

- The carbon budget defines the amount of GHG emissions that a country, a company or an organization produces over the time period $[t_0, t]$.
- The gross carbon budget is equal to:

$$\mathcal{CB}_i(t_0, t) = \int_{t_0}^{t} \mathcal{CE}_i(s)\,\mathrm{d}s$$

In the example, $\mathcal{CB}_i(2020, 2035)$ is equal to 53.4375 $MtCO_2e$ whereas the net carbon budget is equal to 8.4375 $MtCO_2e$

Figure: Example of gross and net carbon budgets



Carbon target

The carbon target setting is defined from the following space:

$$\mathscr{T} = \left\{ k \in [1, m] : \left(i, j, t_1^k, t_2^k, \mathcal{R}_{i,j}\left(t_1^k, t_2^k\right) \right) \right\}$$

where k is the target index, m is the number of historical targets, i is the issuer, j is the scope, t_1^k is the beginning of the target period, t_2^k is the end of the target period, and $\mathcal{R}_{i,j}\left(t_1^k, t_2^k\right)$ is the carbon reduction between t_1^k and t_2^k for the scope j announced by issuer i

Carbon target

Here are the steps to compute the target trajectory

1. The linear annual reduction rate for scope j and target k is given by:

$$\mathcal{R}_{i,j}^{k}(t)=\mathbb{1}\left\{t\in\left[t_1^k,t_2^k\right]\right\}\cdot\frac{\mathcal{R}_{i,j}\left(t_1^k,t_2^k\right)}{t_2^k-t_1^k}$$

2. We aggregate the targets to obtain the annual reduction rate:

$$\mathcal{R}_{i,j}(t)=\sum_{k=1}^{m}\mathcal{R}_{i,j}^{k}(t)$$

3. We compute the global reduction at time t:

$$\mathcal{R}_{i}(t)=\frac{1}{\sum_{j=1}^{3}\mathcal{CE}_{i,j}(t_0)}\cdot\sum_{j=1}^{3}\mathcal{CE}_{i,j}(t_0)\cdot\mathcal{R}_{i,j}(t)$$

4. Finally, we have:

$$\mathcal{CE}_i^{\mathcal{T}arget}(t):=\widehat{\mathcal{CE}}_i(t)=\left(1-\mathcal{R}_i\left(t_{\mathscr{L}ast},t\right)\right)\cdot\mathcal{CE}_i\left(t_{\mathscr{L}ast}\right)$$

Carbon target

Example

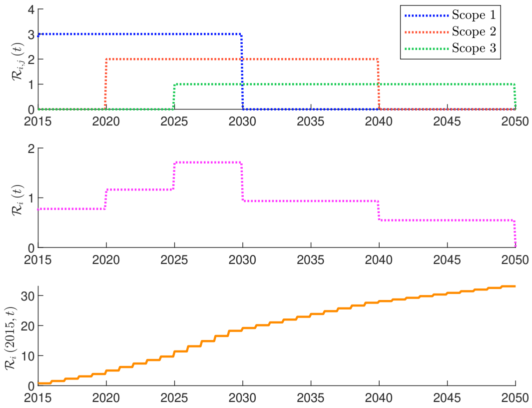
- The dates t_1^k and t_2^k correspond to the 1st January
- We assume that $\mathcal{CE}_{i,1}(2020) = 10.33$, $\mathcal{CE}_{i,2}(2020) = 7.72$ and $\mathcal{CE}_{i,3}(2020) = 21.86$

Table: Carbon reduction targets

k	Release Date	Scope	t_1^k	t_2^k	$\mathcal{R}\left(t_1^k, t_2^k\right)$
1	01/08/2013	$\mathcal{SC}_1$	2015	2030	45%
2	01/10/2019	$\mathcal{SC}_2$	2020	2040	40%
3	01/01/2019	$\mathcal{SC}_3$	2025	2050	25%

Carbon target

Figure: Reduction of the carbon emissions deduced from the three targets (Example 2)



Carbon trend

We define the carbon trend by considering a linear constant trend model:

$$\mathcal{CE}_i(t) = \beta_{i,0} + \beta_{i,1} t + u_i(t)$$

where $t \in [t_{\mathscr{F}irst}, t_{\mathscr{L}ast}]$

The carbon trajectory implied by the current trend is given by:

$$\mathcal{CE}_i^{Trend}(t) := \widehat{\mathcal{CE}}_i(t) = \hat{\beta}_{i,0} + \hat{\beta}_{i,1} t$$

for $t > t_{\mathscr{L}ast}$

Carbon trend

Example

Table: Carbon emissions in $MtCO_2e$

Year	2007	2008	2009	2010	2011	2012	2013
$\mathcal{CE}_i(t)$	57.82	58.36	57.70	55.03	51.73	46.44	47.19
Year	2014	2015	2016	2017	2018	2019	2020
$\mathcal{CE}_i(t)$	46.18	45.37	40.75	39.40	36.16	38.71	39.91

We obtain:

$$\mathcal{CE}_i^{Trend}(t) = 3637.73 - 1.7832 \cdot t = 35.61 - 1.7822 \cdot (t - 2020)$$

The rescaled trend model is:

$$\mathcal{CE}_i^{Trend}(t) = 39.91 - 1.7822 \cdot (t - 2020)$$

The $\mathcal{PAC}$ framework

Three questions:

- Is the trend of the issuer in line with the net zero emissions scenario? $\Rightarrow$ **P**articipation
- Is the commitment of the issuer to fight climate change ambitious? $\Rightarrow$ **A**mbition
- Is the target setting of this issuer relevant and robust? $\Rightarrow$ **C**redibility

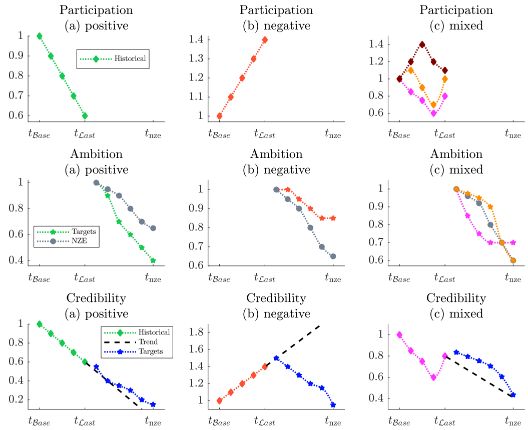
The three pillars depends on the carbon trajectories $\mathcal{CE}_i(t)$, $\mathcal{CE}_i^{\mathcal{T}rend}(t)$, $\mathcal{CE}_i^{\mathcal{T}arget}(t)$ and $\mathcal{CE}_i^{\mathrm{nze}}(t)$ where:

1. $\mathcal{CE}_i(t)$ is the time series of historical carbon emissions
2. $\mathcal{CE}_i^{\mathcal{T}rend}(t)$ and $\mathcal{CE}_i^{\mathcal{T}arget}(t)$ are the estimated carbon emissions deduced from the trend model and the target
3. $\mathcal{CE}_i^{\mathrm{nze}}(t)$ is the market-based NZE scenario

$t_{\mathscr{B}ase}$ is the base date, $t_{\mathscr{L}ast}$ is the last reporting date and t_{nze} is the target date of the NZE scenario

The $\mathcal{PAC}$ framework

Figure: Illustration of the participation, ambition and credibility pillars



Static NZE measures

- The time to reach the NZE scenario (or NZE duration) is defined as follows:

$$\boldsymbol{\tau}_i = \left\{ \inf t : \widehat{\mathcal{CE}}_i(t) \leq \mathcal{CE}_i^{\mathrm{nze}}(t^\star) \right\}$$

- The NZE gap is the expected distance between the estimated carbon emissions (trend model or target scenario) and the NZE scenario:

$$\mathcal{G}ap_i(t^\star) = \widehat{\mathcal{CE}}_i(t^\star) - \mathcal{CE}_i^{\mathrm{nze}}(t^\star)$$

- The NZE slope is the value of $\hat{\beta}_{i,1}$ such that the NZE gap is closed, meaning that $\mathcal{G}ap_i^{\mathcal{T}rend}(t^\star) = 0$
- The NZE budget corresponds to the carbon budget between the current date t_0 and the NZE date $t^\star$:

$$\mathcal{CB}_i(t_0, t^\star) = \int_{t_0}^{t^\star} \left(\widehat{\mathcal{CE}}_i(s) - \mathcal{CE}_i^{\mathrm{nze}}(t^\star) \right) \mathrm{d}s$$

- The NZE budget duration is defined as follows:

$$\boldsymbol{\tau}_i = \inf \left\{ t : \mathcal{CB}_i(t_0, t) \leq 0 \right\}$$

Dynamic NZE measures

- The NZE velocity $\boldsymbol{v}_i(t_1, t_2)$ is defined as the change of the slope:

$$\boldsymbol{v}_i(t_1, t_2) := \frac{\Delta\hat{\beta}_{i,1}(t_1, t_2)}{t_2 - t_1}$$

- The zero-velocity scenario $\mathcal{ZV}_i^{(h)}(t+1)$ is the value of carbon emissions next year to obtain a zero velocity
- The burn-out scenario refers to a sudden and violent reduction of carbon emissions in order to satisfy the NZE trajectory; The NZE burn-out scenario is then the value of the carbon emissions next year such that the gap is equal to zero, meaning that the NZE scenario will be achieved on average

The $\mathcal{PAC}$ framework

Table: The three pillars of an effective NZE strategy

Pillar	Metric	Condition
Participation	Gap	$\mathcal{G}ap_i^{\mathcal{T}rend}(t_{\mathcal{L}ast}) \leq 0$
	Reduction	$\mathcal{R}_i(t_{\mathcal{B}ase}, t_{\mathcal{L}ast}) < 0$
	Time contribution	$\mathcal{TC}_i(t_{\mathcal{L}ast}+1 \mid t_{\mathcal{L}ast}, t_{\mathrm{nze}}) < 0$
	Trend	$\hat{\beta}_{i,1} < 0$ and $\mathbf{R}_i^2 > 50\%$
	Trend	$\mathcal{CE}_i^{\mathcal{T}rend}(t)$ for $t > t_{\mathcal{L}ast}$
	Velocity	$\boldsymbol{v}_i^{(1)}(t_{\mathcal{L}ast}) \leq 0$
Ambition	Budget	$\mathcal{CB}_i^{\mathcal{T}arget}(t_{\mathcal{L}ast}, t_{\mathrm{nze}}) \leq \mathcal{CB}_{\mathcal{S}ector}^{\mathcal{T}arget}(t_{\mathcal{L}ast}, t_{\mathrm{nze}})$
	Budget	$\mathcal{CB}_i^{\mathcal{T}arget}(t_{\mathcal{L}ast}, t_{\mathrm{nze}}) \leq \mathcal{CB}_i^{\mathcal{T}rend}(t_{\mathcal{L}ast}, t_{\mathrm{nze}})$
	Duration	$\boldsymbol{\tau}_i^{\mathcal{T}arget} \leq t_{\mathrm{nze}}$
	Gap	$\mathcal{G}ap_i^{\mathcal{T}arget}(t_{\mathrm{nze}}) \leq 0$
Credibility	Budget	$\mathcal{CB}_i^{\mathcal{T}arget}(t_{\mathcal{L}ast}, t_{\mathrm{nze}}) > \mathcal{CB}_i^{\mathcal{T}rend}(t_{\mathcal{L}ast}, t_{\mathrm{nze}})$
	Burn-out Scenario	$\mathcal{BO}_i(t_{\mathcal{L}ast}+1, \mathcal{CE}_i^{\mathrm{nze}}(t^{\mathrm{nze}})) \geq \varphi_{\mathcal{BO}} \cdot \mathcal{CE}_i(t_{\mathcal{L}ast})$
	Duration	$\boldsymbol{\tau}_i^{\mathcal{T}rend} \leq t_{\mathrm{nze}}$
	Gap	$\mathcal{G}ap_i^{\mathcal{T}rend}(t_{\mathrm{nze}}) \leq 0$
	Gap	$\mathcal{G}ap_i^{\mathcal{T}rend}(t_{\mathrm{nze}}) \leq \mathcal{G}ap_i^{\mathcal{T}arget}(t_{\mathrm{nze}})$
	Slope	$\mathcal{S}lope_i(t_{\mathrm{nze}}) \geq \mathcal{S}lope_{\mathcal{S}ector}(t_{\mathrm{nze}})$
	Slope	$m_i^{\mathcal{S}lope} \ll 1$
	Trend	$\mathbf{R}_i^2 > 50\%$
	Zero-velocity	$\mathcal{ZV}_i^{(1)}(t_{\mathcal{L}ast}+1) \geq \varphi_{\mathcal{ZV}} \cdot \mathcal{CE}_i(t_{\mathcal{L}ast})$

The $\mathcal{PAC}$ scoring system

Figure: Examples

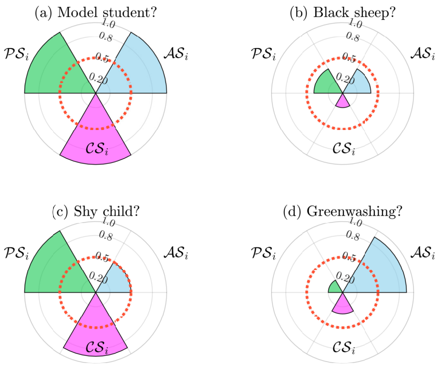
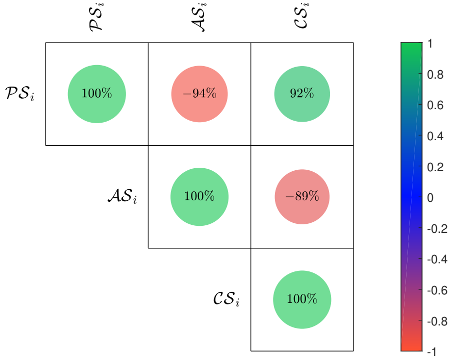
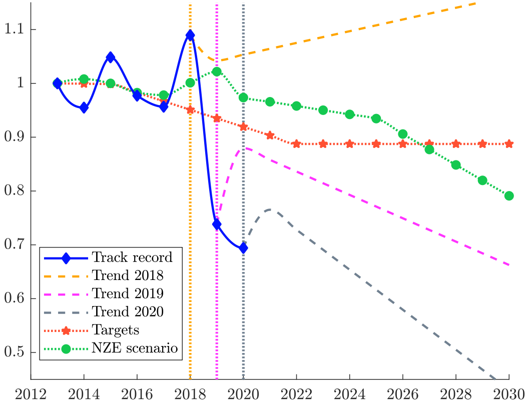


Figure: Rank correlation matrix



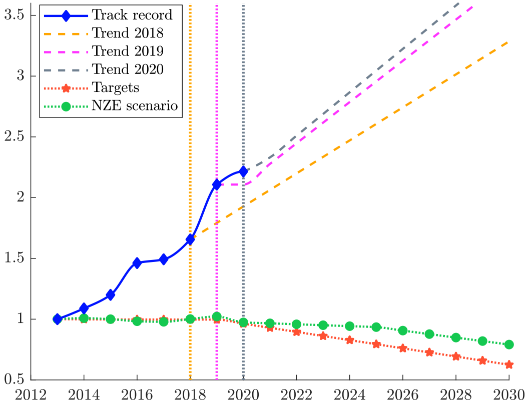
Empirical results

Figure: Carbon emissions, trends and targets and NZE scenario (Company A)



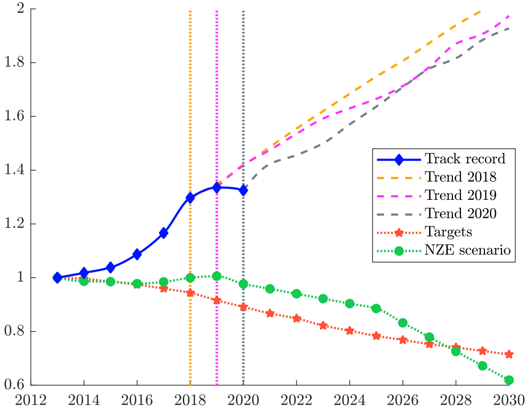
Empirical results

Figure: Carbon emissions, trends and targets and NZE scenario (Company C)



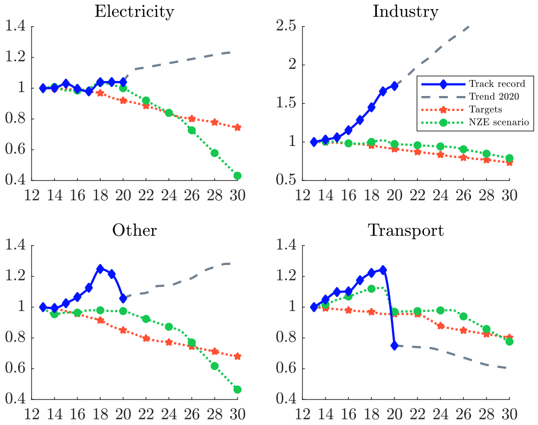
Empirical results

Figure: Carbon emissions, trends and targets and NZE scenario (global analysis)



Empirical results

Figure: Carbon emissions, trends and targets and NZE scenario (sector analysis)



Empirical results

Table: Statistics of the normalized slope and velocity (expressed in %)

Slope		$\frac{\hat{\beta}_{i,1}(t_{\mathscr{L}ast})}{\mathcal{CE}_i(2013)}$			$\frac{\hat{\beta}_{i,1}(t_{\mathscr{L}ast})}{\mathcal{CE}_i(t_{\mathscr{L}ast})}$			$\#\left\{\hat{\beta}_{i,1} < 0\right\}$
		$Q_{25\%}$	$Q_{50\%}$	$Q_{75\%}$	$Q_{25\%}$	$Q_{50\%}$	$Q_{75\%}$	
$t_{\mathscr{L}ast}$	2018	−2.44	6.06	41.29	−2.85	4.46	12.93	32.36
	2019	−2.13	6.38	44.23	−2.31	4.18	11.42	29.56
	2020	−2.97	6.16	52.01	−3.82	3.66	10.60	32.62

Velocity		$\frac{\boldsymbol{v}_i^{(1)}(t_{\mathscr{L}ast})}{\mathcal{CE}_i(2013)}$			$\frac{\boldsymbol{v}_i^{(1)}(t_{\mathscr{L}ast})}{\mathcal{CE}_i(t_{\mathscr{L}ast})}$			$\#\left\{\boldsymbol{v}_i^{(1)}(t_{\mathscr{L}ast}) < 0\right\}$
		$Q_{25\%}$	$Q_{50\%}$	$Q_{75\%}$	$Q_{25\%}$	$Q_{50\%}$	$Q_{75\%}$	
$t_{\mathscr{L}ast}$	2019	−4.38	−0.09	2.62	−2.15	−0.37	1.99	51.27
	2020	−6.99	−1.53	1.15	−3.68	−0.99	1.11	65.11

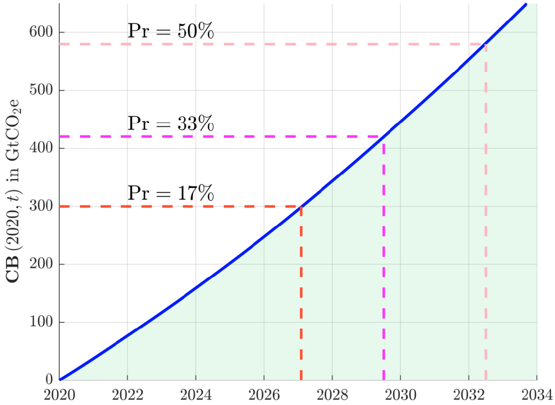
Empirical results

Table: Statistics of the budget difference

$\Delta\mathcal{CB}_i(2020,2030)$	$Q_{25\%}$	$Q_{50\%}$	$Q_{75\%}$	$\#\{<0\}$
$\mathcal{CB}_i^{Trend}(2020,2030) - \mathcal{CB}_i^{\mathrm{nze}}(2020,2030)$	-3.00	5.78	13.45	32.9%
$\mathcal{CB}_i^{Target}(2020,2030) - \mathcal{CB}_i^{\mathrm{nze}}(2020,2030)$	-1.54	-0.18	0.54	59.9%
$\mathcal{CB}_i^{Target}(2020,2030) - \mathcal{CB}_i^{Trend}(2020,2030)$	-14.48	-7.19	2.64	68.9%

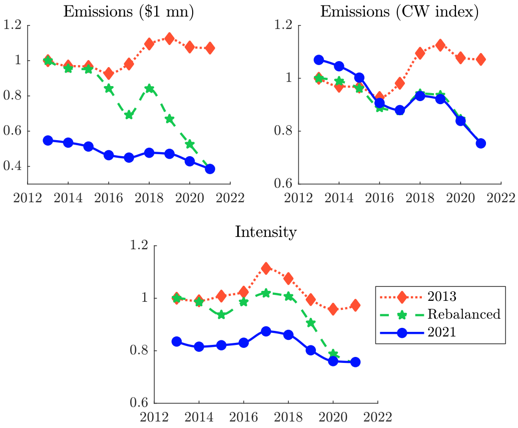
Empirical results

Figure: Probability to reach 1.5°C



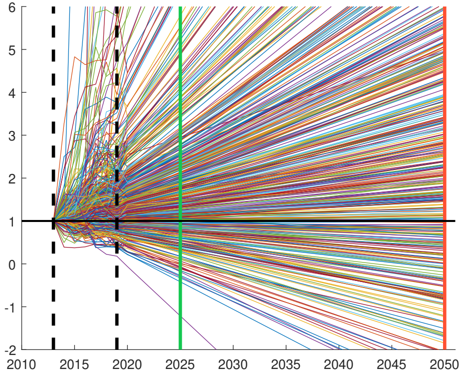
Empirical results

Figure: Scope 1 + 2 + 3 carbon emissions and intensity (MSCI World index)



Empirical results

Figure: Carbon emissions trends of the S&P 500 constituents (scope 1 + 2 + 3)



The trend is not your friend!

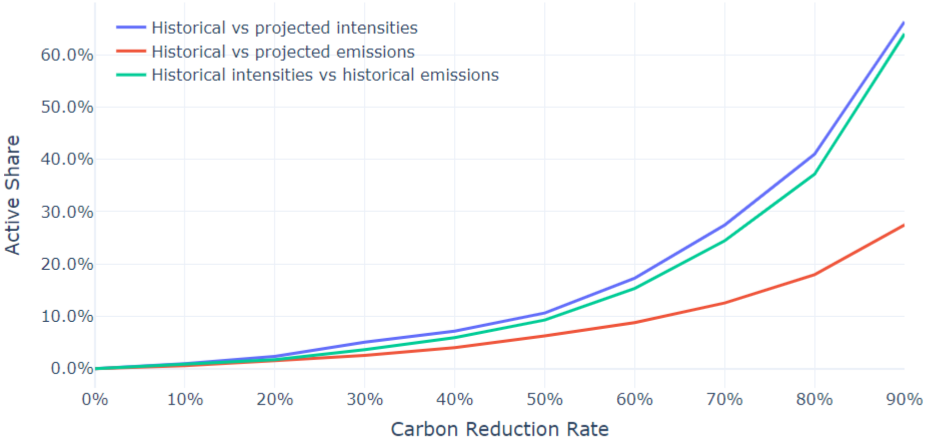
Comparison of NZE portfolios

We consider 4 climate risk metrics:

1. the Scope 1 + 2 + 3 carbon intensity
2. the Scope 1 + 2 + 3 carbon emissions
3. the projected Scope 1 + 2 + 3 carbon intensity (linear trend model)
4. the projected Scope 1 + 2 + 3 carbon emissions (linear trend model)

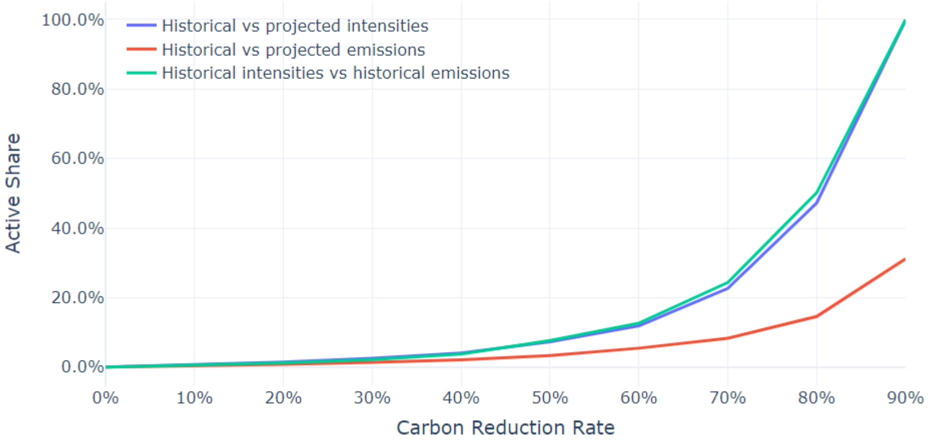
Comparison of NZE portfolios

Figure: Active share between the NZE portfolios (MSCI EMU)



Comparison of NZE portfolios

Figure: Active share between the NZE portfolios (MSCI USA)



Methodology

- The optimisation problem is:

$$x^{\star}(\mathcal{R}) = \arg\min \underbrace{\sum_{s=1}^{n_{\mathcal{S}ector}} \left| \sum_{i \in s} (x_i - b_i)\,\mathrm{DTS}_i \right|}_{DTS\ \ component} + \underbrace{\sum_{i \in b} |x_i - b_i|}_{Weight\ \ component}$$

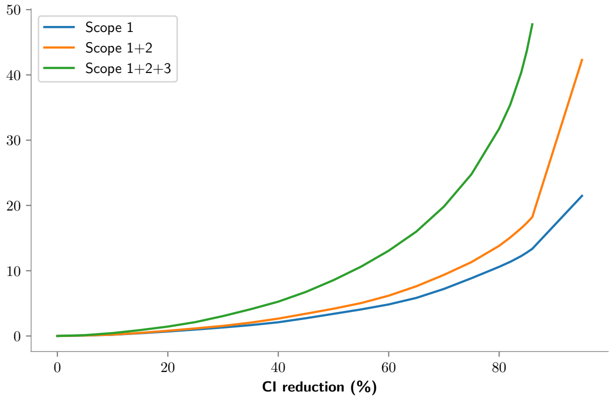
$$\text{s.t.} \quad \begin{cases} \mathbf{1}_n^\top x = 1 \\ x \geq \mathbf{0}_n \\ \sum_{i=1}^n x_i \cdot \mathrm{MD}_i = \mathrm{MD}(b) \\ \sum_{i=1}^n \mathbf{x_i} \cdot \mathcal{CI}_i \leq (\mathbf{1} - \mathcal{R}) \cdot \mathcal{CI}(\mathbf{b}) \end{cases}$$

where x is the portfolio, b is the benchmark portfolio and $\mathcal{R}$ is the reduction rate

- The outcome is a decarbonized portfolio where the active credit risk per sector and the turnover are the lowest, and the duration risk is neutralised at the portfolio level

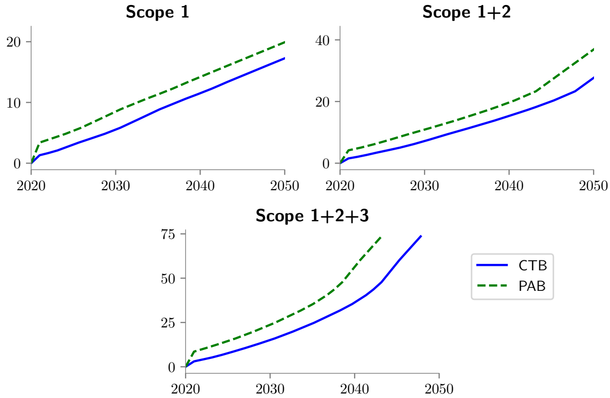
Empirical results

Figure: Active share in % between the decarbonized portfolio and the benchmark portfolio (Global Corp. IG)



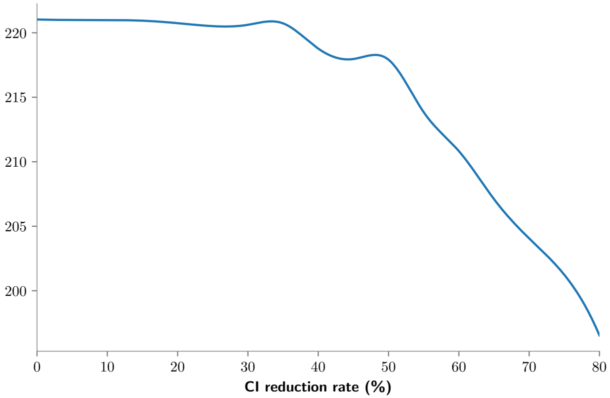
Empirical results

Figure: Active Share in % of CTB and PAB labels (Global Corporates, February 2022)



Impact of the reduction rate $\mathcal{R}$ on the portfolio yield

Figure: Portfolio yield in bps (Scope 1+2+3, Global Corp. IG)



- Yield reduction mainly comes from three sectors: Energy, Materials & Utilities
- BBB-rated issuers $\nearrow$
- Maturity mismatch:
  1. 2Y-5Y $\nearrow$
  2. $5Y+$ $\searrow$

Short duration

Impact of the reduction rate $\mathcal{R}$ on the diversification

Table: Herfindahl index (Global Corp. IG, February 2022)

Sector	Cardinality	Reduction rate (in %)					
		0	30	50	60	70	80
Communication Services	788	16	16	16	16	16	16
Consumer Discretionary	801	24	24	25	24	24	25
Consumer Staples	795	27	26	26	26	27	25
Energy	939	40	40	**21**	**6**	**2**	**1**
Financials	3 713	62	63	61	63	63	62
Health Care	774	33	33	33	33	33	33
Industrials	1 214	69	69	68	66	53	**20**
Information Technology	593	19	19	19	19	19	18
Materials	514	57	52	41	**34**	**15**	**9**
Real Estate	757	54	54	54	54	53	52
Utilities	1 195	47	37	**17**	**11**	**9**	**7**
Total	12 083						

Diversification loss begins when $\mathcal{R} \geq 50\%$

Comparison of CTB, PAB and IEA NZE scenarios

Figure: Electricity

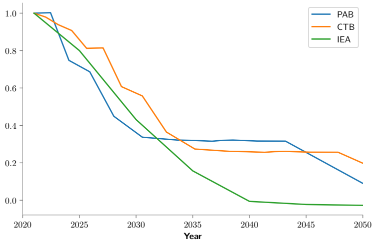


Figure: Transport

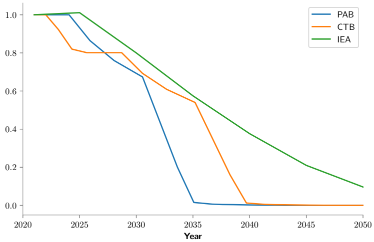
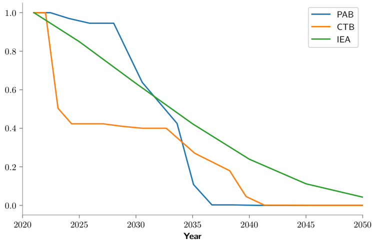


Figure: Buildings



Taxonomy

European Taxonomy (EUT)

There are 6 objectives:

1. Climate change mitigation
2. Climate change adaptation
3. Sustainable and protection of water and marine resources
4. Transition to a circular economy
5. Pollution prevention and control
6. Protection and restoration of biodiversity and ecosystem

1. SC	**Substantially contribute to at least one of the six objectives**
2. DNSH	**Do No Significant Harm** to any other five objectives
3. MS	Comply with **Minimum (Social) Safeguards**
4. TSC	Comply with **Technical Screening Criteria**

Taxonomy

Activities

1. Low carbon activities (or "**green**" activities)
   Activities associated with sequestration or very low absolute emissions
2. Transition activities (or "**greening of**" activities)
   Activities that contribute to a transition to a net zero emissions economy in 2050 but are not currently close to a net zero carbon emissions level
3. Enabling activities (or "**greening by**" activities)
   Activities that enable low-carbon performance or enable substantial emissions reductions (life-cycle considerations)

Source: TEG (2020)

Activities

1. Alternative energy
2. Energy efficiency
3. Green building
4. Pollution prevention and control
5. Sustainable agriculture
6. Sustainable water

Source: MSCI (2022)

Definition of the greenness

- Green revenues $\mathcal{GR}$ (in \$)
- Green share (or intensity) $\mathcal{GI}$ (in %)

$$\mathcal{GI} = \frac{\mathcal{GR}}{Y}$$

where Y is the normalization variable (e.g., revenues)

$\Rightarrow$ the concept can be extended to other variables: Green CAPEX, Green OPEX, etc.

EU taxonomy aligned revenue share (equities)

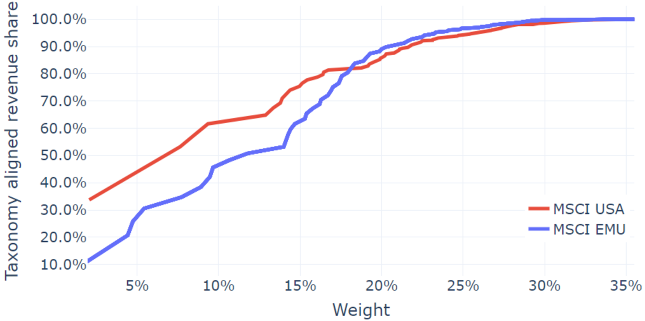
Table: Taxonomy alignment in % (Stocks)

$\mathcal{GI}$	SX5E		MSCI EMU		MSCI USA	
	%	#	%	#	%	#
> 0	25.2	11	33.6	86	36.1	183
> 10	**12.2**	5	**15.7**	40	**16.8**	62
> 20	**7.0**	2	**9.4**	27	**12.3**	31
> 30	**2.9**	1	**5.7**	**21**	**5.5**	**19**
> 40			1.9	14	2.9	13
> 50			1.5	11	2.4	8
> 60			1.4	10	2.3	7
> 70			**1.0**	7	2.3	7
> 80			0.9	6	2.3	6
> 90			0.5	4	**2.2**	4
$= 100$			0.2	2	0.1	1
Total	3.13	50	5.21	233	6.12	628

- **$1/3$ of the universe have a positive green taxonomy**
- If we would like to keep 5% of the original investment universe, the maximum taxonomy can not exceed $20-30\%$
- We can target a taxonomy of 50%, but we must accept to invest in less than $2-3\%$ of the investment universe

EU taxonomy aligned revenue share (equities)

Figure: Lorenz curve of green intensity



- Tesla = 33% of MSCI USA's green revenue
- Schneider Electric = 11% of MSCI EMU's green revenue

EU taxonomy aligned revenue share (equities)

Table: Taxonomy alignment[4] in % by sector

Sector	SX5E				MSCI EMU				MSCI USA			
	WGT	TC	TW	TM	WGT	TC	TW	TM	WGT	TC	TW	TM
Communication Services	1.7				4.1	0.21	0.5	0.5	10.1	0.04	0.5	0.1
Consumer Discretionary	21.4	0.06	0.3	0.57	17.2	0.14	0.9	2.4	12.6	2.34	**18.6**	3.2
Consumer Staples	8.0				7.9		0.02	0.1	5.7			
Energy	4.5	0.26	**5.7**	5.89	3.8	0.24	**6.4**	5.7	2.5	0.01	0.4	0.7
Financials	13.8				14.7				10.5			
Health Care	5.5				7.5	0.01	0.1	0.1	13.1	0.02	0.1	
Industrials	13.8	1.45	**10.5**	7.67	15.6	1.99	**12.8**	15.0	7.8	0.23	3.0	4.2
Information Technology	16.3	0.84	**5.2**	5.38	14.6	0.87	**6.0**	4.9	29.9	2.7	**9.0**	6.4
Materials	10.1	0.01	0.03	0.04	6.9	0.37	**5.3**	9.0	2.5	0.15	**6.2**	4.7
Real Estate	1.1				1.4	0.33	**23.2**	46.0	2.9	0.39	**13.5**	13.7
Utilities	3.7	0.51	**14.0**	13.94	6.2	1.23	**19.7**	24.1	2.4	0.24	**10.0**	7.0
Total	100	3.13			100	5.21			100	6.12		

The current taxonomy is below 7%

[4] WGT = weight, TC = taxonomy contribution, TW = taxonomy weighted, TA = taxonomy average

EU taxonomy aligned revenue share (equities)

Table: Breakdown of green revenues by sector (MSCI EMU)

	Benchmark		$\mathcal{GI} > 0\%$		$\mathcal{GI} > 10\%$		$\mathcal{GI} > 30\%$		$\mathcal{GI} > 50\%$	
	%	#	%	#	%	#	%	#	%	#
Communication Services	4.1	17	1.3	6						
Consumer Discretionary	17.2	30	1.6	6	0.2	2	0.1	**1**		
Consumer Staples	7.9	20	0.4	3						
Energy	3.8	7	3.7	6	0.4	1				
Financials	14.7	36								
Health Care	7.5	22	0.6	1						
Industrials	15.6	40	9.3	23	5.5	15	2.9	**7**	0.6	3
Information Technology	14.5	15	6.4	7	3.3	2	0.7	**1**		
Materials	6.9	19	3.9	12	1.0	4	0.1	**1**	0.1	1
Real Estate	1.4	7	0.4	4	0.4	4	0.4	**4**	0.4	4
Utilities	6.2	20	5.9	18	4.8	12	1.4	**7**	0.3	3
Total	100.0	233	33.6	86	15.7	40	5.7	**21**	1.5	11

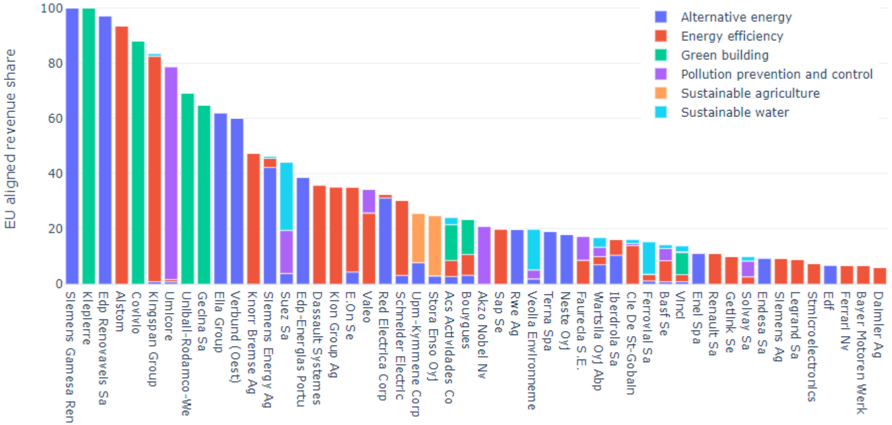
EU taxonomy aligned revenue share (equities)

Table: Breakdown of green revenues by sector (MSCI USA)

	Benchmark		$\mathcal{GI} > 0\%$		$\mathcal{GI} > 10\%$		$\mathcal{GI} > 30\%$		$\mathcal{GI} > 50\%$	
	%	#	%	#	%	#	%	#	%	#
Communication Services	10.1	41	2.0	1						
Consumer Discretionary	12.6	68	6.7	14	2.4	5	2.1	2	2.1	1
Consumer Staples	5.7	33	0.6	2						
Energy	2.5	20	0.3	5						
Financials	10.5	85	0.9	2						
Health Care	13.1	82	1.1	2						
Industrials	7.8	84	3.9	41	0.8	11	0.1	2	0.0	1
Information Technology	29.9	117	15.3	50	11.3	23	2.6	7	0.1	3
Materials	2.5	31	1.1	14	0.4	5	0.2	1		
Real Estate	2.9	36	1.7	23	1.1	13	0.5	6	0.2	3
Utilities	2.4	31	2.4	29	0.6	5	0.1	1		
Total	100.0	628	36.1	183	16.8	62	5.5	19	2.4	8

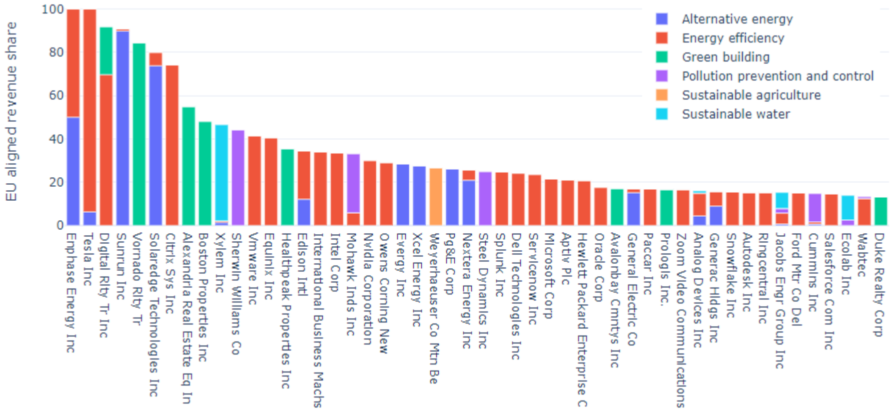
EU taxonomy aligned revenue share (equities)

Figure: Revenue's share aligned with the EU taxonomy (MSCI EMU)



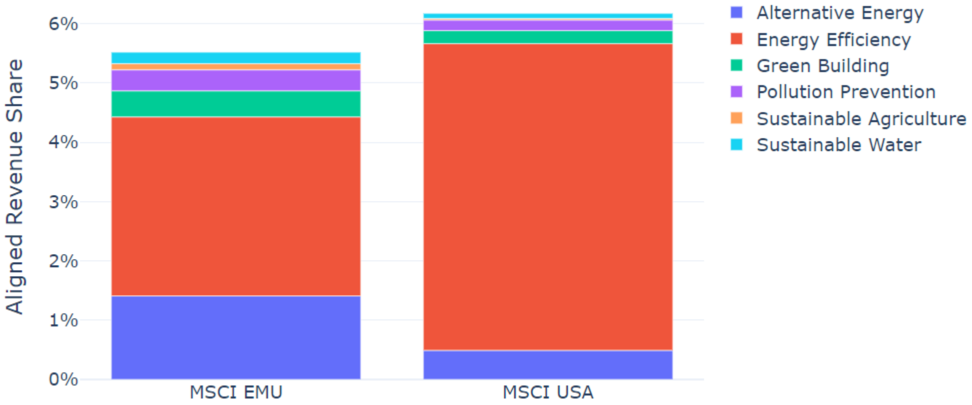
EU taxonomy aligned revenue share (equities)

Figure: Revenue's share aligned with the EU taxonomy (MSCI USA)



EU taxonomy aligned revenue share (equities)

Figure: Breakdown of green share by activities



EU taxonomy aligned revenue share (equities)

Figure: MSCI EMU

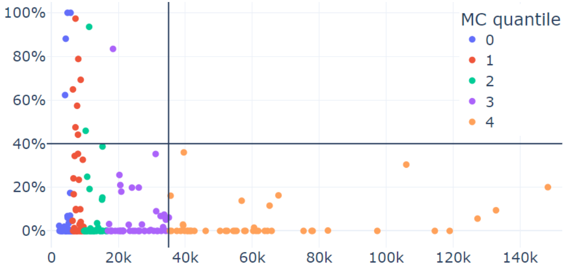


Figure: MSCI USA

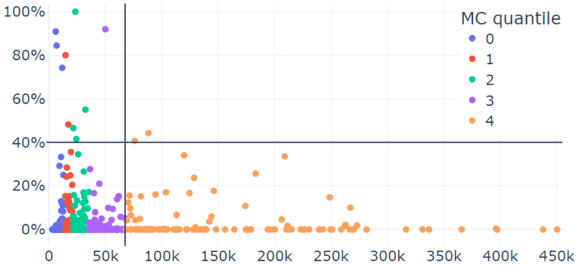


Illustration of the small cap bias

EU taxonomy aligned revenue share (corporate bonds)

Table: Taxonomy alignment in % (Corp. IG)

$\mathcal{GI}$	Global	EUR	USD
> 0	28.40	32.60	27.20
> 10	**9.20**	**11.60**	**8.30**
> 20	**5.40**	**6.50**	**5.10**
> 30	3.00	**4.80**	2.20
> 40	1.60	2.90	**1.00**
> 50	**1.00**	2.30	0.40
> 60	0.80	2.10	0.30
> 70	0.50	**1.10**	0.20
> 80	0.40	0.90	0.20
> 90	0.20	0.60	0.10
$= 100$	0.05	0.20	0.00
Total	3.34	4.71	2.81

- **Less than 33% of the universe have a positive green taxonomy**
- If we would like to keep 5% of the original investment universe, the maximum taxonomy can not exceed $20 - 30\%$
- We can target a taxonomy of 50%, but we must accept to invest in less than $1 - 2\%$ of the investment universe

EU taxonomy aligned revenue share (corporate bonds)

Table: Taxonomy alignment[5] in % by sector (Corp. IG)

Sector	Global				EUR				USD			
	WGT	TC	TW	TM	WGT	TC	TW	TM	WGT	TC	TW	TM
Communication Services	8.15	0.05	0.63	0.57	7.14	0.05	0.67	0.45	8.22	0.05	0.62	0.80
Consumer Discretionary	6.38	0.32	**5.00**	3.64	7.79	0.36	4.62	5.46	6.01	0.30	**5.04**	3.21
Consumer Staples	6.33	0.01	0.11	0.28	7.00	0.00	0.07	0.43	6.33	0.01	0.13	0.14
Energy	8.05	0.15	1.81	1.45	5.25	0.22	4.14	2.81	9.38	0.12	1.33	1.20
Financials	33.41	0.02	0.05	0.10	34.97	0.00	0.00	0.00	31.79	0.02	0.06	0.10
Health Care	7.70	0.01	0.12	0.10	5.95	0.02	0.39	0.17	9.02	0.00	0.05	0.11
Industrials	8.54	0.35	4.14	7.16	9.88	0.61	**6.21**	7.85	8.24	0.25	2.98	6.38
Information Technology	6.12	0.69	**11.23**	7.17	2.94	0.34	**11.52**	7.36	7.99	0.91	**11.33**	7.70
Materials	3.47	0.18	**5.06**	5.42	3.44	0.13	3.72	4.98	3.79	0.21	**5.60**	5.21
Real Estate	4.18	0.74	**17.62**	18.61	5.97	1.63	**27.26**	27.85	2.99	0.40	**13.23**	14.82
Utilities	7.66	0.84	**10.92**	11.26	9.67	1.35	**14.00**	18.32	6.25	0.54	**8.61**	7.29
Total	100	3.34			100	4.71			100	2.81		

The current taxonomy is below 5%

[5] WGT = weight, TC = taxonomy contribution, TW = taxonomy weighted, TA = taxonomy average

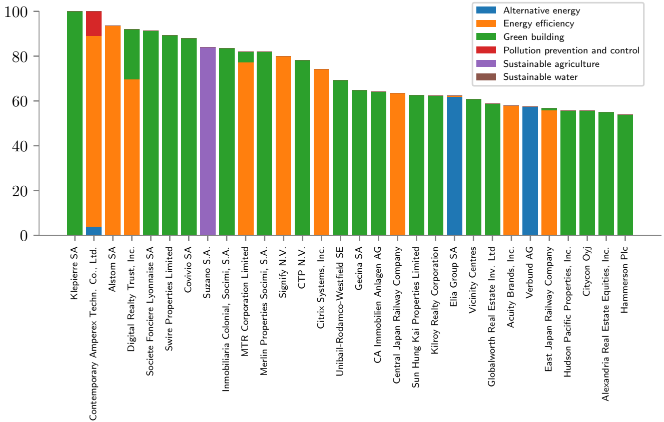
EU taxonomy aligned revenue share (corporate bonds)

Table: Number of issuers (Global Corp. IG)

Sector	Benchmark	$\mathcal{GI} > 0\%$	$\mathcal{GI} > 10\%$	$\mathcal{GI} > 30\%$	$\mathcal{GI} > 40\%$	$\mathcal{GI} > 50\%$
Communication Services	69	15				
Consumer Discretionary	96	36	12	2	1	1
Consumer Staples	91	7	1			
Energy	119	32	1			
Financials	459	6	1			
Health Care	90	4				
Industrials	259	93	31	12	9	7
Information Technology	92	55	20	6	2	1
Materials	116	49	15	3	3	1
Real Estate	192	86	48	30	**25**	19
Utilities	188	97	38	12	7	4
Total	1771	480	167	65	**47**	33

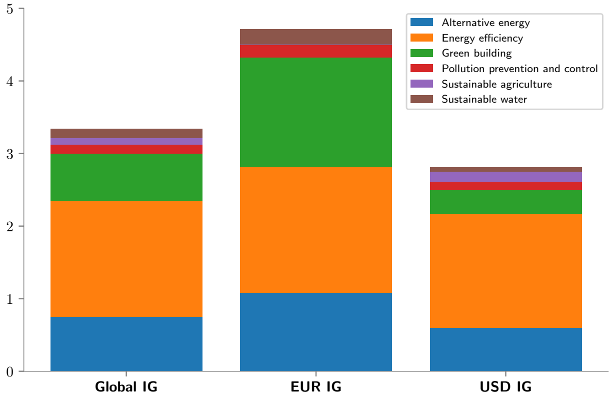
EU taxonomy aligned revenue share (corporate bonds)

Figure: Green revenue share aligned with the EU taxonomy (Global Corp. IG)



EU taxonomy aligned revenue share (corporate bonds)

Figure: Breakdown of green share by activities



Portfolio optimization

We solve the following optimization problem :

$$
\begin{aligned}
x^\star\left(\mathcal{GI}^-\right) & = & \arg\min \frac{1}{2}(x-b)^\top \Sigma (x-b) \\
& & \text{s.t.} \quad \left\{ \begin{array}{l} \mathbf{1}_n^\top x = 1 \\ x \geq \mathbf{0}_n \\ \sum_{i=1}^{n} x_i \cdot \mathcal{GI}_i \geq \mathcal{GI}^- \end{array} \right.
\end{aligned}
$$

where:

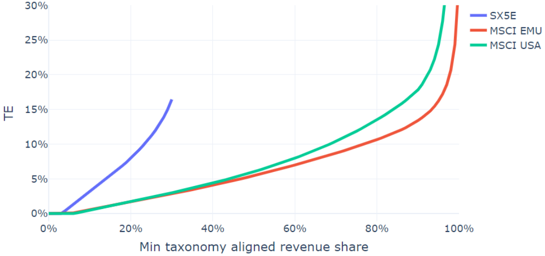
- b is the benchmark
- $\mathcal{GI}_i$ is the green intensity of company i
- $\mathcal{GI}^-$ varies between 0 and 100%

Portfolio attrition & tracking error risk

Table: Number of constituents

$\mathcal{GI}^-$	SX5E	MSCI EMU	MSCI USA
0%	**50**	**233**	**628**
10%	49	228	600
20%	11	168	312
30%	2	113	148
40%		**75**	**74**
50%		56	44
60%		41	29
70%		27	19
80%		18	11
90%		11	7
100%		2	1

Figure: Tracking error volatility



Building a **mainstream** portfolio with more than 40% of green revenues is not suitable on MSCI EMU and MSCI USA ⇒ **thematic** portfolios

Impact of the taxonomy on diversification

Table: Herfindahl index

$\mathcal{GI}$	SX5E				MSCI EMU				MSCI USA			
	Comp.	Sub.	Ind.	Sec.	Comp.	Sub.	Ind.	Sec.	Comp.	Sub.	Ind.	Sec.
0%	32.0	18.4	16.3	7.5	78.2	30.5	25.2	8.3	74.9	35.5	25.7	6.4
10%	15.8	12.9	12.5	5.7	77.5	30.9	25.6	8.3	71.7	33.8	23.8	6.4
20%	4.6	4.3	4.3	2.6	66.6	27.4	23.0	7.4	56.3	26.3	16.4	5.7
30%	1.0	1.1	1.1	1.1	51.8	22.1	18.4	5.9	40.6	19.2	10.6	4.8
40%					39.5	18.1	14.7	4.8	28.6	14.3	7.4	4.1
50%					30.0	16.1	12.2	4.1	20.3	10.9	5.7	3.9
60%					22.2	13.5	9.6	3.6	14.4	8.5	4.3	3.5
70%					16.4	11.0	7.6	3.4	9.6	6.3	3.3	2.9
80%					11.6	9.0	6.3	3.4	6.4	4.9	2.7	2.5
90%					7.4	7.1	5.3	3.1	3.9	3.8	2.7	2.5
100%					1.8	1.8	1.8	1.8	1	1	1	1
Index	50	33	29	11	233	82	53	11	628	126	63	11

Diversification is divided by 2 before 40% and three before 60%

Taxonomy alignment implies portfolio concentration on sector and issuers

Table: Top 10 holdings – 50% taxonomy aligned portfolios

MSCI EMU			MSCI USA		
Stock	Benchmark	$\mathcal{GI}^- = 50$	Stock	Benchmark	$\mathcal{GI}^- = 50$
Alstom	0.20%	6.82%	Digital Rlty Tr	0.12%	10.4%
Schneider Electric	1.84%	5.98%	**Alexandria Real Estate**	0.07%	9.31%
Edp Renovaveis	0.12%	5.72%	**Microsoft**	5.58%	7.13%
Kingspan Group	0.32%	4.73%	Sherwin Williams Co	0.20%	6.24%
Gecina	0.11%	4.72%	**Xylem**	0.05%	6.10%
Asml Holding	5.78%	4.17%	**Citrix Sys**	0.03%	5.16%
Siemens Gamesa	0.10%	3.84%	**Tesla**	2.07%	4.17%
Umicore	0.14%	3.77%	Equinix	0.18%	4.00%
Elia Group	0.07%	3.67%	**Vornado Rlty Tr**	0.02%	3.64%
Covivio	0.07%	3.66%	IBM	0.28%	3.59%
Total	8.75%	47.1%	Total	8.60%	59.8%

Small cap bias & liquidity problems!!!

Taxonomy aligned revenues, MSCI EMU

Figure: MSCI EMU

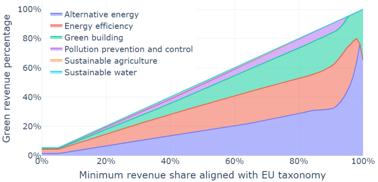


Figure: MSCI USA

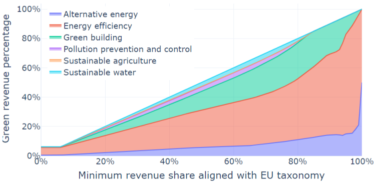
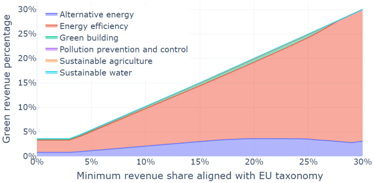


Figure: SX5E



Aligned revenues of optimized portfolios are not diversified

Portfolio optimisation

We consider the following optimisation problem :

$$x^{\star}\left(\mathcal{GI}^{-}\right) = \arg\min \underbrace{\sum_{s=1}^{n_{\mathscr{S}ector}} \left| \sum_{i \in s} (x_i - b_i) \, \mathrm{DTS}_i \right|}_{DTS \ \ component} + \underbrace{\sum_{i \in b} |x_i - b_i|}_{Weight \ \ component}$$

$$\text{s.t.} \quad \begin{cases} \mathbf{1}_n^\top x = 1 \\ x \geq \mathbf{0}_n \\ \sum_{i=1}^{n} x_i \cdot \mathrm{MD}_i = \mathrm{MD}(b) \\ \sum_{i=1}^{n} x_i \cdot \mathcal{GI}_i \geq \mathcal{GI}^{-} \end{cases}$$

where:

- b is the benchmark
- $\mathcal{GI}_i$ is the green intensity of company i
- $\mathcal{GI}^{-}$ is the minimum taxonomy threshold and varies between 0 and 100%

No weight constraint on issuers

Table: Herfindahl index (Corp. IG)

$\mathcal{GI}^-$	0%	10%	20%	30%	40%	50%	60%	70%	80%
Communication Services	16	16	16	16	15	14	13	10	**2**
Consumer Discretionary	24	24	23	22	22	23	19	9	**1**
Consumer Staples	27	27	24	21	19	18	16	10	**1**
Energy	40	40	39	35	35	34	34	22	**1**
Financials	62	62	60	57	55	43	17	4	**1**
Health Care	33	33	33	34	32	32	26	19	**1**
Industrials	69	4	**2**	**1**	**1**	**1**	**1**	**1**	**1**
Information Technology	19	19	20	20	19	16	13	9	**1**
Materials	57	58	51	37	29	19	8	**2**	**1**
Real Estate	54	4	**2**	**1**	**1**	**1**	**1**	**1**	**1**
Utilities	47	47	47	45	43	39	19	4	**1**

Not realistic $\Rightarrow$ The solution is made up of four issuers when $\mathcal{GI}^- \geq 20\%$!!!

No weight constraint on issuers

Table: Sector weights in % (Corp. IG)

$\mathcal{GI}^-$	0%	10%	20%	30%	40%	50%	60%	70%	80%
Communication Services	8.1	8.1	7.7	7.1	6.6	6.0	5.1	4.0	2.9
Consumer Discretionary	6.4	6.4	6.2	5.9	5.0	4.2	3.1	2.1	1.5
Consumer Staples	6.3	6.2	5.4	4.6	4.2	3.9	3.1	2.3	1.1
Energy	8.1	8.0	7.3	6.6	6.0	5.4	4.6	3.4	2.0
Financials	33.4	33.3	28.7	23.7	19.6	15.2	12.0	9.1	7.9
Health Care	7.7	7.6	6.8	5.9	5.2	4.7	3.8	3.2	1.6
Industrials	8.6	8.4	10.0	19.0	23.4	23.5	23.6	23.6	23.7
Information Technology	6.1	6.1	5.7	5.2	5.0	4.6	4.0	3.1	2.0
Materials	3.5	3.3	2.7	2.3	2.0	1.8	1.5	1.1	1.0
Real Estate	4.2	5.0	11.9	12.5	15.8	24.5	33.8	42.8	**50.8**
Utilities	7.7	7.7	7.6	7.4	7.0	6.3	5.5	5.2	5.6

With a taxonomy of 80%, 50.8% of the portfolio is concentrated...
... on one issuer in the Real Estate sector

Portfolio optimisation

We consider the following optimisation problem :

$$x^{\star}\left(\mathcal{GI}^{-},\mathcal{B}^{+}\right) = \arg\min \underbrace{\sum_{s=1}^{n_{\mathcal{S}ector}} \left| \sum_{i\in s} (x_i - b_i)\,\mathrm{DTS}_i \right|}_{DTS\ \ component} + \underbrace{\sum_{i\in b} |x_i - b_i|}_{Weight\ \ component}$$

$$\text{s.t.} \quad \begin{cases} \mathbf{1}_n^{\top} x = 1 \\ x \geq \mathbf{0}_n \\ \sum_{i=1}^{n} x_i \cdot \mathrm{MD}_i = \mathrm{MD}(b) \\ \sum_{i=1}^{n} x_i \cdot \mathcal{GI}_i \geq \mathcal{GI}^{-} \\ \forall j, \sum_{i\in j} x_i \leq \mathcal{B}^{+} \end{cases}$$

where:

- j is an issuer
- $\mathcal{B}^{+}$ is the maximum weight of one issuer

Weight constraint on issuers

Table: Maximum green taxonomy with respect to the weight bound (Corp. IG)

$\mathcal{B}^+$	0.25%	0.50%	0.75%	1%	**1.5%**	2%	3%
$\mathcal{GI}^+$	20%	25%	30%	35%	**40%**	45%	50%

There is a trap:

When $\mathcal{GI}^+ > 40\%$, sectors such as Communication Services, Consumer Discretionary, Consumer Staples, Energy, Financials, Health Care and Materials can be made up of 2 issuers at the most

Weight constraint on issuers ($\mathcal{B}^+ = 1.5\%$)

Table: Corp. IG – 40% taxonomy aligned portfolios (Global Corp. IG)

	Herfindahl Index		Weights (in %)		Top 10 Issuers (in %)	
	Benchmark	$\mathcal{GI}^- = 40\%$	Benchmark	$\mathcal{GI}^- = 40\%$	Benchmark	$\mathcal{GI}^- = 40\%$
Communication Services	16	13	8.1	4.8	5.3	3.6
Consumer Discretionary	24	6	6.4	4.7	3.6	4.6
Consumer Staples	27	13	6.3	2.7	3.2	1.7
Energy	40	12	8.1	3.9	3.2	2.7
Financials	62	28	33.4	12.1	11.0	6.2
Health Care	33	28	7.7	3.9	3.3	1.9
Industrials	69	**13**	**8.6**	17.5	2.5	**15.0**
Information Technology	19	7	6.1	8.4	3.6	7.7
Materials	57	4	3.5	4.9	1.0	4.8
Real Estate	54	**13**	**4.2**	18.7	1.4	**15.0**
Utilities	47	**15**	**7.7**	18.4	2.9	**14.8**
Total	297	98	100.0	100.0	41.1	78.0

$\Rightarrow$ Issuer diversification is divided by 3, concentration on Utilities, Real Estate and Industrials and Top 10 issuers

Weight constraint on issuers ($\mathcal{B}^+ = 1.5\%$)

Table: Global Corp. IG – 40% taxonomy aligned portfolios

	Weights (in %)			Contrib. to yield (in bps)		
	Benchmark	$\mathcal{GI}^- = 40\%$	Δ	Benchmark	$\mathcal{GI}^- = 40\%$	Δ
0Y-2Y	11	10	-1	12	5	**-7**
2Y-5Y	36	41	**5**	62	49	**-13**
5Y-7Y	16	8	**-8**	34	15	**-19**
7Y-10Y	14	19	**5**	33	43	**10**
10Y+	24	23	-1	79	78	-1
Total	100	100	0	221	191	**-30**

- **Yield** $\searrow$
- Lower contribution of short durations not offset by the contribution of higher durations.

Green revenues & carbon intensity ($\mathcal{B}^+ = 1.5\%$)

Figure: Corp IG – Green revenues

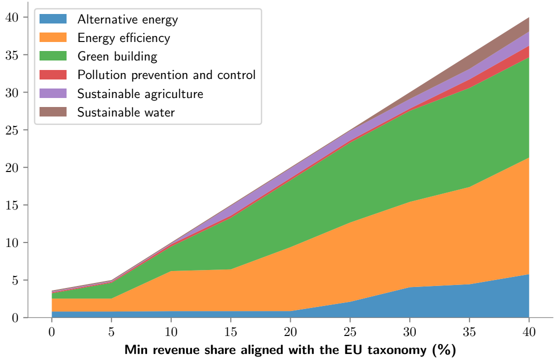
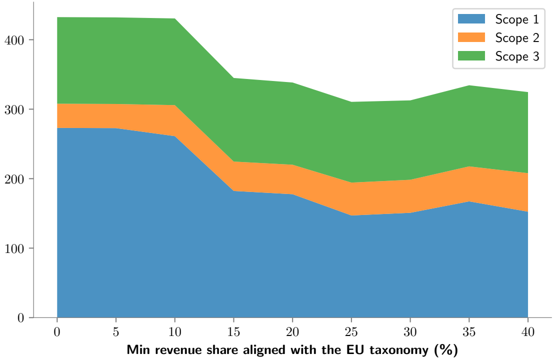


Figure: Corp IG – Carbon intensity



Conclusion

- Disruptive impact of the extra-financial information on the asset management industry $\Rightarrow$ Convergence between fundamental analysis & extra-financial analysis (what is a fair price?)
- Climate risk measures: **Standardization** & **Accounting** needs
- The issue of Scope 3
- The new topic of Net Zero Portfolio Alignment
  - New climate risk measures
  - Decarbonization $\neq$ Low-carbon economy financing
- Impact of the green taxonomy

Huge/disruptive impact on the Asset management Industry

Emerging risks: capital allocation, diversification shortage, crowding risk & economy/finance gap

Conclusion

Decarbonization	
Communication Services	
Consumer Discretionary	
Consumer Staples	−−
Energy	−−−
Financials	++
Health Care	+
Industrials	
Information Technology	+
Materials	−−−
Real Estate	
Utilities	−−−

Taxonomy	
Communication Services	−−−
Consumer Discretionary	
Consumer Staples	−−−
Energy	−
Financials	−−−
Health Care	−−−
Industrials	+++
Information Technology	+
Materials	
Real Estate	+++
Utilities	+++

We have to manage contradictory objectives

Conclusion

Portfolio decarbonization

$\Downarrow$

Capital **reallocation**

Green taxonomy

$\Downarrow$

Capital **allocation**

Does it all make sense?

It will depend on the economy decarbonization!

A new asset bubble?

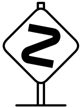
It will depend on the supply!

Impact of climate risk measures $\gg$ Impact of ESG scoring

The risk is to then take investment decisions using wrong/noisy/inappropriate risk measures

Conclusion

- Scope 3 $\Rightarrow$ portfolio decarbonization is more difficult
- Negative correlation between green revenues and carbon emissions/intensity
- HCIS constraint $\Rightarrow$ sector distortion (Financials/Luxury solution)
- Solution with carbon emissions $\neq$ solution with carbon intensity
- Solution with carbon trends $\neq$ solution with historical figures
- **Negative externalities**: food & beverages, utilities, construction materials



Portfolio decarbonization $\neq$ portfolio alignment

Asset allocation issue: Diversification $\searrow$

Gap between finance and economy decarbonization $\nearrow$

What could be a NZE portfolio alignment policy?

Two building blocks of NZE portfolios

Decarbonized portfolio

- Decarbonization pathway(s)
- Top-down approach
- Portfolio optimization
- Carbon measures
- Net zero **carbon** metrics

+

Green solution portfolio

- Financing the transition
- Bottom-up approach
- Security selection
- $\neq$ Carbon measures
- Net zero **transition** metrics

$\alpha\%$ $\qquad$ $(1-\alpha)\%$

$\Rightarrow$ The issue of engagement and time horizon — Choose your answer: ,  or 

Disclaimer