



Weathered for climate risk

a bond investment proposition



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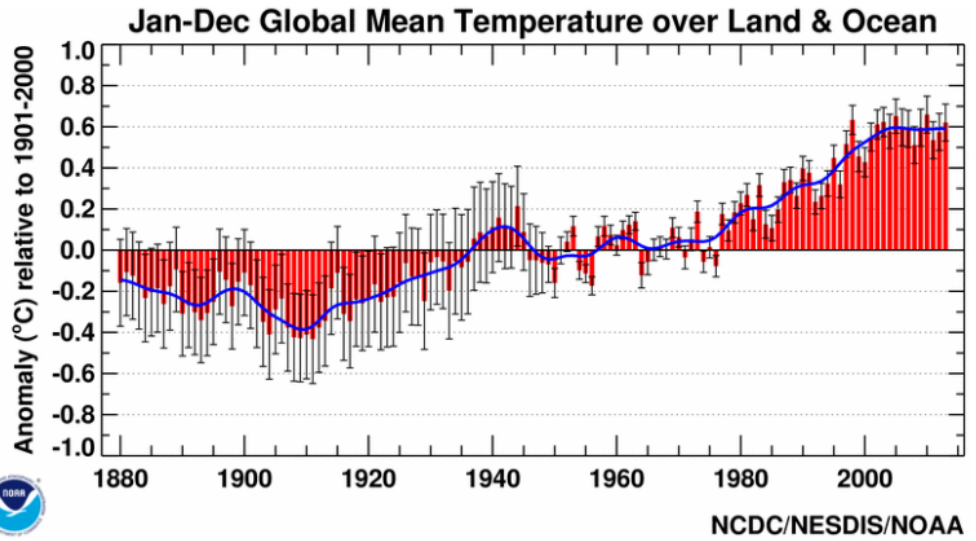
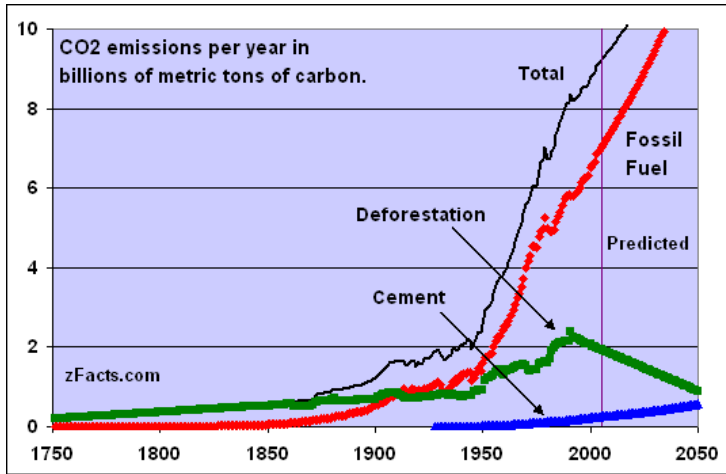


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The Earth is heating up – invested capital may be at risk

Scientific evidence mounts regarding the contribution of uncontrolled carbon emissions to global warming.



Threats to invested capital

■ Government policies called in to mitigate global warming

– Carbon tax

- Clean Energy Act	in Australia	2011 – 2014
- Climate Action Plan	in British Columbia, Canada	since 2008
- Carbon Price Floor Tax	in the UK	since 2013
- Clean Power Plan	in the US	imminent

– Withdrawal of industrial licenses

- permits for shale gas exploration granted in 2007 and withdrawn in 2011 in France
- coal mining permit revoked in West Virginia (in context of Clean Water Act)

– Tightening environmental regulation

- Clean Air Act – case of Volkswagen

Threats to invested capital

- Stranded assets
 - potential of CO₂ emissions exceeds planet's absorption capacity

- Top ten stranded assets
 - **Gazprom Russia**
 - **Coal India**
 - **China Coal Energy**
 - **China Shenhua Energy**
 - **Peabody Energy US**
 - **Jindal Steel India**
 - **Rosneft Russia**
 - **Exxon US**
 - **Petrochina**
 - **Mechel Mining Russia**

Biggest carbon producers - firms

In absolute terms (tons of CO₂)

- Huaneng Power China
- Datang Power China
- Korea Power
- China Power
- NTPC Power India
- ArcelorMittal Steel
- China Petroleum
- RWE Power Germany
- Tokyo Power
- Engie Power France
- Exxon
- Duke Energy
- Gazprom
- American Elec Power
- E.ON Energy Germany
- ENEL Energy Italy
- LafargeHolcim Cement

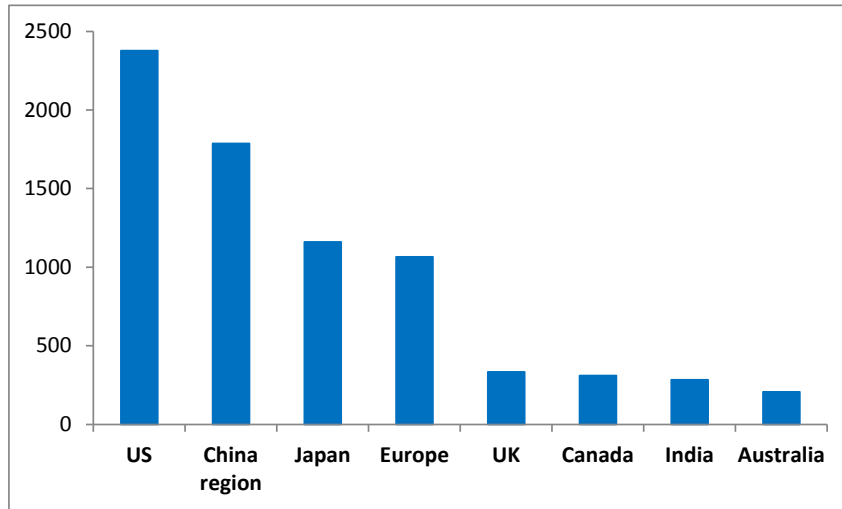
In relative terms (tons per sales)

- American Vanguard (agriculture)
- Qatar Electricity
- Zespil Electricity Poland
- China Power
- Hopewell Hong Kong (infrastructure)
- FSK Yees Russia (electricity)
- Dynegy US (electricity)
- Datang Power India
- Huaneng Power China
- Séché France (recycling)
- E.CL Energy Chili
- NTPC Power India
- Transalta Canada
- NRG Yield US Energy
- Allete US Energy
- Atlantic Power
- Westar Energy

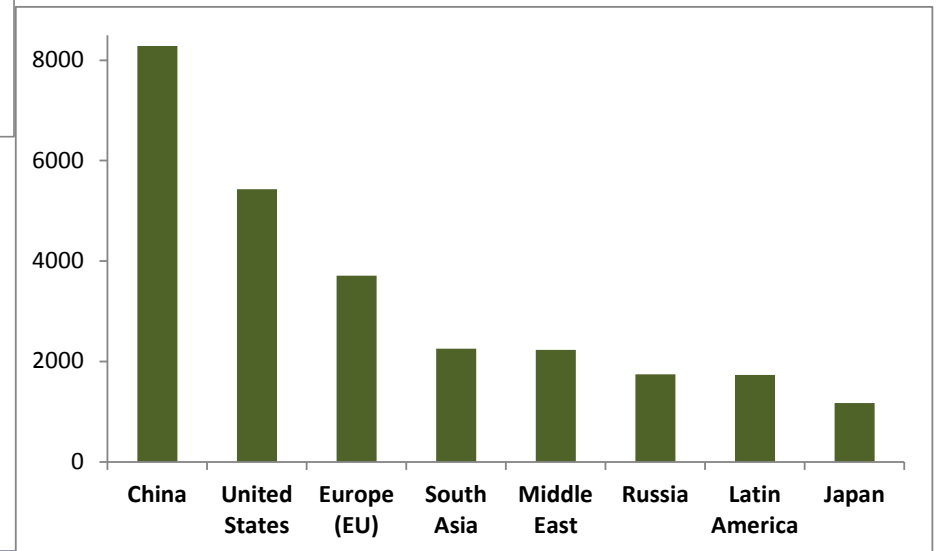
Biggest carbon producers - regions

Tons of CO₂

Aggregate firm data for 2013



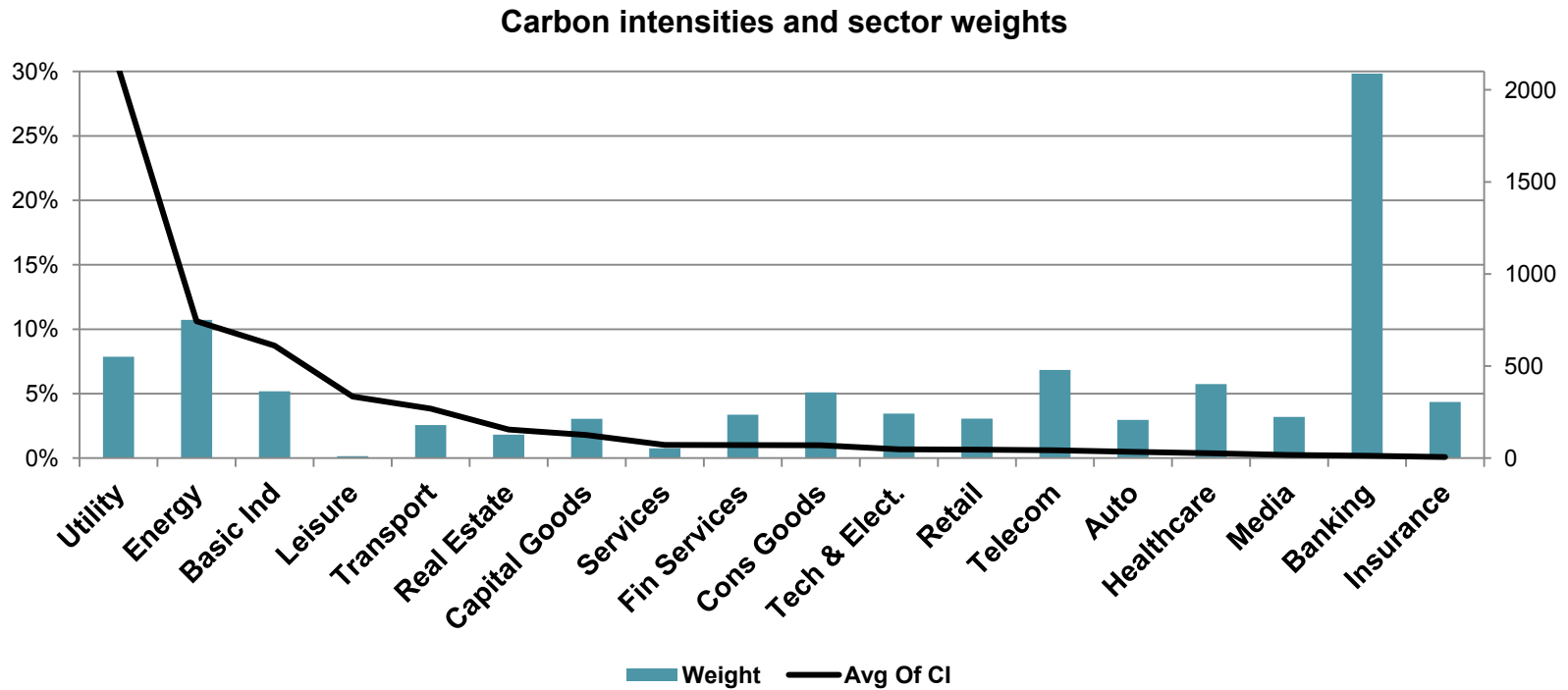
World Bank country-level data for 2010



Source: Carbon Disclosure Project for firm data
World Bank for country data

Carbon-intensive industry

Tons of CO₂ per \$mln of sales revenues



Source: BoA Merrill Lynch Global Large Cap Corporate Index end 2014 and MSCI ESG Research carbon intensities

Weathered for climate risk

- **Protect capital** against write-downs due to reinforced environmental policies by **divesting** from carbon-intensive activity.
- Forthcoming: special issue of the *Financial Analysts Journal* on low carbon investing
 - Introduction by Steve Brown, new Chief Editor of *FAJ*
 - **Weathered for Climate Risk** - corporate bonds - de Jong and Nguyen
 - **Hedging Climate Risk** - equity - Andersson, Bolton, Samama

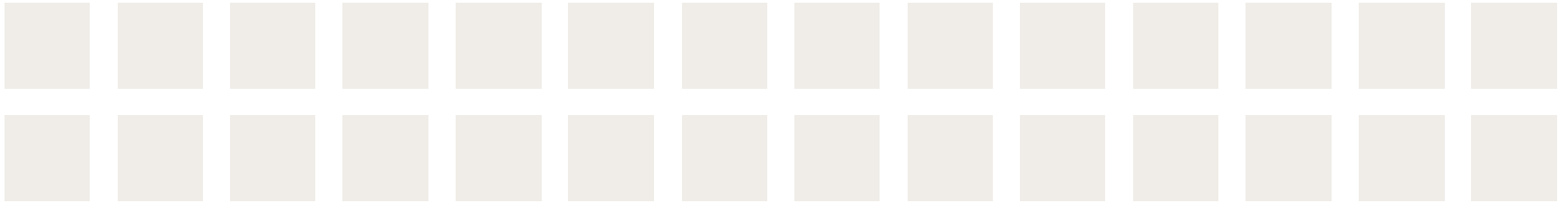
Divest from carbon-intensive activity

- Reduce portfolio's carbon intensity without altering its performance objectives.
 - Typically, the carbon footprint of a tracking portfolio can be reduced by 50% without notable sacrifice in terms of tracking error.
This holds today for equity- as well as for corporate bond investments.
 - Low-carbon investing is as it stands a free lunch.
It protects capital against a latent risk at low cost.
 - No new exposure is introduced to the fund, an existing exposure is eliminated.
Low-carbon investing is not akin to Green- or Socially Responsible Investing.
 - It recognizes, as Bob Litterman puts it, a long-term price disequilibrium stemming from the fact that carbon-inflicted economical losses are not (yet) factored in.

Carbon entering the equilibrium pricing process

- Investment philosophy consistent with Capital Asset Pricing theory
 - Carbon investments are made on the basis of tractable CO₂ emission disclosures.
 - Divestments send out pricing signals.
 - Since asset prices tend to be driven by market anticipations before the outcome, the capital markets may be an effective medium to incite carbon clean-up *before* an eventual overheating.
 - For a carbon pricing process to take effect, it suffices that anticipations express concerns, not per se accurate estimates of carbon-inflicted loss, which would be too complex to make.*
 - * See Litterman (2013) ‘What is the Right Price for Carbon Emissions?’

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- 2. Low-carbon portfolio construction**
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Low-carbon portfolio construction

- Add a carbon reduction target to the existing performance objectives
- We look at the construction of low-carbon tracking portfolios

- Carbon Intensity (CI) enters the problem objective function

Markowitz optimization $\max. -CI^T x - \lambda \cdot x^T \cdot V \cdot x$

- Benchmark serves as reference for defining

risk, i.e. tracking error (TE)

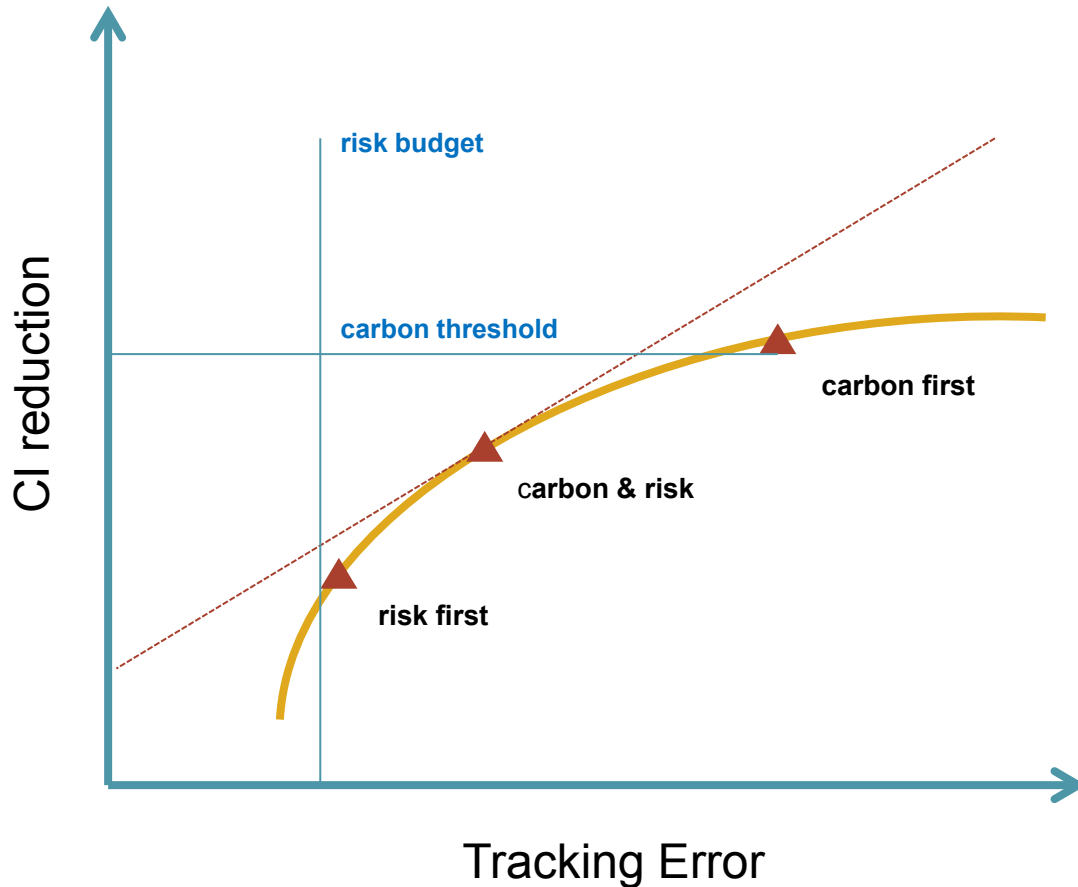
reduction in carbon intensity

- Investment vehicle

managed portfolio – manager in position to integrate carbon news

ETF – rules-based construction based on tractable carbon data

Portfolio selection



e.g.
MSCI Low Carbon Leader:
- minimise TE for a CI reduction of at least 50%

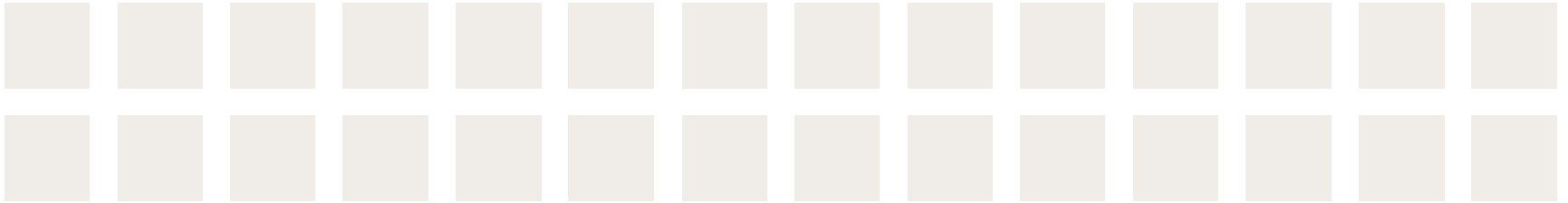
MSCI Low Carbon Target:
- Maximise CI reduction given a TE budget of 30bp

A bond investment proposition

- Corporate bond portfolios are built through stratified sampling, not Markowitz.
 - Stratified sampling objective*: match portfolio with benchmark in terms of
 - duration (D)
 - spread level (S)
 - sample per sample (J). Samples defined by region times sector breakdown.
 - Add carbon matching criterion by
 - initialising benchmark as carbon free
 - defining a carbon tolerance (λ)
 - defining negative carbon scores (CI^-), or carbon savings scores
 - Objective function:
$$\sum_J \sum_{i \in J} \left| x_i \cdot D_i \cdot S_i \cdot (CI_i^- \cdot \lambda) \right|$$

Solution of the portfolio optimization problem

- By means of a computer programming algorithm that operates in three steps
 - 1. Retain first percentile of contributing firms in terms of $w_i \cdot D_i \cdot S_i \cdot CI_i^-$
 - w benchmark weight
 - D duration
 - S spread
 - CI^- carbon saving score
 - 2. Local search
 - * for each pair of firms establish potential gain (in terms of matching) while reallocating weight between them
 - * execute those reallocations in descending order until saturation
 - * small portfolio weights are discarded
 - 3. Select bonds to represent the retained firms



1. Low-carbon investment philosophy
2. Low-carbon portfolio construction
- 3. Measuring carbon**
4. Back-tests

Measuring carbon

- **Absolute measure** *For how much carbon am I responsible?*

$$\text{Carbon footprint} = \sum_{\text{firms}} (\text{stake} \cdot \text{CO}_2)$$

optimization zooms in on low-carbon activity

- **Relative measure** *Is my portfolio carbon efficient?*

$$\text{Carbon Intensity} = \frac{\sum_{\text{firms}} (\text{weight} \cdot \text{CO}_2)}{\sum_{\text{firms}} (\text{weight} \cdot \text{sales})}$$

Alternatives to sales revenues:

deployed capital (book value)

firm value (market value of equity+bonds)

optimization zooms in on carbon-efficient activity

Measuring carbon intensity

■ Intensity measures

	CO ₂ /sales	CO ₂ /deployed capital	CO ₂ /value
Definition	CO ₂ per unit of production	CO ₂ on assets	CO ₂ on investment
Measure	measures production efficiency	measures the efficiency of assets	measures the efficiency of an investment
Time variation	sales vary over years	stable if book value is used	incurs market price volatility
Advantages	provided by all data vendors	method also applies to fossil reserves	method also applies to fossil reserves

■ Scope*

scope 1: inherent to production process

scope 2: inherent to consumption of the product

scope 3: overhead

e.g. car industry

car production

car usage

staff commuting to work

* As defined by the Carbon Disclosure Project

Measuring carbon - outstanding issues

Inconsistency problem

- Due to Jensen’s inequality, the average CI is superior to the aggregate CI

$$CI_p^a = \sum_i w_i \cdot CI_i \quad \geq \quad CI_p^b = \frac{\sum_i w_i \cdot CO_{2i}}{\sum_i w_i \cdot sales_i}$$

■ e.g.

weight	CO ₂	sales	CI
0.5	5000	250	20
0.5	5000	750	6.7
	10 000	1 000	(a) 13.3
			(b) 10

- It makes the portfolio optimization complex
 a standard Markowitz optimizer cannot deal with it
 our stratified sampling algorithm deals with it

Measuring carbon – outstanding issues

What do stranded assets imply for bonds?

- The extent to which firms are stranded is defined in equity terms

condemned fossil fuel reserves
equity market cap

- No consensus on a bond equivalent.
Some consensus on a stranded economy **heavy reliance on fossil fuel reserves**

Duration matters?

- Consensus says no, lending period doesn't change carbon intensity

Pitch firm consolidation level

- e.g. Renault financing subsidiary integrated in Renault Cars Holding
- G.E. Capital separate from G.E. Holding

Up- and down stream dependence

- ignored, except by TruCost and South Pole

Carbon data providers

Principle ones

- TruCost cross check disclosures against in-house model
- South Pole
- MSCI ESG Research

- Innovest
- Bloomberg
- Corporate Knights
- Oekom
- Inrate
- Grizzly
- Profundo
- Carbone 4
- Eiris
- Cross Asset Footprint

Data stability

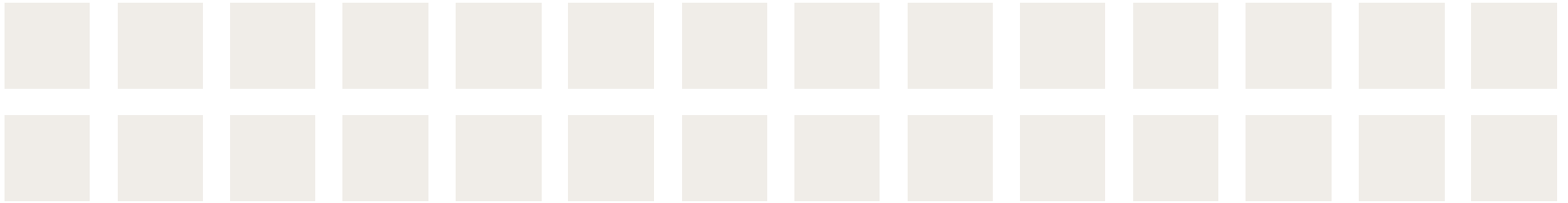
- Transition matrices between firms, CI ranked and regrouped per quintile.

- The diagonal terms confirm stability *(figures are averages over 4 years)*.

Global Corporate Index						
from\to	1	2	3	4	5	Total
1	19%	1%	0%	0%	0%	20%
2	1%	18%	1%	0%	0%	20%
3	0%	1%	18%	1%	0%	20%
4	0%	0%	1%	18%	1%	20%
5	0%	0%	0%	1%	19%	20%
Total	20%	20%	20%	20%	20%	100%

Utility						
from\to	1	2	3	4	5	Total
1	17%	1%	1%	0%	0%	19%
2	2%	16%	1%	1%	1%	20%
3	0%	3%	16%	2%	0%	21%
4	0%	1%	2%	16%	1%	19%
5	0%	0%	1%	2%	19%	21%
Total	19%	21%	20%	20%	20%	100%

Energy						
from\to	1	2	3	4	5	Total
1	18%	2%	0%	0%	0%	20%
2	1%	16%	2%	1%	0%	20%
3	0%	2%	16%	1%	1%	20%
4	0%	0%	3%	15%	3%	20%
5	0%	0%	0%	3%	17%	20%
Total	19%	20%	20%	20%	20%	100%



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Low-carbon backtests

Equity

- Methodology
 1. carbon filter: discard 20% highest CI stocks while conserving 70% per sector (in weight)
 2. Markowitz optimisation
- Dataset

MSCI
2011 – 2014
monthly rebalancing
- Portfolio objective

minimise TE keeping carbon reduction over 50%

Corporate bonds

1. (optional) warm start by carbon filter
 2. stratified sampling
- BoA Merrill Lynch
2011 – 2014
monthly rebalancing
- minimise TE and CI simultaneously

Backtest on equities

Key figures	MSCI Europe	MSCI Low Carbon Leaders
Total return¹ (%)	11.5	12.1
Total risk¹ (%)	11.9	11.8
Sharpe	0.93	0.99
Active return¹ (%)	-	0.7
Tracking Error¹ (%)	-	0.7
Information Ratio	-	0.91
Turnover² (%)	1.9	11.3
Exclusions #	-	91
Exclusions in weight (%)	-	23.5
Reduction in carbon intensity (tCO²/mm USD) (%)	-	62
Reduction in stranded assets (tCO²/mm USD) (%)	-	81

(1) Performance brute annualisée en EUR pour la période du 30/11/2010 au 30/06/2014.

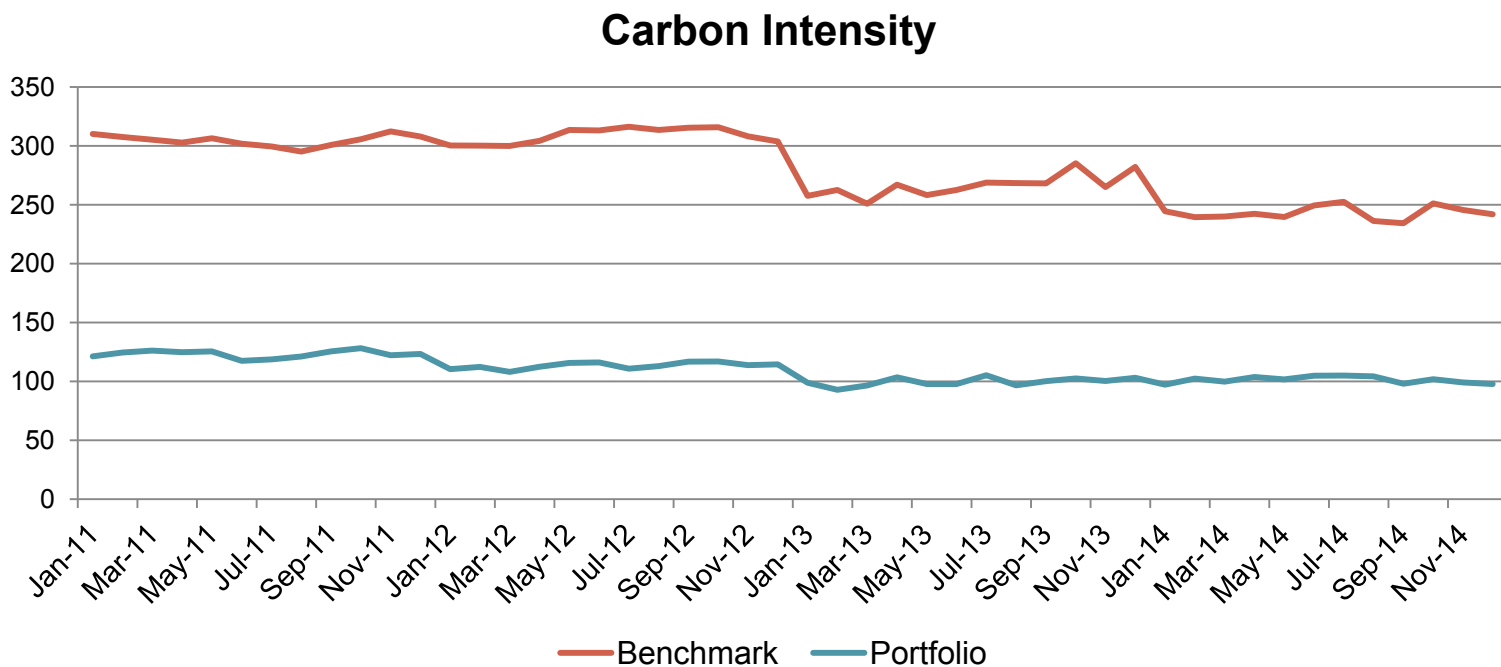
(2) Turnover de l'indice annualisé unilatéralement pour la période du 30/11/2010 au 30/06/2014.

Backtest on bonds

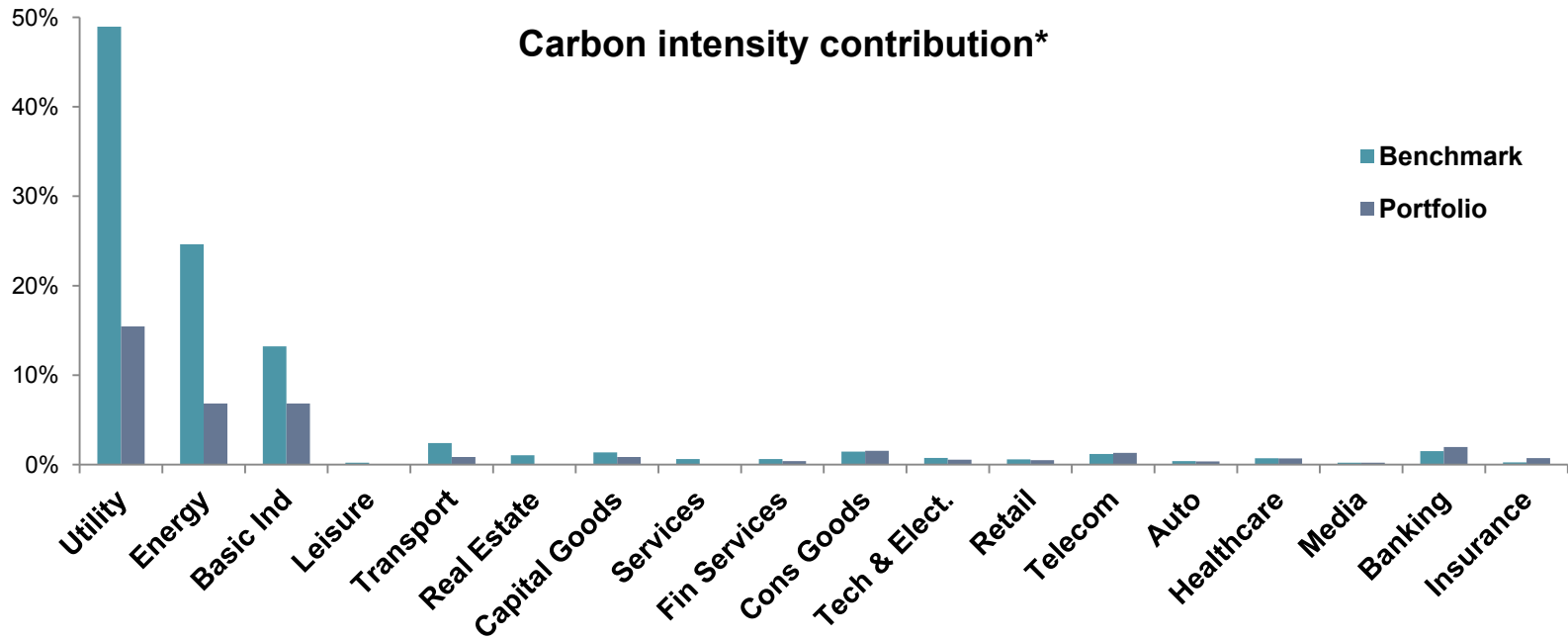
Key figures	Benchmark	Regular portfolio	Low carbon portfolio
Total Return (%)	2.19	2.41	2.42
Total Risk (%)	3.61	3.64	3.70
Sharpe	0.61	0.66	0.65
Active return (%)	-	0.22	0.23
Tracking error (%)	-	0.28	0.29
Information ratio	-	0.80	0.80
average MD	5.80	6.10	6.00
average Yield	3.0	3.0	3.0
average DTS	996	964	976
Carbon intensity reduction (%)	-	-	61

Backtest on bonds

Reduction of carbon intensity by 55-65% over the test period



Backtest on bonds

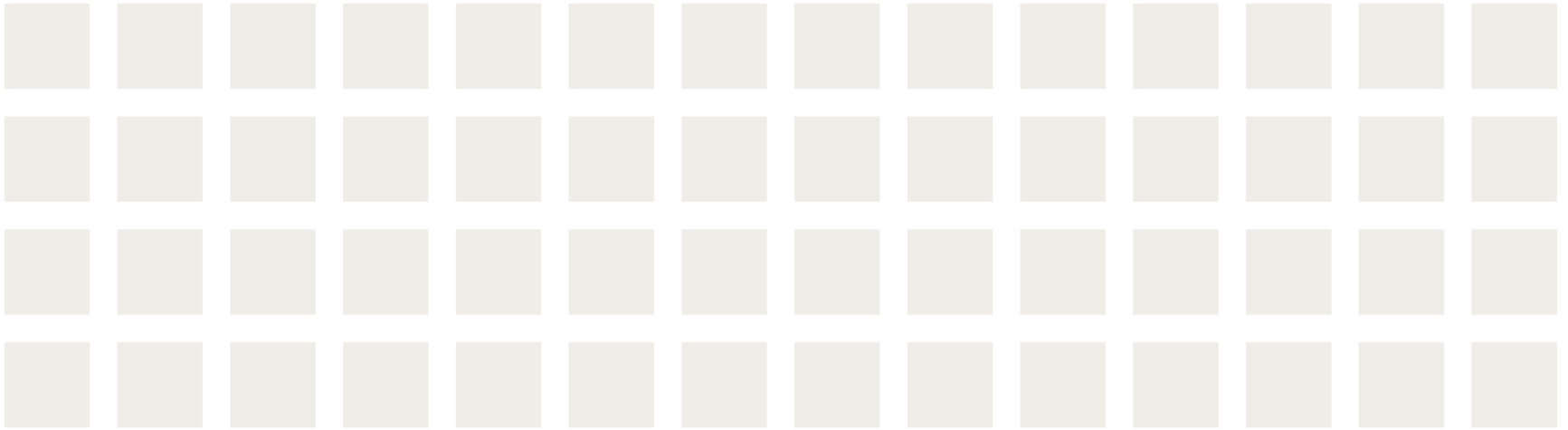


* Base: carbon intensity of the benchmark

Data source: Merrill Lynch & MSCI

Index: BofA ML Global Large Cap Corporate as of 12/31/2014

Calculation made by Quant Research Team



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