The Impact of ESG Investing on Asset Pricing, Credit Rating, Financial Analysis and the Cost of the Debt

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[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.

Some Amundi publications

1. How ESG Investing Has Impacted the Asset Pricing in the Equity Market, DP-36-2018, 36 pages, November 2018
2. ESG Investing in Recent Years: New Insights from Old Challenges, DP-42-2019, 32 pages, December 2019
3. ESG Investing and Fixed Income: It's Time to Cross the Rubicon, DP-45-2019, 36 pages, January 2020
4. ESG & Factor Investing: A New Stage Has Been Reached, Amundi Viewpoint, May 2020
5. Measuring and Managing Carbon Risk in Investment Portfolios, WP-99-2020, 67 pages, August 2020
6. The Market Measure of Carbon Risk and its Impact on the Minimum Variance Portfolio, WP-105-2021, 24 pages, January 2021
7. ESG and Sovereign Risk: What is Priced by the Bond Market and Credit Rating Agencies?, WP-114-2021, 102 pages, October 2021

Available at `https://research-center.amundi.com`, `www.ssrn.com`, `https://arxiv.org` and `www.researchgate.net`

2010 – 2017: From hell to heaven

- ESG investing tended to penalize both passive and active ESG investors between 2010 and 2013
- Contrastingly, ESG investing was a source of outperformance from 2014 to 2017 in Europe and North America
- Two success stories between 2014 and 2017: **E**nvironmental in North America and **G**overnance in the Eurozone
- ESG was a risk factor (or a beta strategy) in the Eurozone, whereas it was an alpha strategy in North America

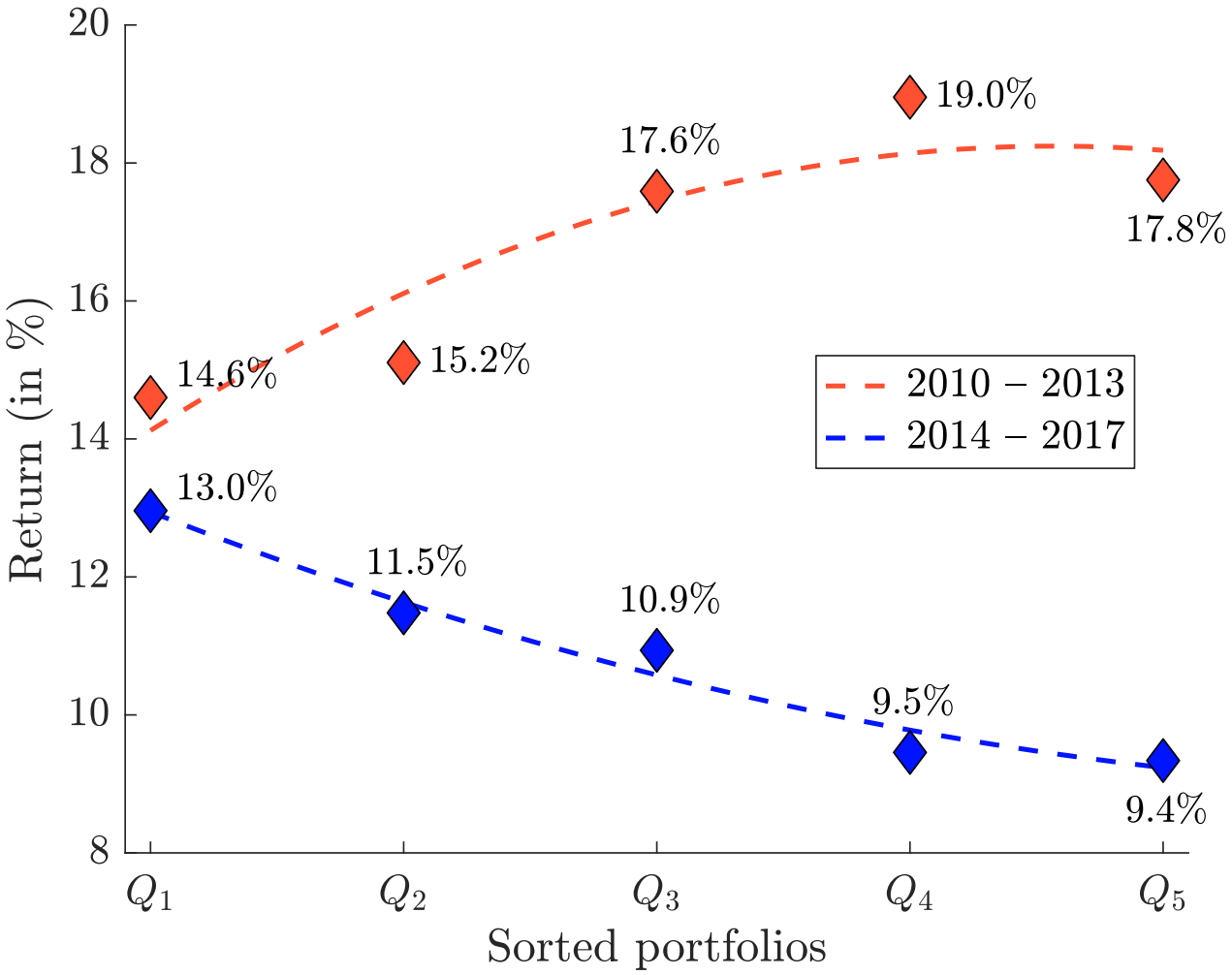
Sorted portfolio methodology

Sorted-portfolio approach

- Sorted-based approach of Fama-French (1992)
- At each rebalancing date t, we rank the stocks according to their Amundi **ESG** z-score $s_{i,t}$
- We form the five quintile portfolios Q_i for $i = 1, \ldots, 5$
- The portfolio Q_i is invested during the period $]t, t+1]$:
  - Q_1 corresponds to the best-in-class portfolio (best scores)
  - Q_5 corresponds to the worst-in-class portfolio (worst scores)
- Quarterly rebalancing
- Universe: MSCI World Index
- Equally-weighted and sector-neutral portfolio (and region-neutral for the world universe)

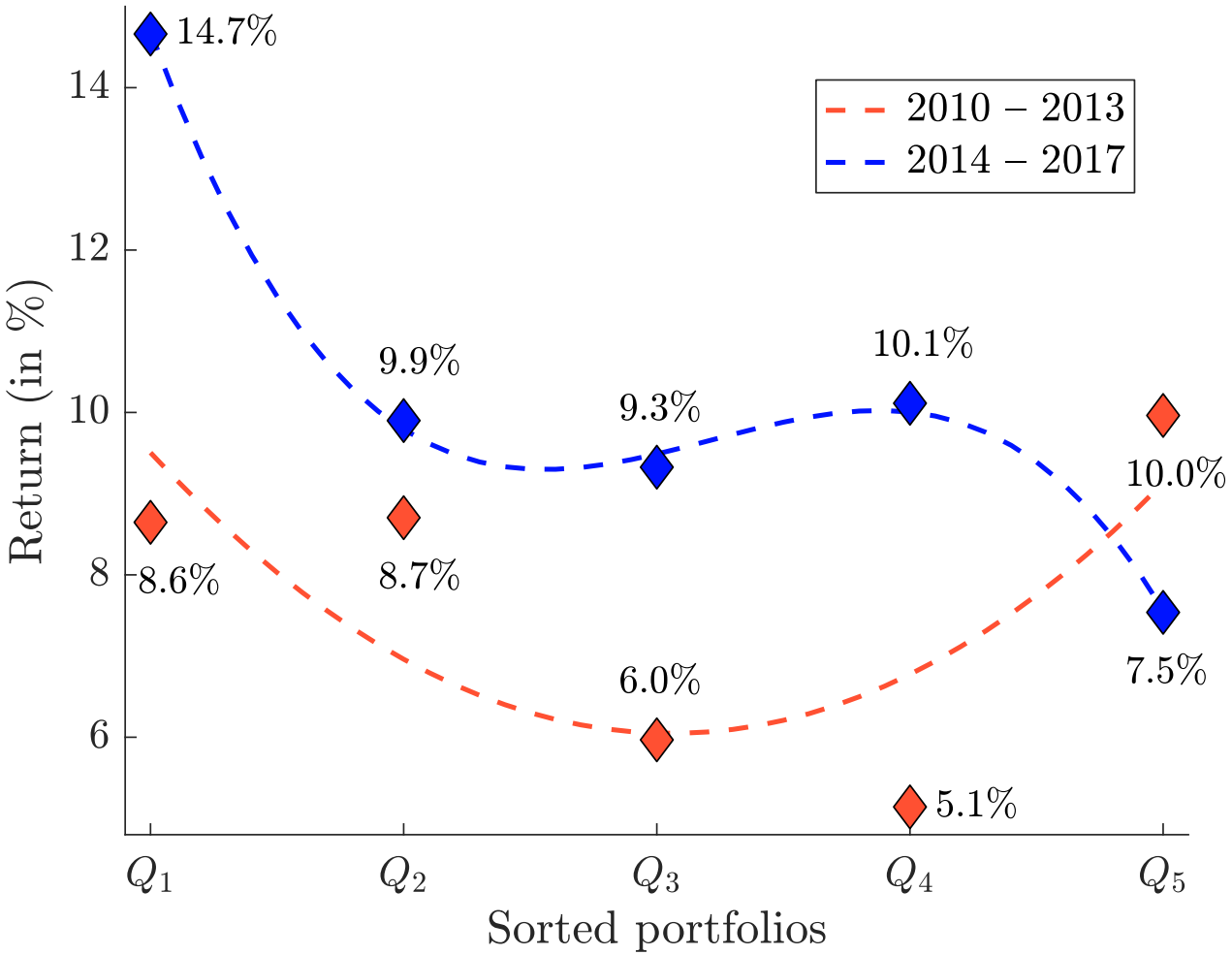
North America (2010 – 2017)

Figure: Annualized return of **ESG** sorted portfolios (North America)



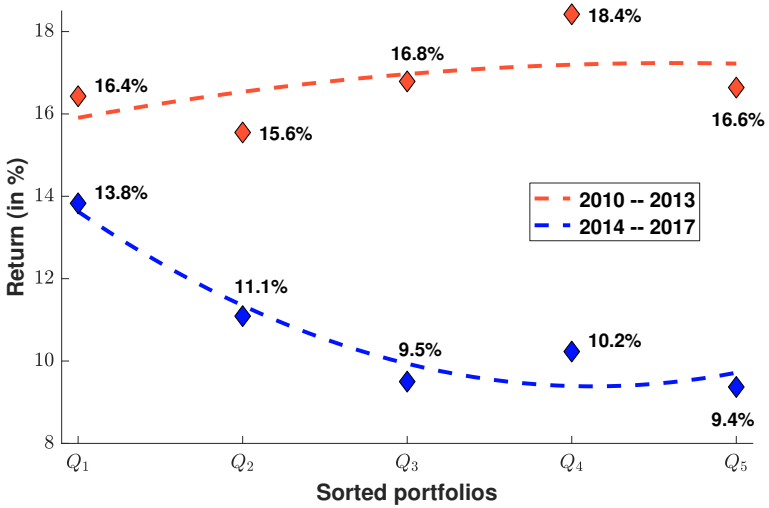
Eurozone (2010 – 2017)

Figure: Annualized return of **ESG** sorted portfolios (Eurozone)

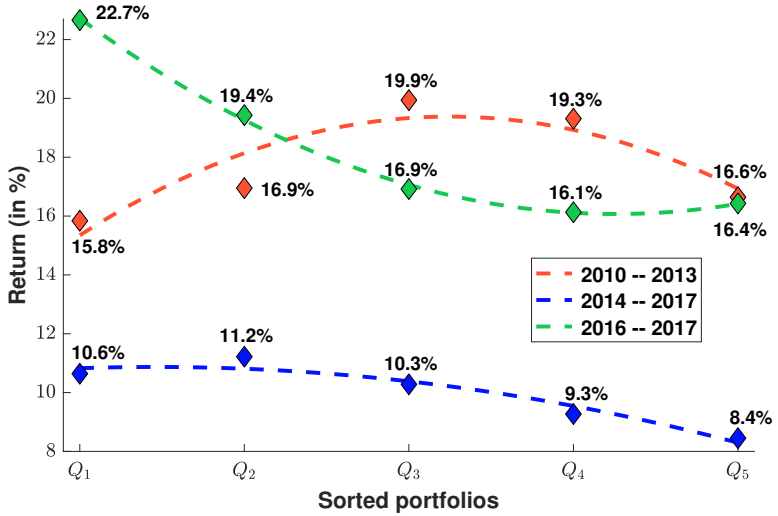


North America (2010 – 2017)

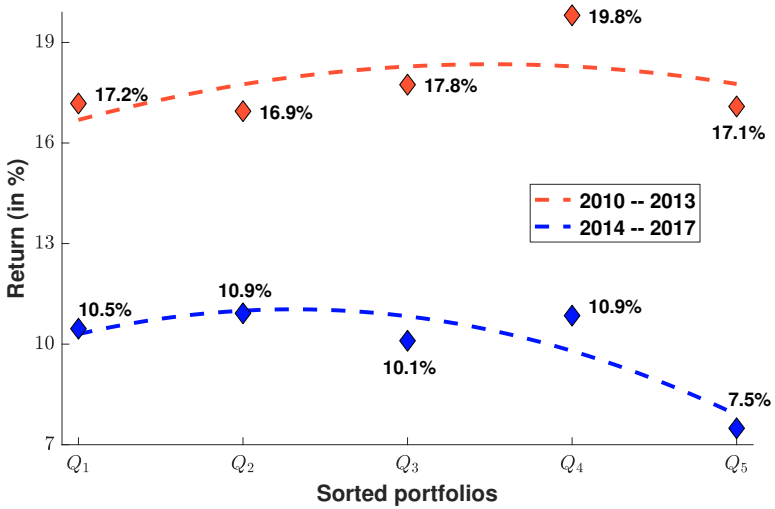
Environmental



Social

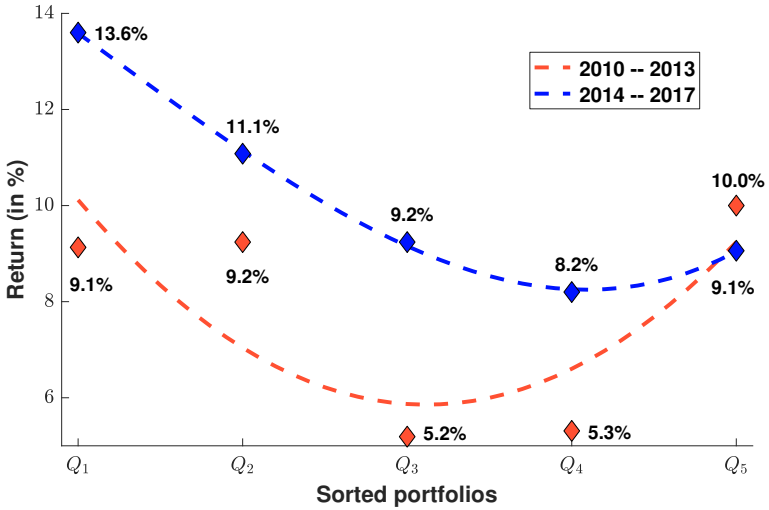


Governance

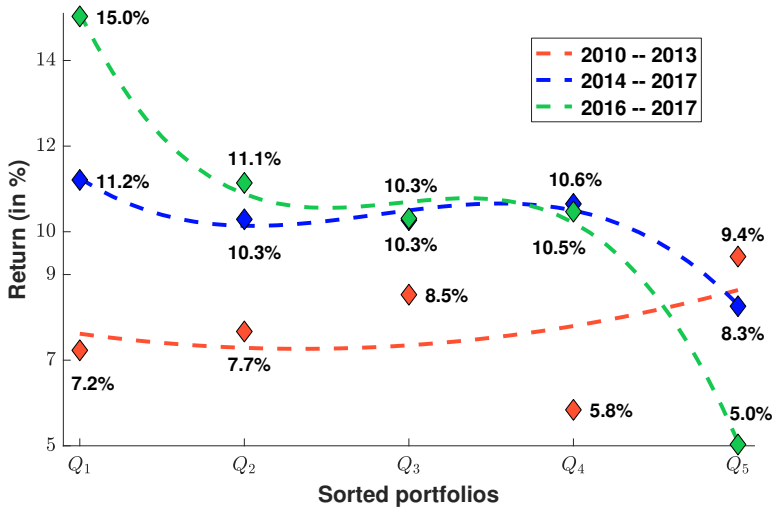


Eurozone (2010 – 2017)

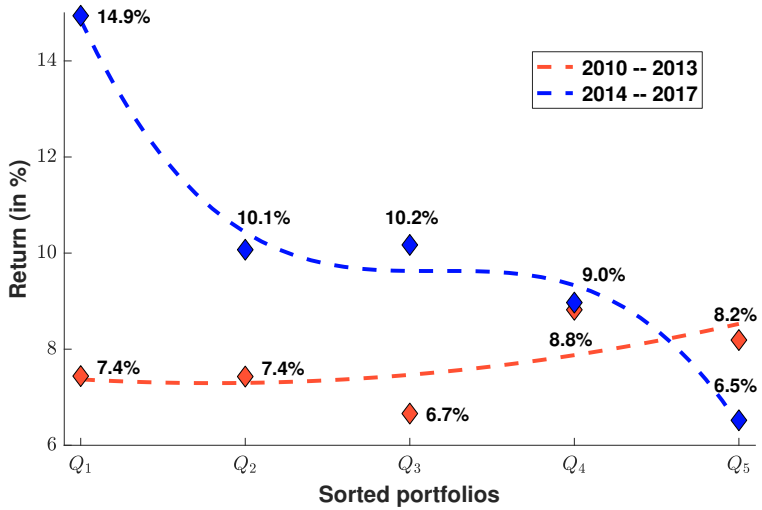
Environmental



Social



Governance



The 2014 break

Table: Summary of the results (sorted portfolios, 2010 – 2017)

Before 2014					
Factor	North America	Eurozone	Europe ex-EMU	Japan	World DM
ESG	−−	−	**0**	+	**0**
E	−	**0**	+	−	**0**
S	−	−	**0**	−	−
G	−	**0**	+	**0**	+
Since 2014					
Factor	North America	Eurozone	Europe ex-EMU	Japan	World DM
ESG	++	++	**0**	−	+
E	++	++	−	+	++
S	+	+	**0**	**0**	+
G	+	++	**0**	+	++

The 2014 break

How to explain the 2014 break?

1. **The intrinsic value of ESG screening** or **the materiality of ESG**

   "Since we observe a feedback loop between extra-financial risks and asset pricing, we may also wonder whether the term 'extra' is relevant, because ultimately, we can anticipate that these risks may no longer be extra-financial, but simply financial"(Bennani et al., 2018).

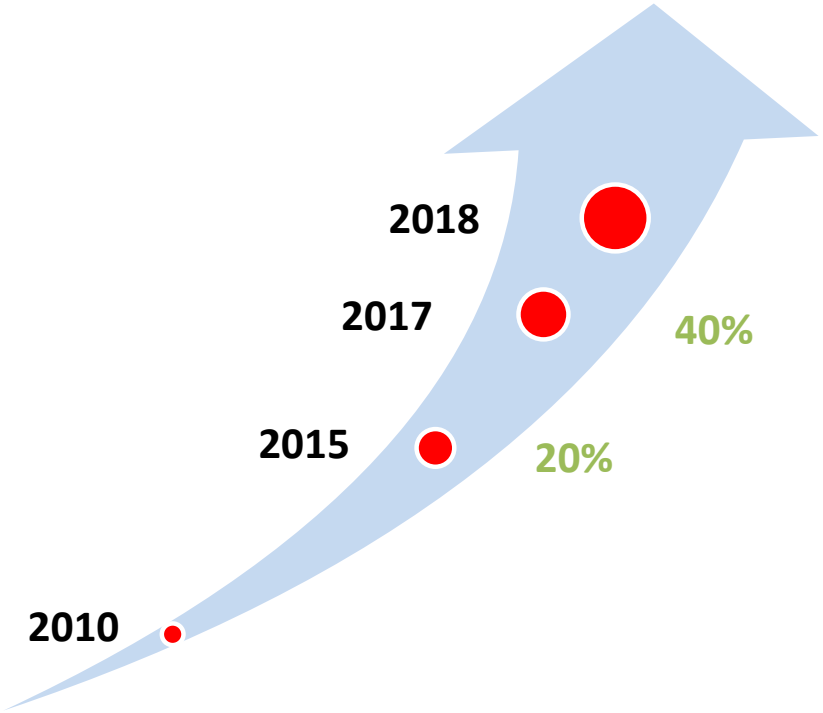
   ESG risks ⇒ Asset pricing

2. **The extrinsic value of ESG investing** or **the supply/demand imbalance**

   Investment flows matter!

The steamroller of ESG for institutional investors

Figure: Frequency of institutional RFPs that require ESG filters



Source: Based on RFPs received at Amundi.

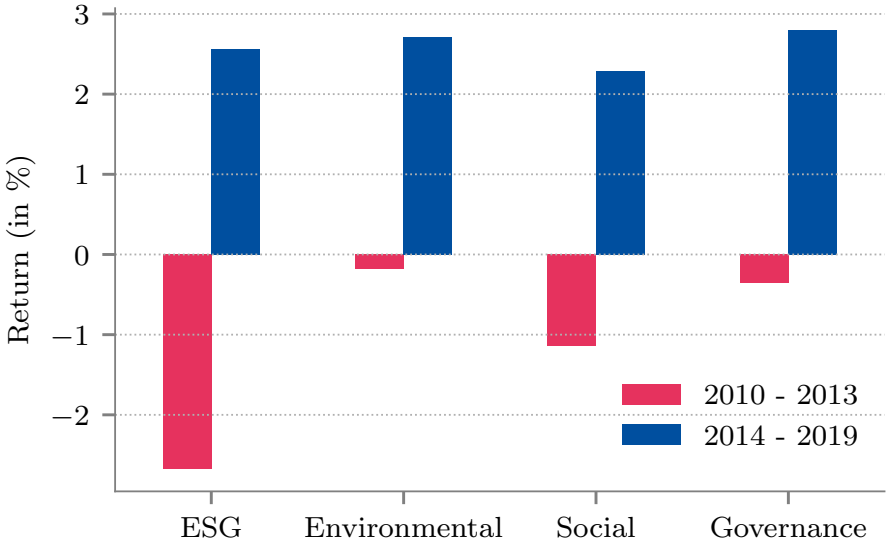
- In some countries, 100% of RFPs require ESG filters
- For some institutional investors, 100% of RFPs require ESG filters (public, para-public and insurance investors)
- For some strategies, 100% of RFPs require ESG filters (index tracking)

2018 – 2019: On the road again

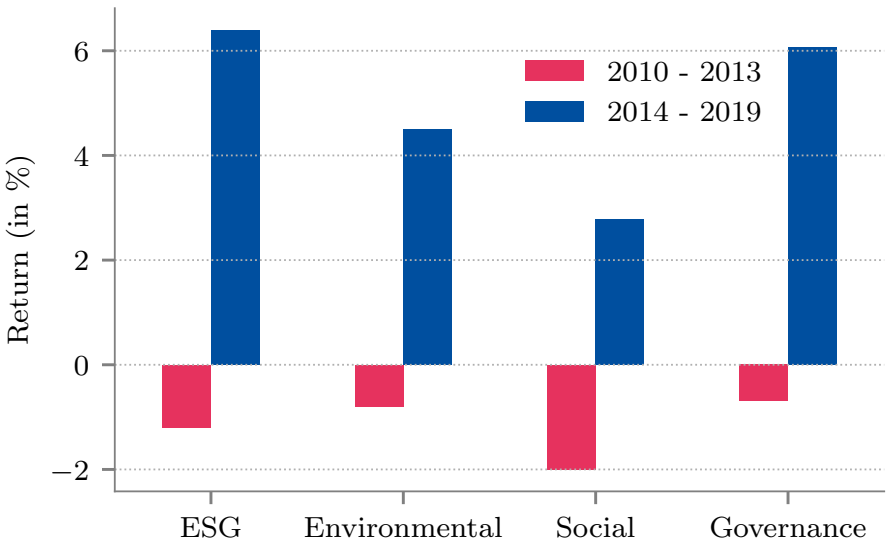
Main result

The 2018 – 2019 period seems to be a continuity of the 2014 – 2017 period rather than another distinctive phase

North America



Eurozone



New findings in the stock market

1. **The transatlantic divide**

   $$\text{Eurozone} \succ \text{North America}$$

2. **Social: from laggard to leader**[2]

   $$\mathbf{S} \succ (\mathbf{E}, \mathbf{G})$$

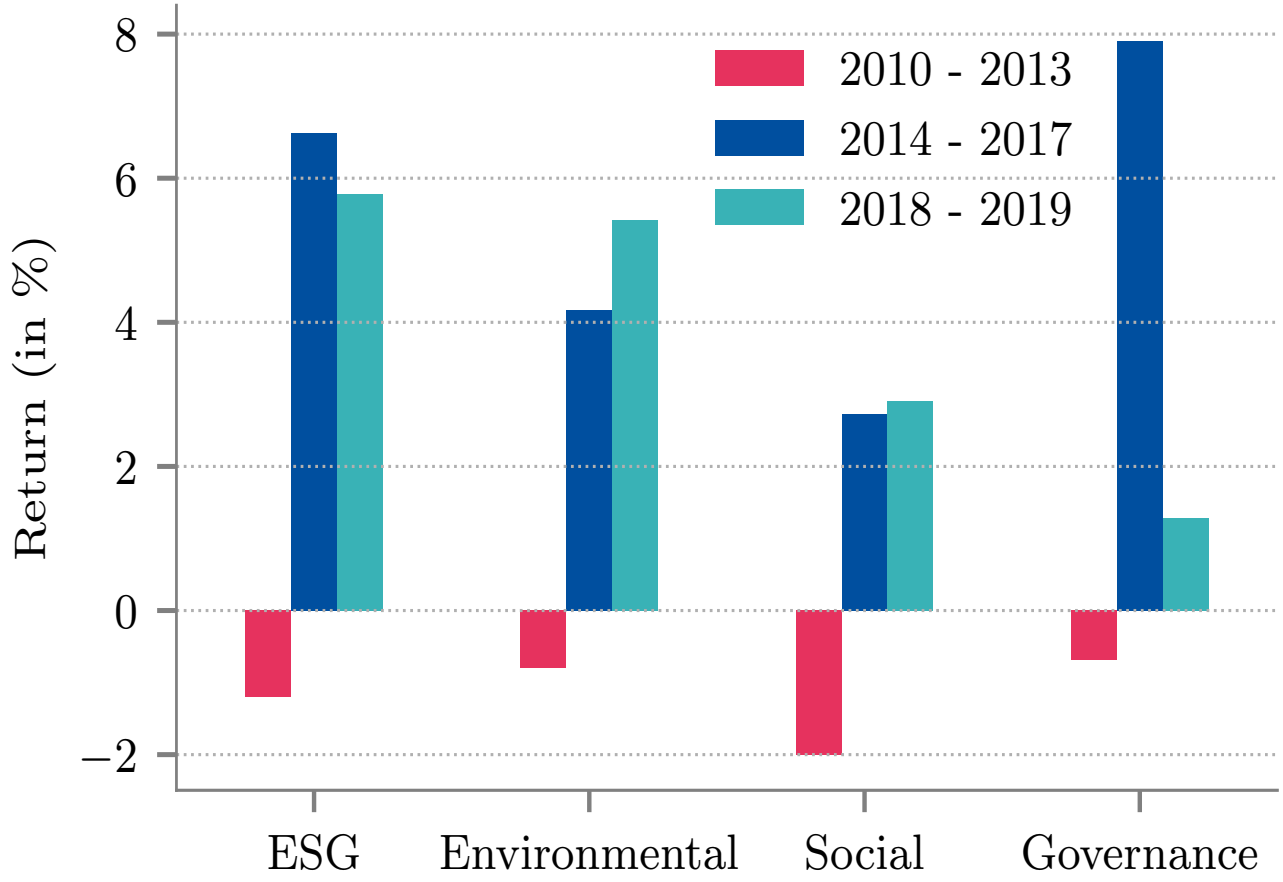
3. **ESG investing: growing in complexity**

   Beyond worst-in-class exclusion and best-in-class selection strategies

[2] In the Eurozone: 2010 – 2013: **E**, then 2014 – 2017: **G**, then 2018 – 2019: **S**
In North America: 2010 – 2013: **G**, then 2014 – 2017: **E**, then 2018 – 2019: **S**

The transatlantic divide: the case of the Eurozone

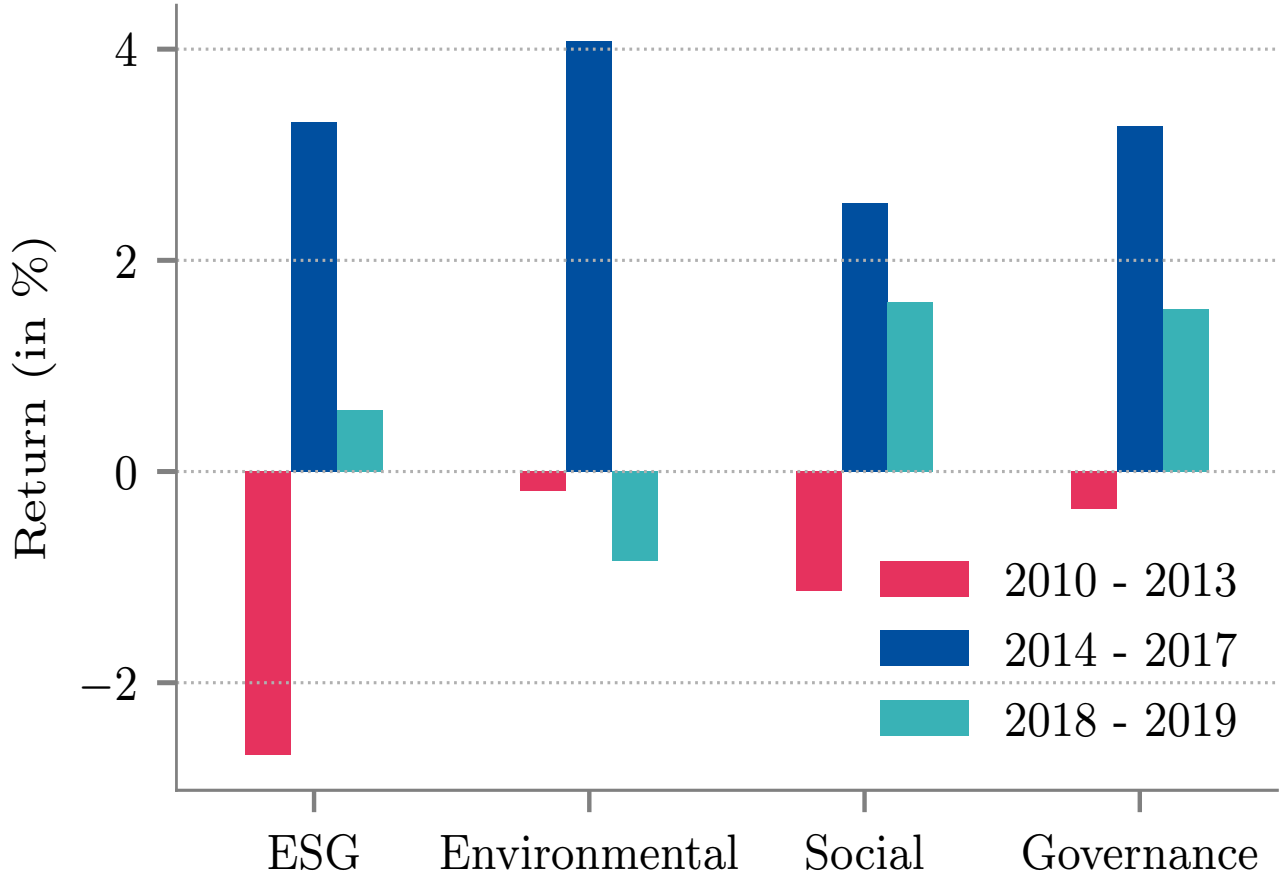
Figure: Annualized return of long/short $Q_1 - Q_5$ sorted portfolios



$\Rightarrow$ Performance remains highly positive, and is improved for **E** and **S**

The transatlantic divide: the case of North America

Figure: Annualized return of long/short $Q_1 - Q_5$ sorted portfolios



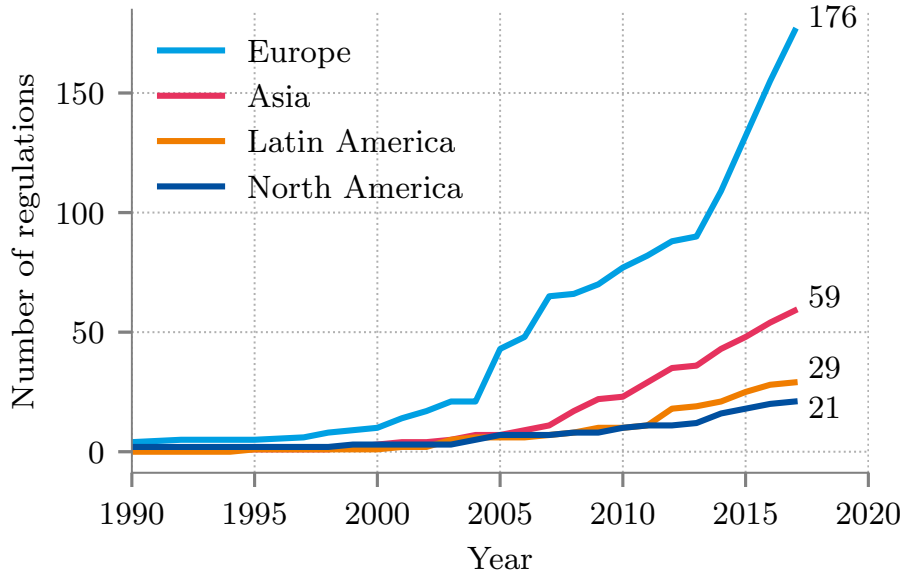
⇒ Performance is positive, but reduced for **S** and **G**, whereas **E** is negative

How to explain the American setback?

The regulatory value of ESG investing (or the intrinsic value *revisited*)

- Trump election effect
- Regulatory environment

Figure: Number of ESG regulations



ESG regulations are increasing, with a strong momentum in Europe but a weaker one in North America

US withdrawal from Paris Climate Agreement

Source: PRI, responsible investment regulation database, 2019.

How to explain the American setback?

The extrinsic value of ESG investing

- The 2014 break
  - November 2013: Responsible Investment and the Norwegian Government Pension Fund Global (2013 Strategy Council)
  - Strong mobilization of the largest institutional European investors: NBIM, APG, PGGM, ERAFP, FRR, etc.
  - They are massively invested in European stocks and America stocks:
    $$\text{NBIM} \succ \text{CalPERS} + \text{CalSTRS} + \text{NYSCRF for U.S. stocks}$$
- The 2018-2019 period
  - Implication of U.S. investors continues to be weak
  - Strong mobilization of medium (or tier two) institutional European investors, that have a low exposure on American stocks
  - Mobilization of European investors is not sufficient

$\Rightarrow$ The extrinsic value of ESG investing is temporary, and a new equilibrium will be found on the long run

Social is strong in Eurozone since 2016

Figure: Eurozone, 2010 – 2017

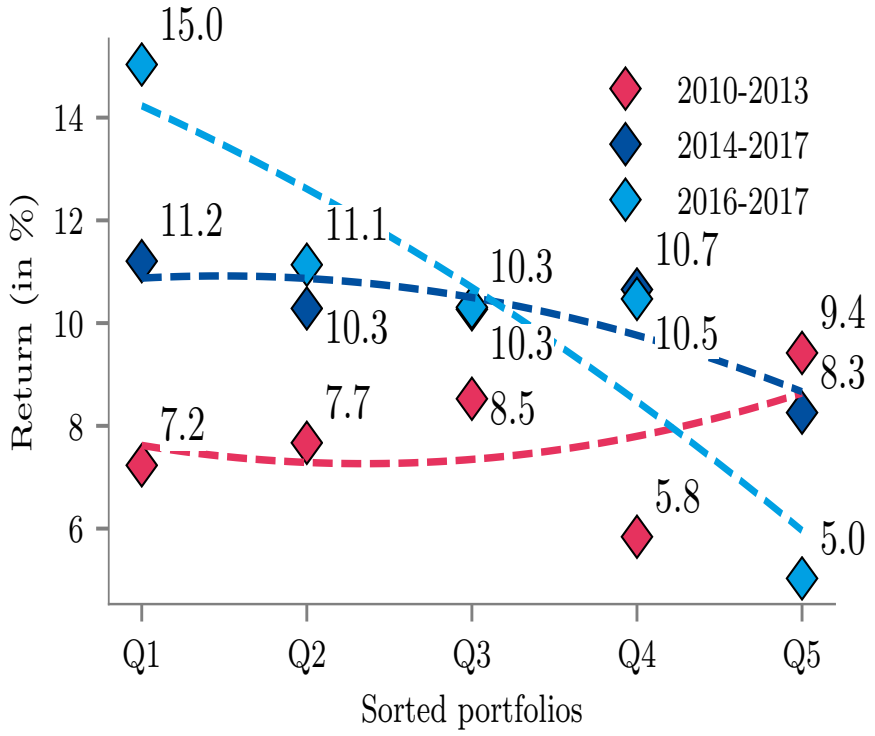
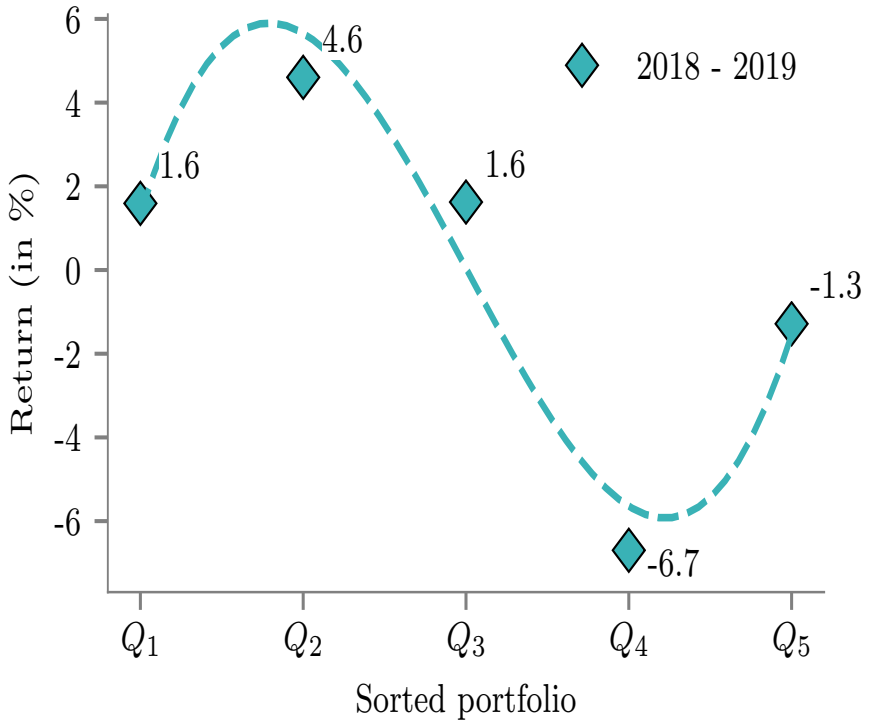


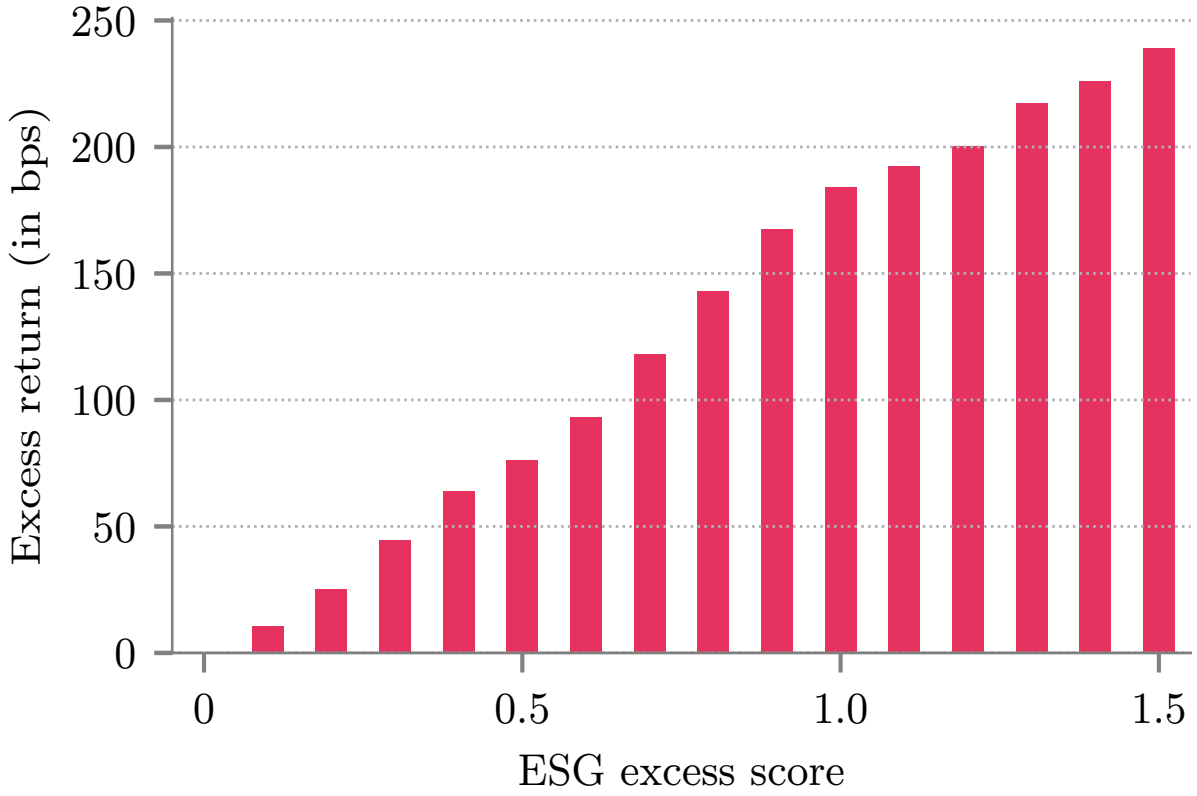
Figure: Eurozone, 2018 – 2019



$\Rightarrow$ The trend were already identified

Performance of optimized portfolios

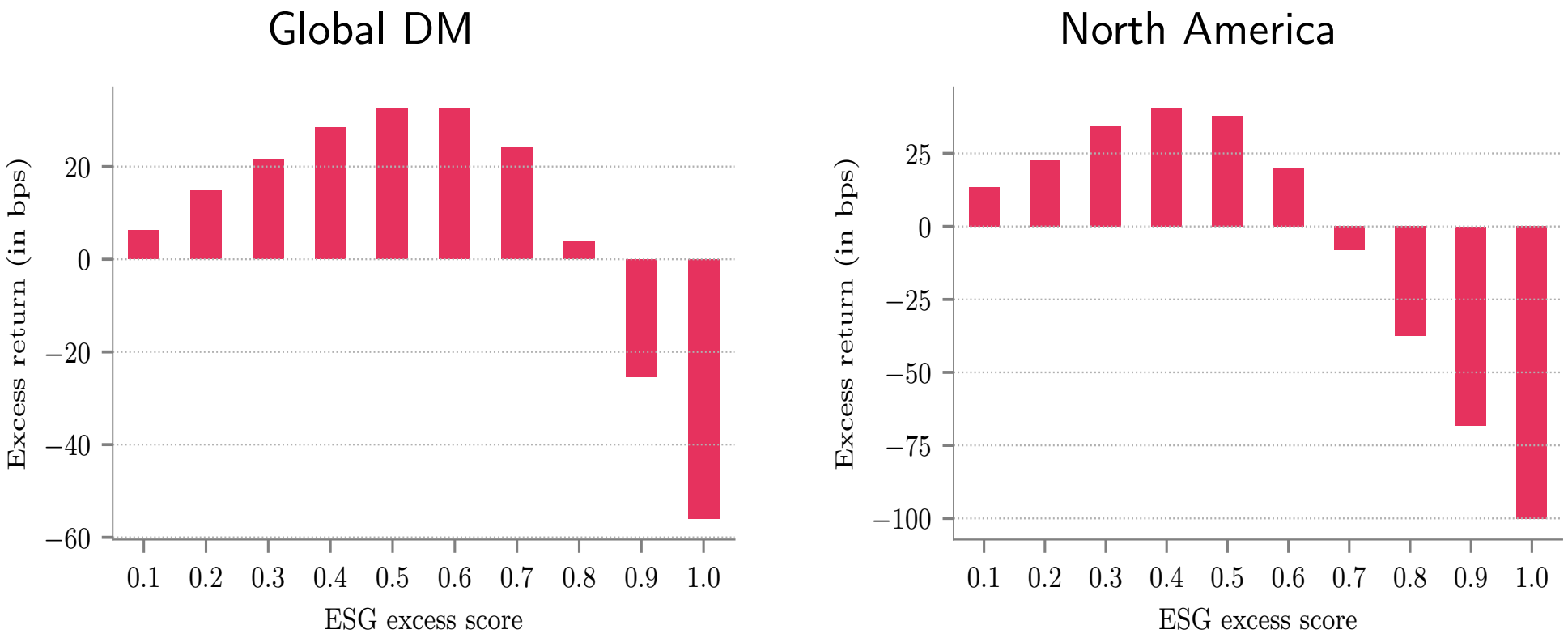
Figure: **S**ocial optimized portfolios in Eurozone (2018 – 2019)



$\Rightarrow$ **S** is very strong (no diversification loss)

Performance of optimized portfolios

Figure: **S**ocial optimized portfolios (2018 – 2019)



⇒ **S** is the winning pillar in ESG passive management

Social is also in action in North America

Figure: 2010 – 2017

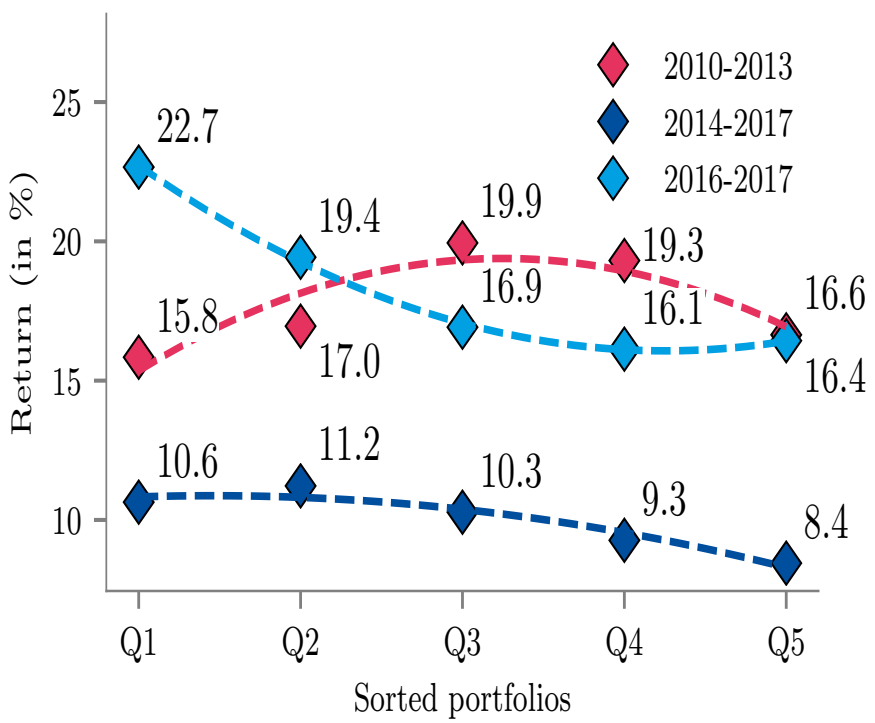
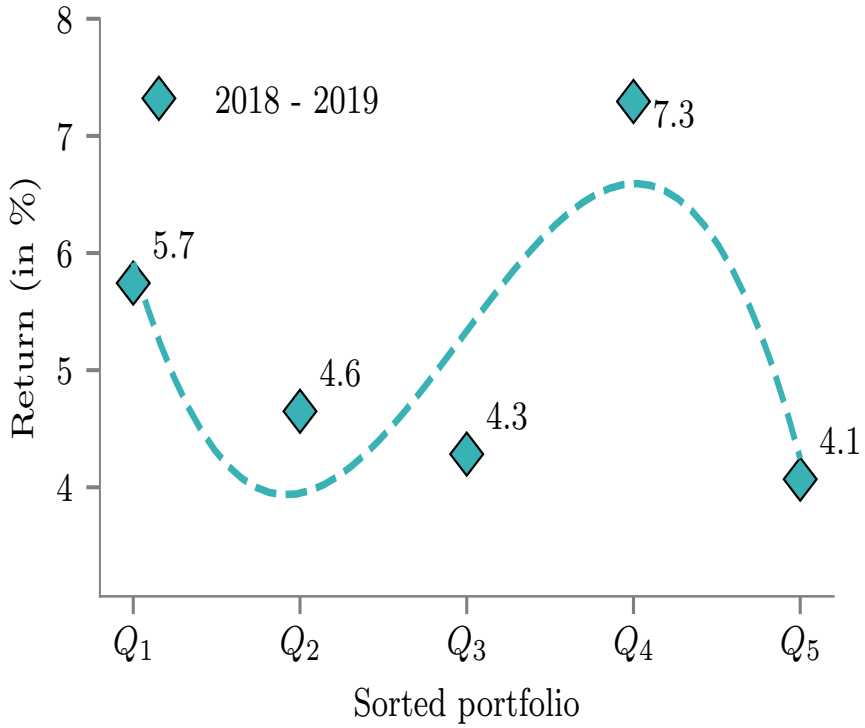


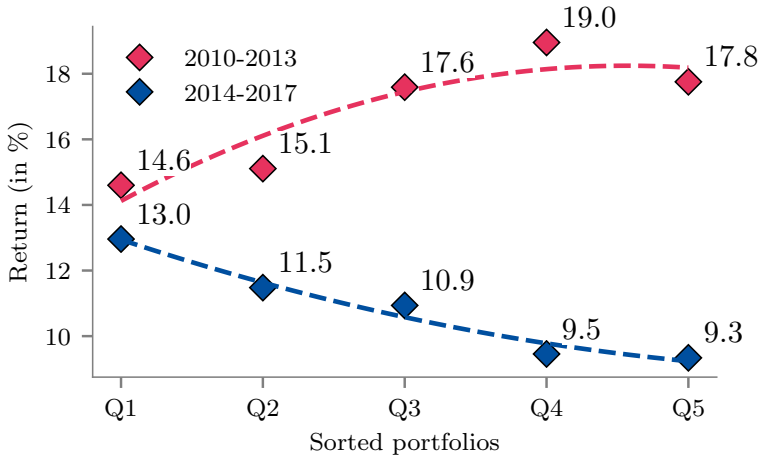
Figure: 2018 – 2019

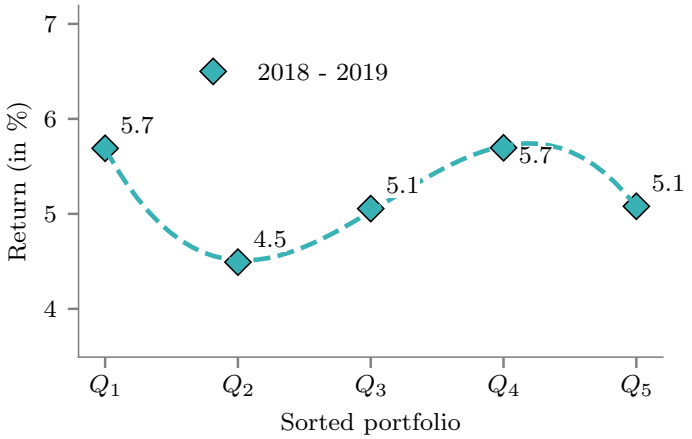


$\Rightarrow$ Similar trend in North America + Q_4 effect

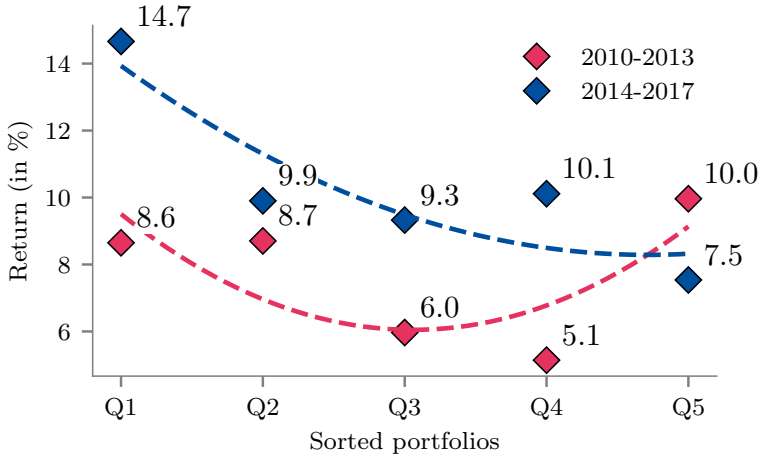
ESG investing: growing in complexity

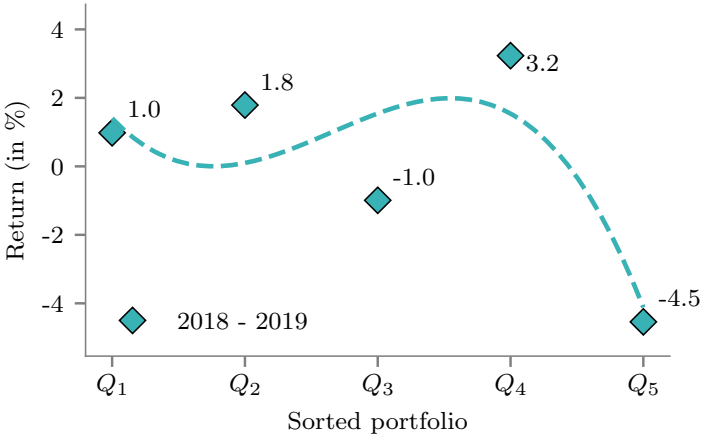
North America, **ESG**-Sorted portfolios, 2010 – 2019





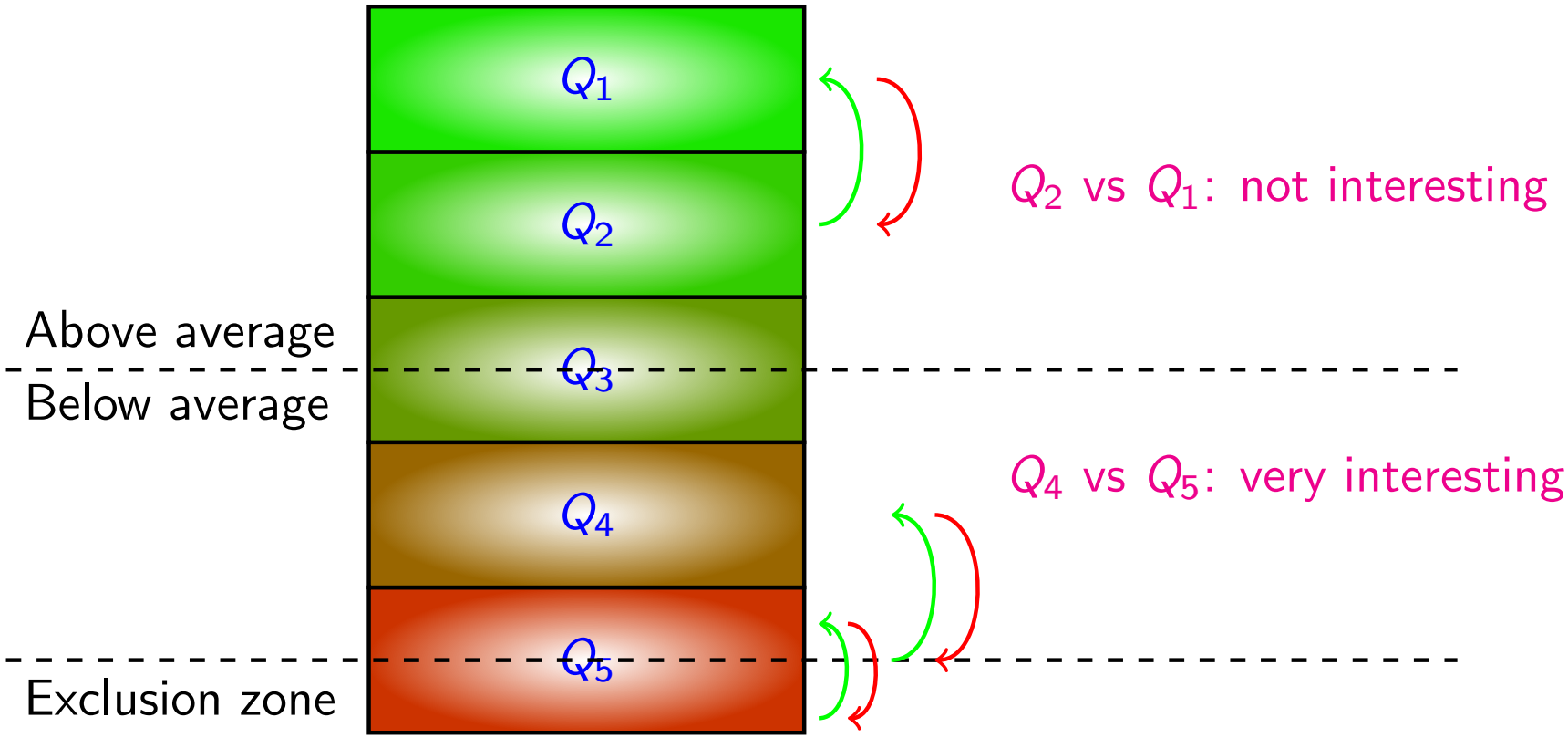
Eurozone, **ESG**-Sorted portfolios, 2010 – 2019





The dynamic view of ESG investing

Figure: How to play ESG momentum?



The 2020-2021 period

- Reverse transatlantic divide?
- Covid-19 catalyst
- Biden puzzle
- Rise of EM ESG investing

Single-factor model

Regression model

We have:

$$R_{i,t} = \alpha_i + \beta_i^j \mathscr{F}_{j,t} + \varepsilon_{i,t}$$

where $\mathscr{F}_{j,t}$ can be: market, size, value, momentum, low-volatility, quality or ESG.

Single-factor model

Table: Results of cross-section regressions with long-only risk factors (average R^2)

Factor	North America		Eurozone	
	2010 – 2013	2014 – 2019	2010 – 2013	2014 – 2019
Market	40.8%	28.6%	42.8%	36.3%
Size	39.3%	26.1%	37.1%	23.3%
Value	38.9%	26.7%	41.6%	33.6%
Momentum	39.6%	26.3%	40.8%	34.1%
Low-volatility	35.8%	25.1%	38.7%	33.4%
Quality	39.1%	26.6%	42.4%	34.6%
ESG	40.1%	27.4%	42.6%	35.3%

- Specific risk has increased during the period 2014 – 2019
- Since 2014, we find that:
  - ESG $\succ$ Value $\succ$ Quality $\succ$ Momentum $\succ$ ... (North America)
  - ESG $\succ$ Quality $\succ$ Momentum $\succ$ Value $\succ$ ... (Eurozone)

Multi-factor model

Regression model

We have:

$$R_{i,t} = \alpha_i + \sum_j^{n_{\mathscr{F}}} \beta_i^j \mathscr{F}_{j,t} + \varepsilon_{i,t}$$

- 1F = market
- 5F = size + value + momentum + low-volatility + quality
- 6F = 5F + ESG

Multi-factor model

Table: Results of cross-section regressions with long-only risk factors (average R^2)

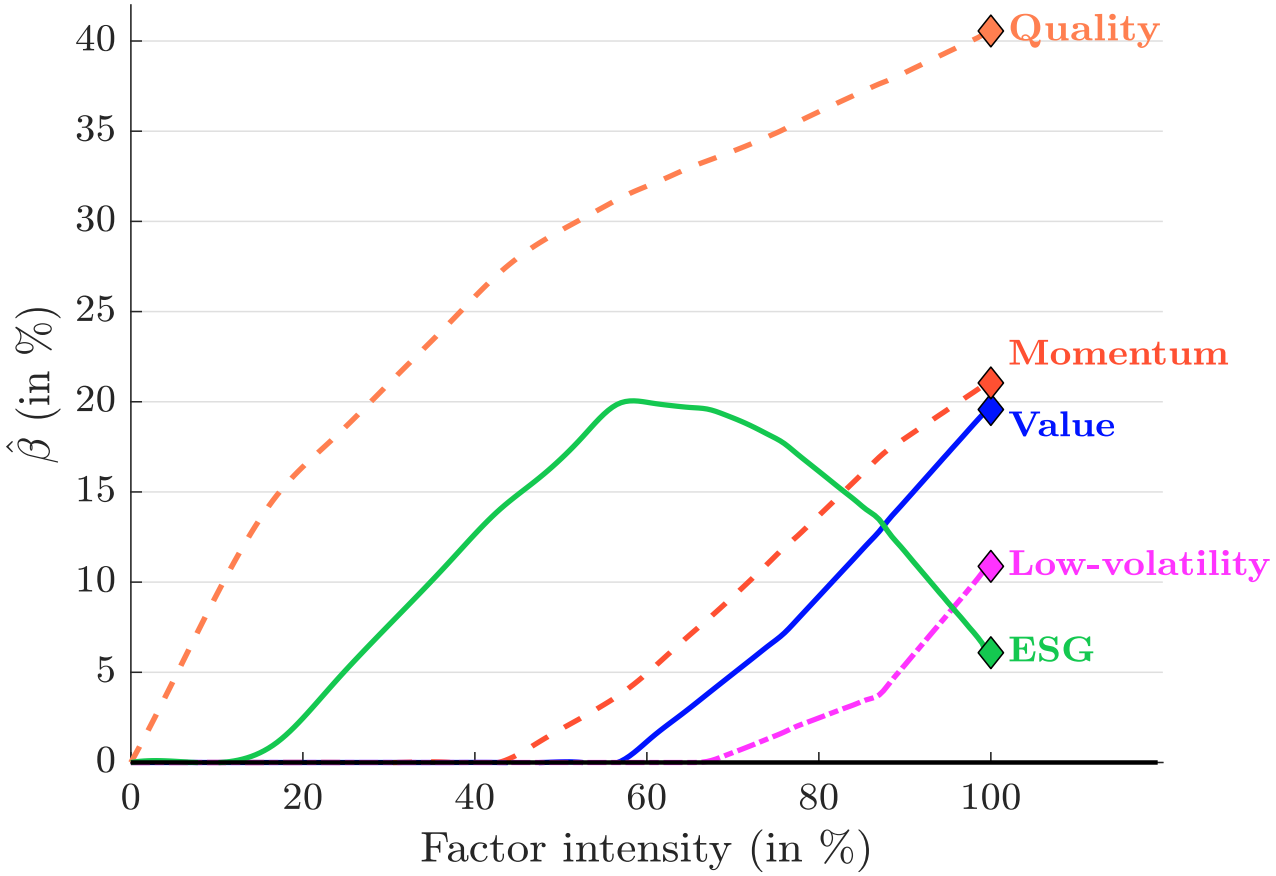
Factor	North America		Eurozone	
	2010 – 2013	2014 – 2019	2010 – 2013	2014 – 2019
Market	40.8%	28.6%	42.8%	36.3%
5F model	46.1%	38.4%	49.5%	45.0%
6F model (5F + ESG)	46.7%	39.7%	50.1%	45.8%

***p-value statistic for the MSCI Index (time-series, 2014 – 2019):

- 6F = ~~Size~~, Value, Momentum, Low-volatility, Quality, ~~ESG~~ (North America)
- 6F = Size, Value, Momentum, ~~Low-volatility~~, Quality, ESG (Eurozone)

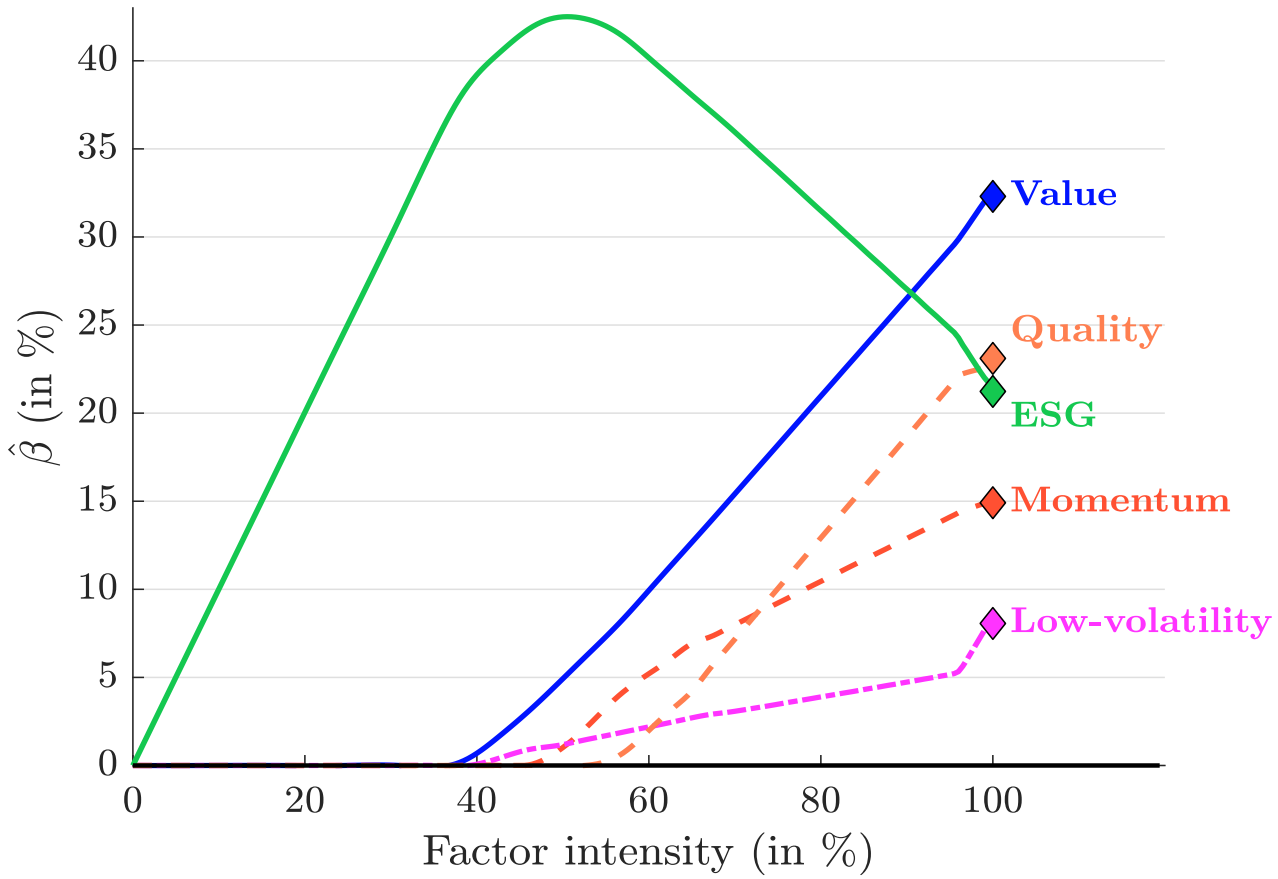
Factor selection

Figure: North America



Factor selection

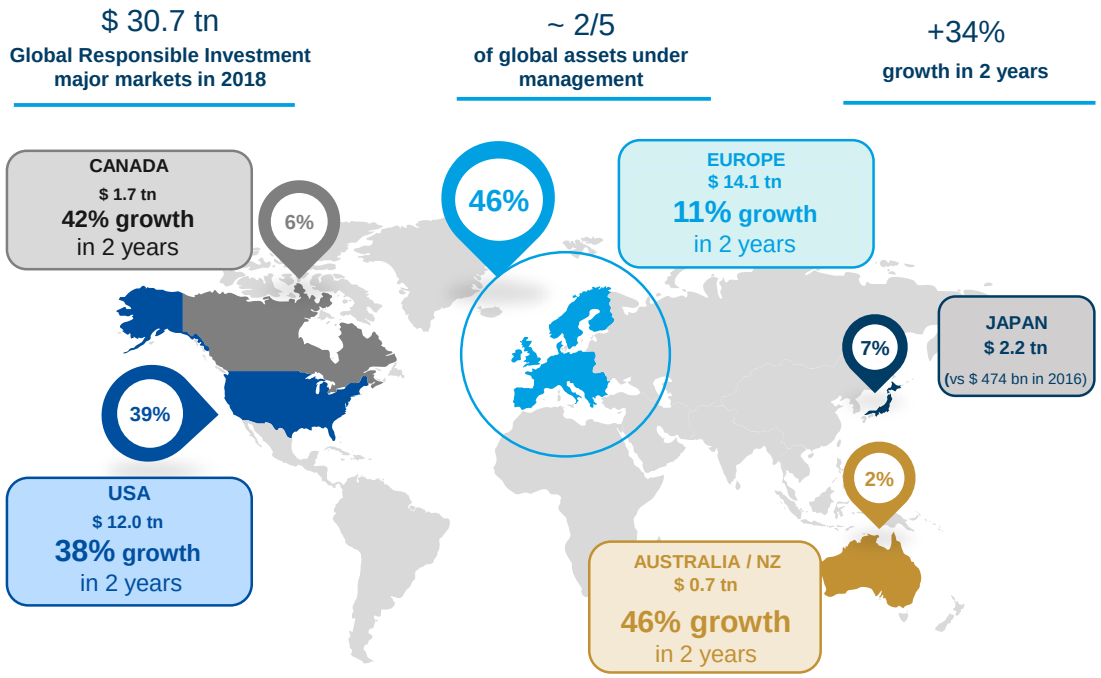
Figure: Eurozone



What is the difference between alpha and beta?

- ESG remains an alpha strategy in North America
- ESG becomes a beta strategy (or a risk factor) in Europe

Figure: The market of ESG investing at the start of 2018



Source: Global Sustainable Investment Alliance (2019)

Why ESG investing in bond markets is different than ESG investing in stock markets

Stocks

- ESG scoring is incorporated in portfolio management
- ESG = long-term business risk ⇒ strongly impacts the equity
- Portfolio integration
- Managing the business risk

Bonds

- ESG integration is generally limited to exclusions
- ESG lowly impacts the debt
- Portfolio completion
- Fixed income = impact investing
- Development of pure play ESG securities (green and social bonds)

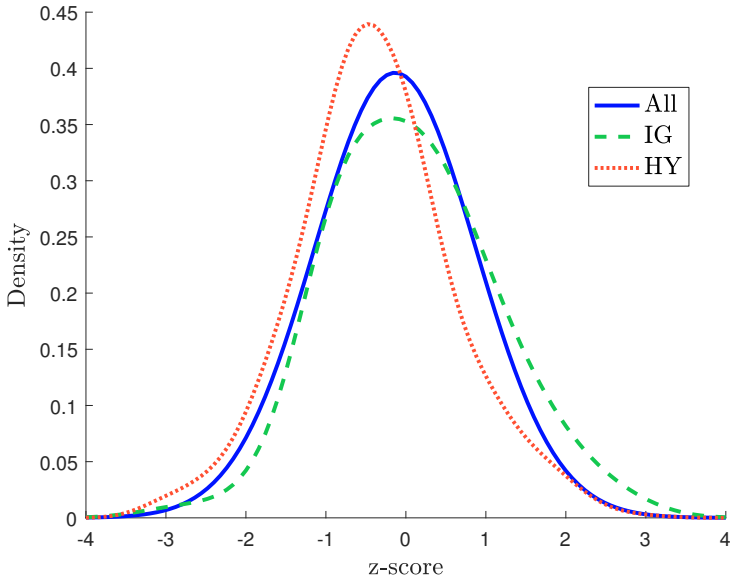
⇒ Stock holders are more ESG sensitive than bond holders because of the capital structure

Why ESG investing in bond markets is different than ESG investing in stock markets

ESG investment flows affect asset pricing differently:

- Impact on carry (coupon effect)?
- Impact on price dynamics (credit spread/mark-to-market effect)?

The distinction between IG and HY bonds



$\Rightarrow$ There are more worst-in-class issuers in the HY universe, and best-in-class issuers in the IG universe

Sorted portfolio methodology

Sorted-portfolio approach

- Sorted-based approach of Fama-French (1992)
- At each rebalancing date t, we rank the bonds according to their Amundi **ESG** z-score
- We form the five quintile portfolios Q_i for $i = 1, \ldots, 5$
- The portfolio Q_i is invested during the period $]t, t+1]$:
  - Q_1 corresponds to the best-in-class portfolio (best scores)
  - Q_5 corresponds to the worst-in-class portfolio (worst scores)
- Monthly rebalancing
- Universe: ICE (BofAML) Large Cap IG EUR Corporate Bond
- Sector-weighted and sector-neutral portfolio
- Within a sector, bonds are equally-weighted

ESG sorted portfolios

Figure: Annualized credit return in bps of **ESG** sorted portfolios (EUR IG, 2010 – 2019)

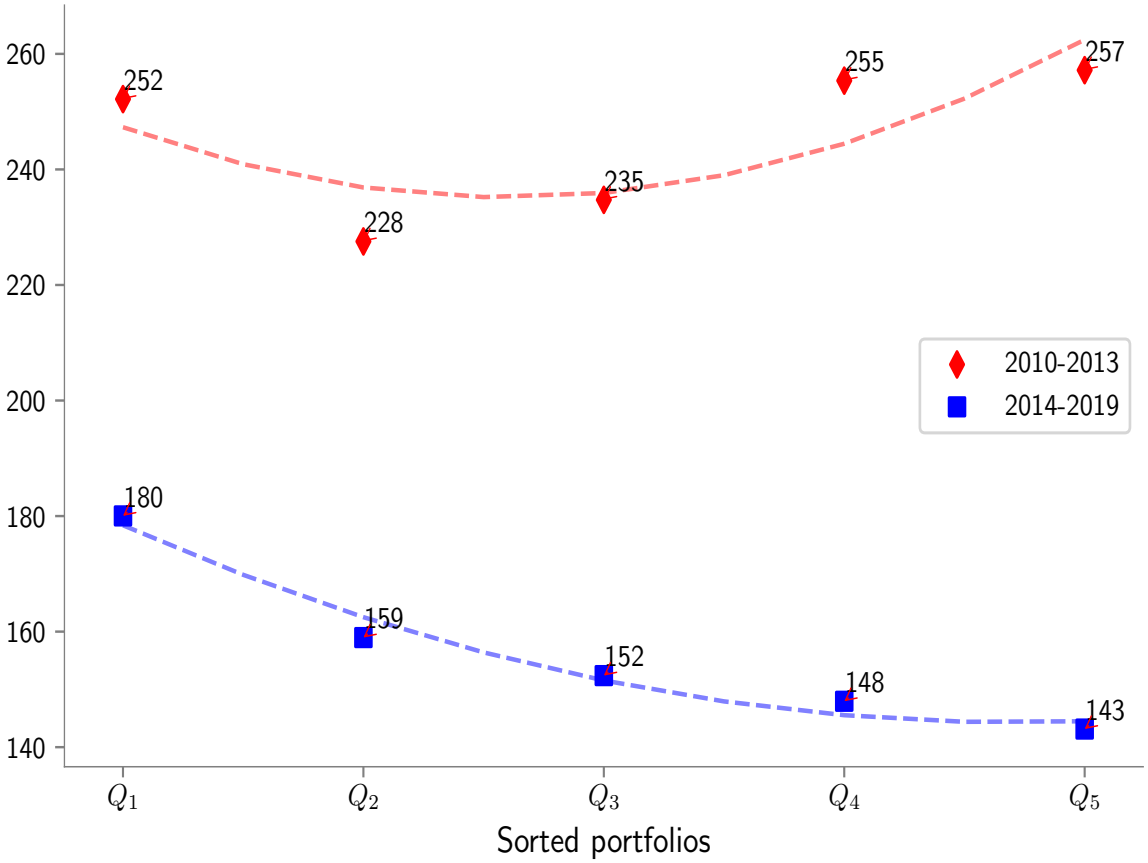


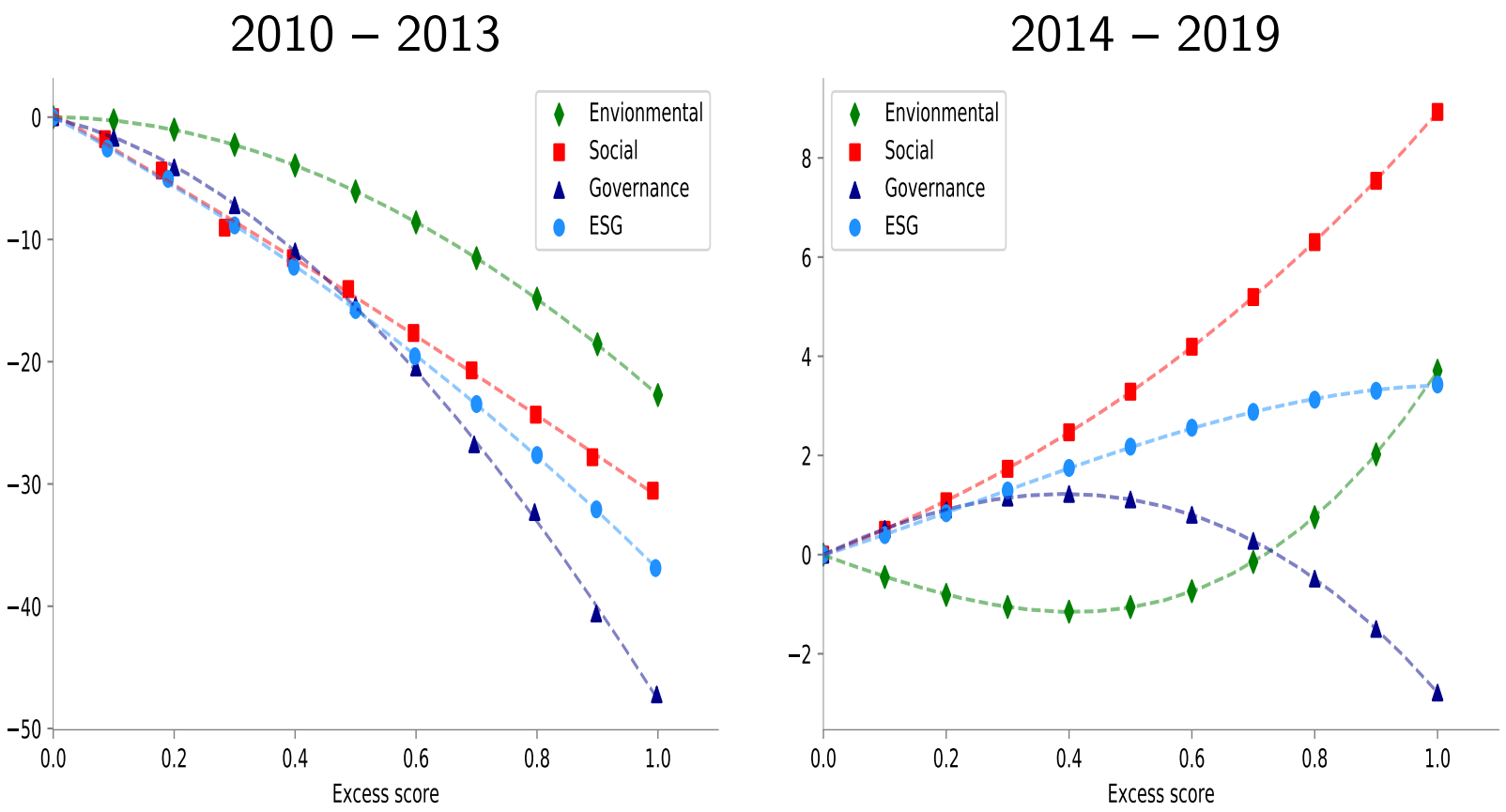
Table: Carry statistics (in bps)

Period	Q_1	Q_5
2010-2013	175	192
2014-2019	113	128

- Negative carry (coupon level)
- Positive mark-to-market (dynamics of credit spreads and bond prices)

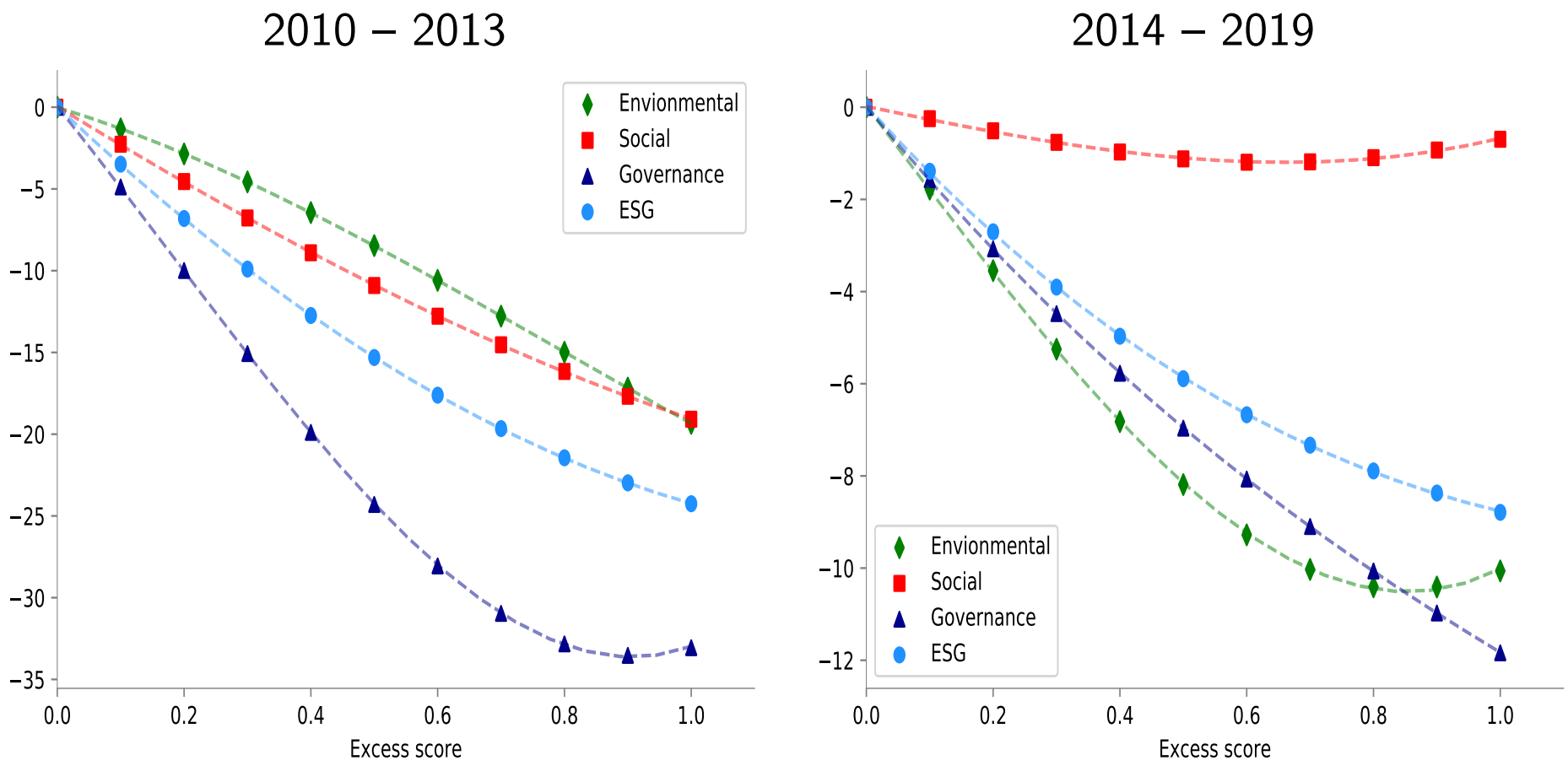
Performance of optimized portfolios

Figure: Excess credit return in bps of optimized portfolios (EUR IG)



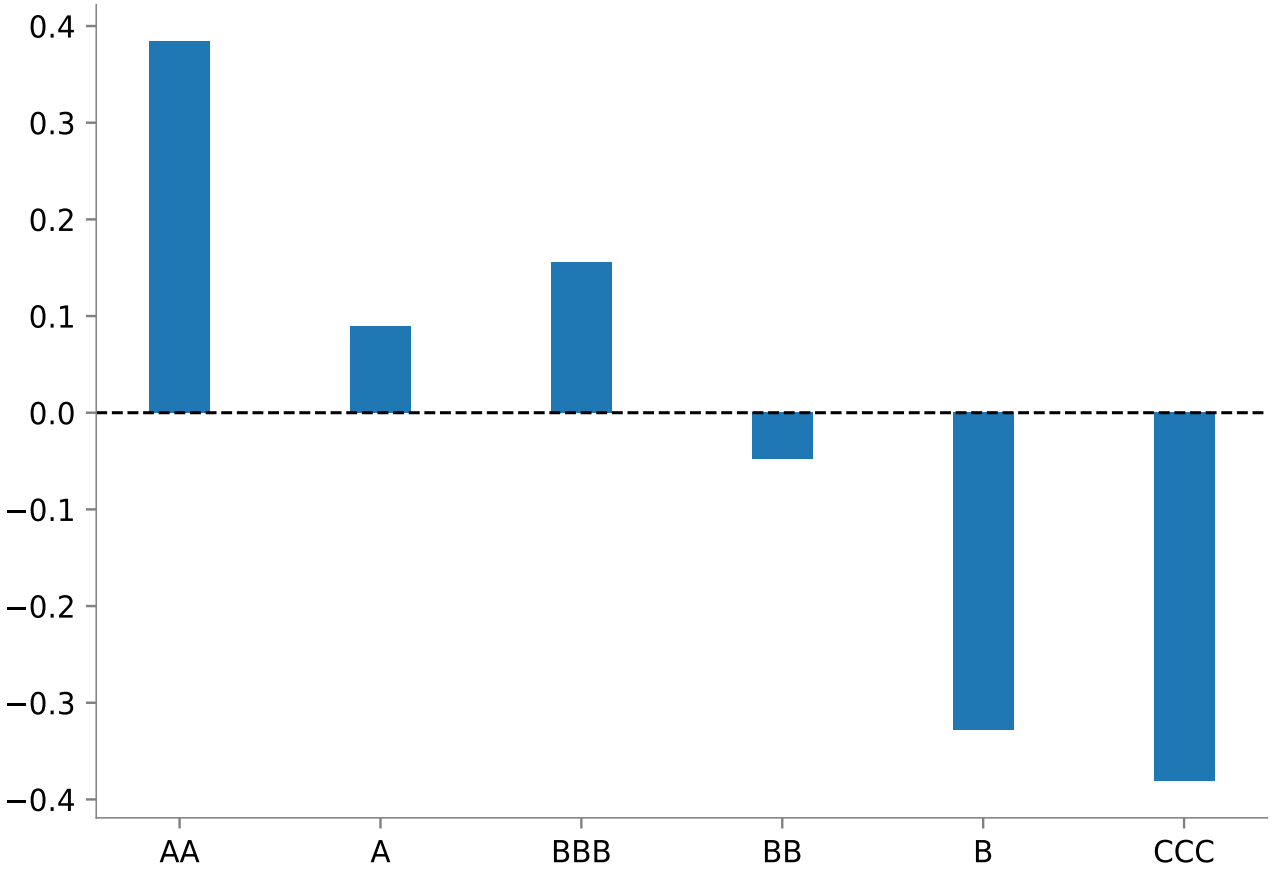
Performance of optimized portfolios (USD IG)

Figure: Excess credit return in bps of optimized portfolios (USD IG)



ESG ratings and credit ratings

Figure: Average **ESG** score with respect to the credit rating (2010 – 2019)



An integrated Credit-ESG model

We consider the following regression model:

$$\begin{aligned}\ln \mathrm{OAS}_{i,t} &= \alpha_t + \beta_{esg} \cdot \mathscr{S}_{i,t} + \beta_{md} \cdot \mathrm{MD}_{i,t} + \sum_{j=1}^{N_{\mathscr{S}ector}} \beta_{\mathscr{S}ector}(j) \cdot \mathscr{S}ector_{i,t}(j) + \\ &\quad \beta_{sub} \cdot \mathrm{SUB}_{i,t} + \sum_{k=1}^{N_{\mathscr{R}ating}} \beta_{\mathscr{R}ating}(k) \cdot \mathscr{R}ating_{i,t}(k) + \varepsilon_{i,t}\end{aligned}$$

where:

- $\mathscr{S}_{i,t}$ is the **ESG** z-score of Bond i at time t
- $\mathrm{SUB}_{i,t}$ is a dummy variable accounting for subordination of the bond
- $\mathrm{MD}_{i,t}$ is the modified duration
- $\mathscr{S}ector_{i,t}(j)$ is a dummy variable for the j^{th} sector
- $\mathscr{R}ating_{i,t}(k)$ is a dummy variable for the k^{th} rating

An integrated Credit-ESG model

Table: Results of the panel data regression model (EUR IG, 2010 – 2019)

	2010–2013				2014–2019			
	ESG	**E**	**S**	**G**	**ESG**	**E**	**S**	**G**
R^2	60.0%	59.4%	59.5%	60.3%	66.3%	65.0%	65.2%	64.6%
Excess R^2 of ESG	0.6%	0.0%	0.2%	1.0%	4.0%	2.6%	2.9%	2.3%
$\hat{\beta}_{esg}$	-0.05	-0.01	-0.02	-0.07	-0.09	-0.08	-0.08	-0.08
t-statistic	-32	-7	-16	-39	-124	-98	-104	-92

The assumption $\mathscr{H}_0 : \beta_{esg} < 0$ is not rejected

ESG cost of capital with min/max score bounds

We calculate the difference between:

(1) the funding cost of **the worst-in-class issuer** and

(2) the funding cost of **the best-in-class issuer**

by assuming that:

- the two issuers have the same credit rating;
- the two issuers belong to the same sector;
- the two issuers have the same capital structure;
- the two issuers have the same debt maturity.

$\Rightarrow$ Two approaches:

1. Theoretical approach: ESG scores are set to -3 and $+3$ (not realistic)
2. Empirical approach: ESG scores are set to observed min/max score bounds (e.g. min/max $= -2.0/+1.9$ for Consumer Cyclical A-rated EUR, $-2.1/+3.2$ for Banking A-rated EUR, etc.)

ESG cost of capital with min/max score bounds

Table: **ESG** cost of capital (IG, 2014 – 2019)

	EUR				USD			
	AA	A	BBB	Average	AA	A	BBB	Average
Banking	23	45	67	45	11	19	33	21
Basic	9	25	44	26	5	15	34	18
Capital Goods	8	32	42	27	6	15	26	16
Communication		26	48	37	5	11	23	13
Consumer Cyclical	3	26	43	28	2	8	17	10
Consumer Non-Cyclical	15	29	31	25	6	12	19	12
Utility & Energy	12	32	56	33	9	14	31	18
Average	12	31	48	**31**	7	13	26	**15**

ESG and sovereign risk

Motivation

- Financial analysis **versus/and** extra-financial analysis
- Sovereign risk $\neq$ Corporate risk
- Which ESG metrics are priced and not priced by the market?
- What is the nexus between ESG analysis and credit analysis?

Sovereign ESG thematics

Environmental

- Biodiversity
- Climate change
- Commitment to environmental standards
- Energy mix
- Natural hazard
- Natural hazard outcome
- Non-renewable energy resources
- **Temperature**
- Water management

Social

- Civil unrest
- Demographics
- **Education**
- Gender
- Health
- Human rights
- **Income**
- Labour market standards
- Migration
- Water and electricity access

Governance

- Business environment and R&D
- **Governance effectiveness**
- Infrastructure and mobility
- International relations
- Justice
- **National security**
- **Political stability**

Data

Endogenous variable

10Y sovereign bond yield spread

Explanatory variables

- 269 ESG variables grouped into 26 ESG thematics
- 6 control variables: GDP Growth, Net Debt, Reserves, Account Balance, Inflation and **Credit Rating**

Panel dimensions

- 67 countries
- $2015 - -2020$

Single-factor analysis

Let $s_{i,t}$ be the bond yield spread of the country i at time t. We consider the following regression model:

$$s_{i,t} = \alpha + \underbrace{\beta x_{i,t}}_{\text{ESG metric}} + \underbrace{\sum_{k=1}^{6} \gamma_k z_{i,t}^{(k)}}_{\text{Control variables}} + \varepsilon_{i,t}$$

and:

$$\sum_{k=1}^{6} \gamma_k z_{i,t}^{(k)} = \gamma_1 g_{i,t} + \gamma_2 \pi_{i,t} + \gamma_3 d_{i,t} + \gamma_4 ca_{i,t} + \gamma_5 r_{i,t} + \gamma_6 \mathscr{R}_{i,t}$$

where $g_{i,t}$ is the economic growth, $\pi_{i,t}$ is the inflation, $d_{i,t}$ is the debt ratio, $ca_{i,t}$ is the current account balance, $r_{i,t}$ is the reserve adequacy and $\mathscr{R}_{i,t}$ is the credit rating

Single-factor analysis

Table: 10 most relevant indicators of the single-factor analysis

Pillar	Thematic	Indicator	$\Delta\mathfrak{R}^2_c$	F-test
S	Human rights	Freedom of assembly	8.74%	89.58
S	Human rights	Extent of arbitrary unrest	8.04%	80.10
S	Human rights	Extent of torture and ill treatment	7.63%	75.48
S	Labour market standards	Severity of working time violations	7.21%	70.46
G	National security	Severity of kidnapping	6.80%	64.49
G	Business environment and R&D	Ease of access to loans	6.77%	73.57
G	Infrastructure and mobility	Roads km	6.45%	63.66
S	Labour market standards	Forced labor violations (extent)	6.10%	54.40
S	Labour market standards	Child labor (extent)	5.83%	54.68
S	Migration	Vulnerability of migrant workers	5.83%	53.76

Single-factor analysis

Table: Summary of the results

	E	S	G
Relevant	**Temperature** Climate change Natural hazard outcome	Labour market standards Human rights Migration	Infrastructure and mobility **National security** Justice
Less relevant	Water management Energy mix	**Income** **Education** Water and electricity access	**Political stability**

Multi-factor analysis

We consider the following multi-factor regression model:

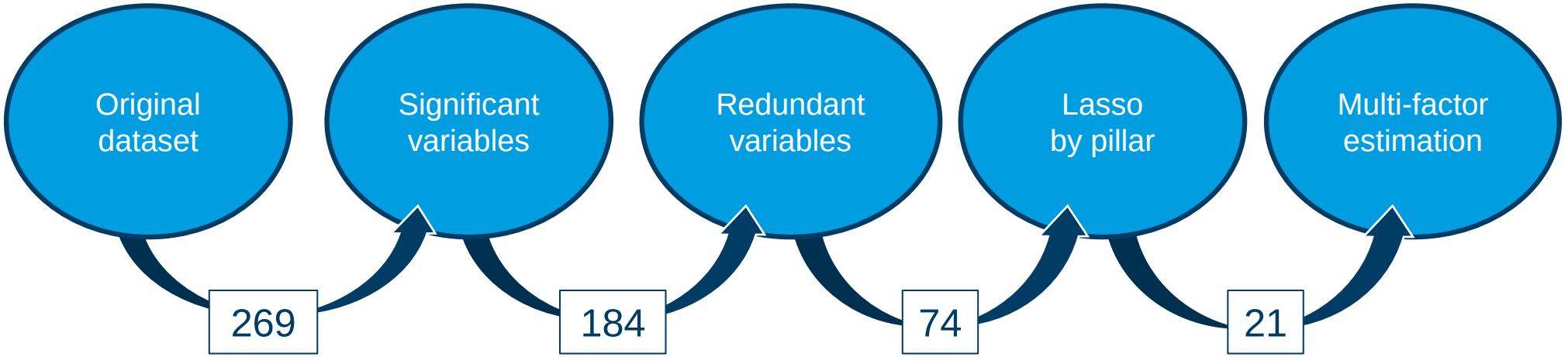
$$s_{i,t} = \alpha + \underbrace{\sum_{j=1}^{m} \beta_j x_{i,t}^{(j)}}_{\text{ESG variables}} + \underbrace{\sum_{k=1}^{6} \gamma_k z_{i,t}^{(k)}}_{\text{Control variables}} + \varepsilon_{i,t}$$

A 4-step process

1. We consider the significant variables of the single-factor analysis at the 1% level
2. We filter the variables selected at Step 1 in order to eliminate redundant variables (cross-correlation greater than 80%) within each ESG theme
3. We perform a lasso regression to retain the seven most relevant variables for each ESG pillar
4. We perform a multi-factor analysis:
   1. Lasso estimation to rank the seven E, S and G variables ($m = 21$)
   2. Panel estimation to estimate the final model ($m = 7$)

Multi-factor analysis

Figure: Filtering process



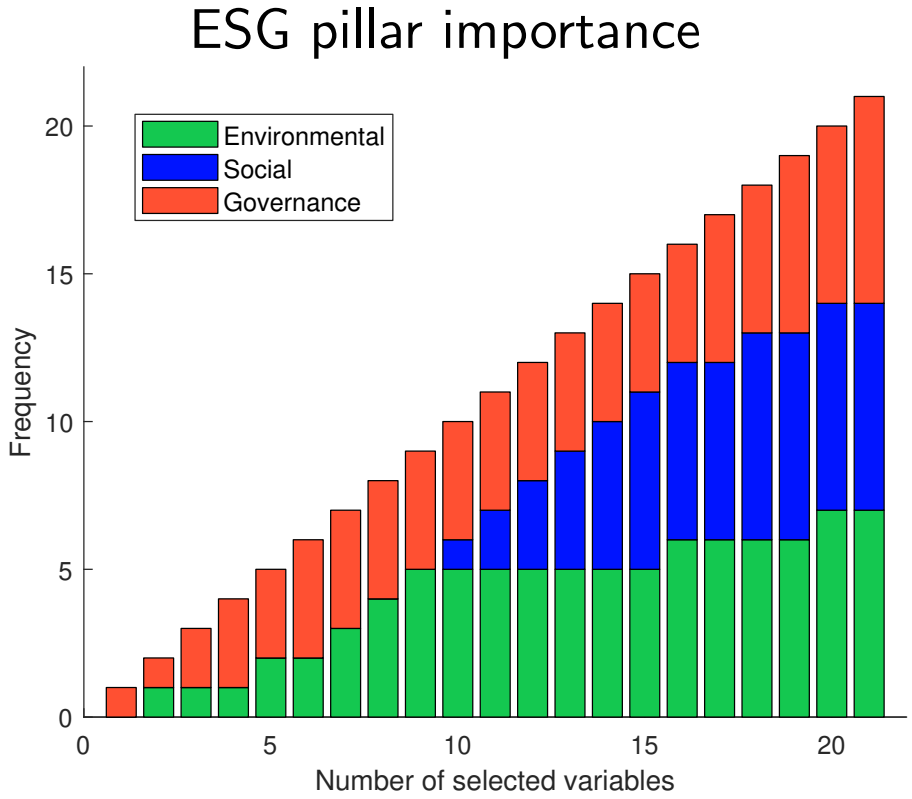
Multi-factor analysis

Table: Results after Step 3

Rank	Pillar	Thematic	Variable	Sign
1		Non-renewable energy resources	Total GHG emissions	−
2		Biodiversity	Biodiversity threatening score	−
3		Natural hazard	Severe storm hazard (absolute high extreme)	−
4	**E**	Temperature	Temperature change	+
5		Non-renewable energy resources	Fossil fuel intensity of the economy	−
6		Natural hazard	Drought hazard (absolute high extreme)	−
7		Commitment to environmental standards	Paris Agreement	−
1		Migration	Vulnerability of migrant workers	−
2		Demographics	Projected population change (5 years)	+
3		Civil unrest	Frequency of civil unrest incidents	−
4	**S**	Labor market standards	Index of labor standards	−
5		Labor market standards	Right to join trade unions (protection)	−
6		Human rights	Food import security	−
7		Income	Average monthly wage	−
1		International relationships	Exporting across borders (cost)	+
2		Business environment and R&D	Ethical behaviour of firms	−
3		National security	Severity of kidnappings	−
4	**G**	Business environment and R&D	Capacity for innovation	−
5		Infrastructure and mobility	Physical connectivity	−
6		Infrastructure and mobility	Air transport departures	−
7		Infrastructure and mobility	Rail lines km	−

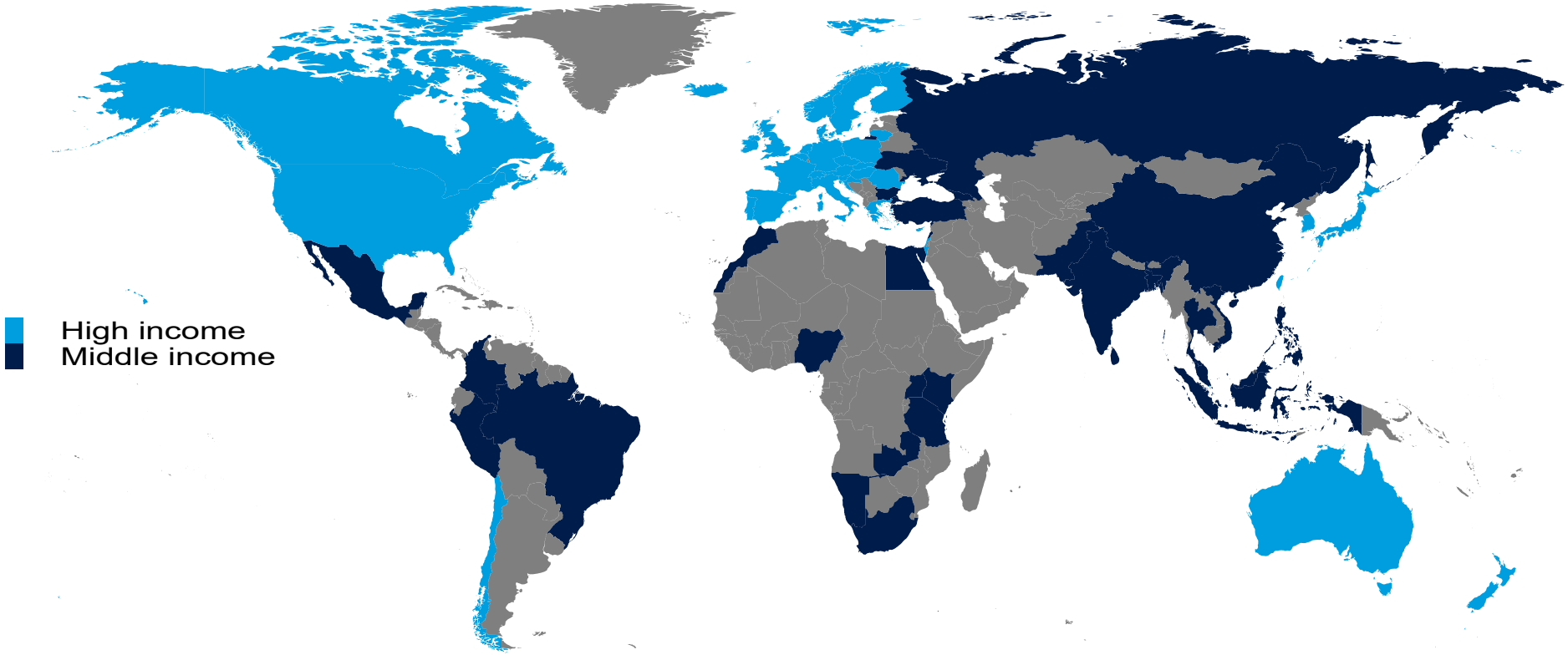
Multi-factor analysis
Global analysis

Pillar	Indicator	Rank
G	Exporting across borders (cost)	1
E	Severe storm hazard	2
G	Capacity for innovation	3
G	Ethical behaviour of firms	4
E	Temperature change	5
G	Severity of kidnappings	6
E	Drought hazard	7
E	Fossil fuel intensity of the economy	8
E	Biodiversity threatening score	9
S	Index of labor standards	10



Multi-factor analysis

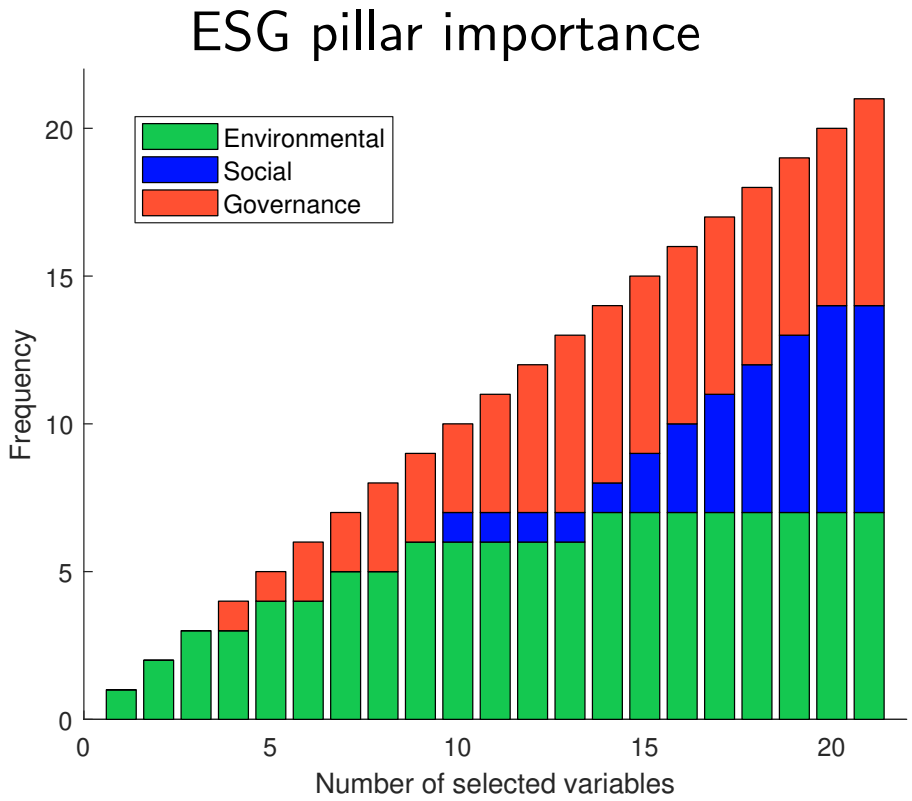
High- vs middle-income countries



Multi-factor analysis

High-income countries

Pillar	Indicator	Rank
E	Fossil fuel intensity of the economy	1
E	Temperature change	2
E	Cooling degree days annual average	3
G	Capacity for innovation	4
E	Heat stress (future)	5
G	Severity of kidnappings	6
E	Biodiversity threatening score	7
G	Efficacy of corporate boards	8
E	Total GHG emissions	9
S	Significant marginalized group	10

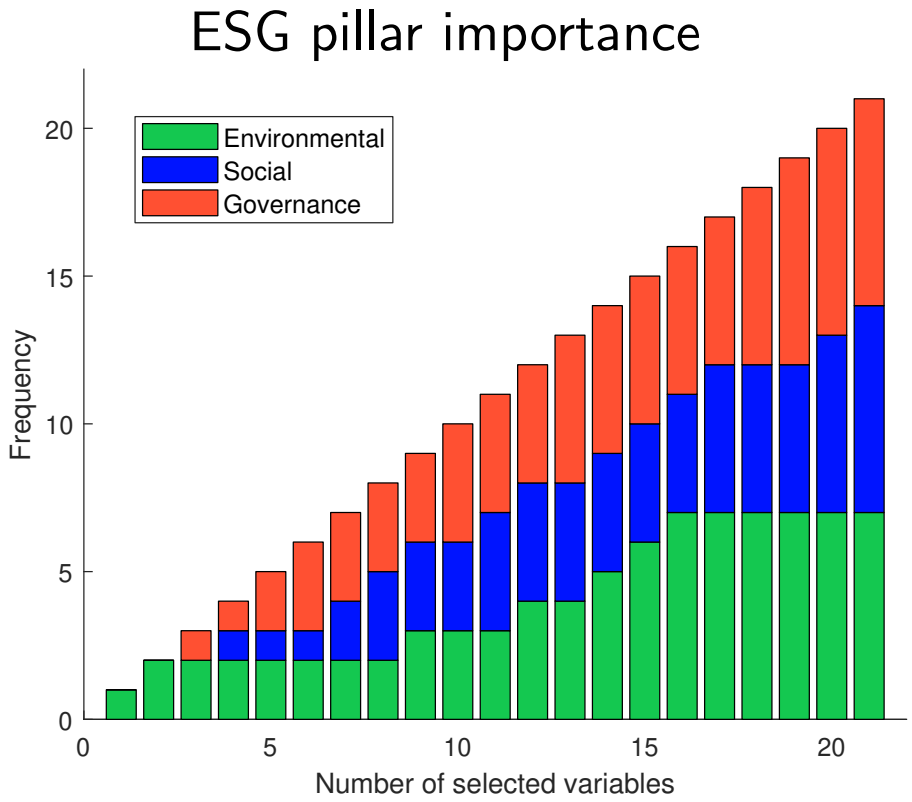


- Transition risk
- **S** is lagging

Multi-factor analysis

Middle-income countries

Pillar	Indicator	Rank
E	Tsunami hazard	1
E	Transport infrastructure exposed to natural hazards	2
G	Severity of kidnappings	3
S	Discrimination based on LGBT status	4
G	Air transport departures	5
G	Exporting across borders (cost)	6
S	Index of labour standards	7
S	Vulnerability of migrant workers	8
E	Paris Agreement	9
G	Military expenditure (% of GDP)	10



- Physical risk
- **S**ocial issues are priced

Explaining credit ratings with ESG metrics

We consider the logit model:

$$\Pr\left\{\mathscr{G}_{i,t}=1\right\}=\mathbf{F}\left(\beta_0+\underbrace{\sum_{j=1}^{m}\beta_j x_{i,t}^{(j)}}_{\text{ESG variables}}\right)$$

where:

- $\mathscr{G}_{i,t}=1$ indicates if the country i is rated upper grade at time t
- $\mathbf{F}(z)$ is the logistic cumulative density function
- $x_{i,t}^{(j)}$ is the j^{th} selected indicator

We note $\theta_j=e^{\beta_j}$ is the odds-ratio coefficient

Explaining credit ratings with ESG metrics

Table: List of selected ESG variables for the logistic regression

Theme	Variable	Rank
Commitment to environmental standards	Domestic regulatory framework	1
Climate change	Climate change vulnerability (average)	2
Water management	Water import security (average)	3
Energy mix	Energy self sufficiency	4
Water management	Wastewater treatment index	5
Water management	Water intensity of the economy	6
Biodiversity	Biodiversity threatening score	7
Health	Health expenditure per capita	1
Water and electricity access	Public dissatisfaction with water quality	2
Education	Mean years of schooling of adults	3
Income	Base pay / value added per worker	4
Demographic	Urban population change (5 years)	5
Human rights	Basic food stuffs net imports per person	6
Human rights	Food import security	7
Government effectiveness	Government effectiveness index	1
Business environment and R&D	Venture capital availability	2
Business environment and R&D	R&D expenditure (% of GDP)	3
Infrastructure and mobility	Customs efficiency	4
Business environment and R&D	Enforcing a contract (time)	5
Business environment and R&D	Paying tax (process)	6
Business environment and R&D	Getting electricity (time)	7

Explaining credit ratings with ESG metrics

E pillar

Table: Logit model with environmental variables

Variable	$\hat{\theta}_j$	$\hat{\sigma}\left(\hat{\theta}_j\right)$	t-student	p-value
Domestic regulatory framework	1.415	0.156	3.16^{***}	0.00
Climate change vulnerability (average)	2.929	0.572	5.51^{***}	0.00
Water import security (average)	1.385	0.147	3.07^{***}	0.00
Energy self sufficiency	0.960	0.033	-1.16	0.24
Wastewater treatment index	1.011	0.008	1.36	0.17
Water intensity of the economy	1.000	0.000	-1.02	0.30
Biodiversity threatening score	0.887	0.026	-4.02^{***}	0.00

$\ell\left(\hat{\beta}\right) = -107.60$, $\text{AIC} = 231.19$, $\mathfrak{R}^2 = 49.1\%$, $\text{ACC} = 83.6\%$

Explaining credit ratings with ESG metrics

S pillar

Table: Logit model with social variables

Variable	$\hat{\theta}_j$	$\hat{\sigma}\left(\hat{\theta}_j\right)$	t-student	p-value
Health expenditure per capita	1.001	0.000	3.47^{***}	0.00
Public dissatisfaction with water quality	0.889	0.024	-4.27^{***}	0.00
Mean years of schooling of adults	2.710	0.583	4.64^{***}	0.00
Base pay / value added per worker	0.000	0.000	-5.13^{***}	0.00
Urban population change (5 years)	1.653	0.131	6.36^{***}	0.00
Basic food stuffs net imports per person	0.996	0.001	-3.58^{***}	0.00
Food import security	0.973	0.006	-4.33^{***}	0.00

$\ell\left(\hat{\beta}\right) = -72.41$, $\text{AIC} = 160.83$, $\mathfrak{R}^2 = 65.6\%$, $\text{ACC} = 87.9\%$

Explaining credit ratings with ESG metrics

G pillar

Table: Logit model with governance variables

Variable	$\hat{\theta}_j$	$\hat{\sigma}\left(\hat{\theta}_j\right)$	t-student	p-value
Government effectiveness index	1.096	0.035	2.81^{***}	0.00
Venture capital availability	1.020	0.005	4.16^{***}	0.00
R&D expenditure (% of GDP)	2.259	1.006	1.83^{*}	0.06
Customs efficiency	2.193	1.657	1.04	0.29
Enforcing a contract (time)	0.997	0.001	-3.69^{***}	0.00
Paying tax (process)	0.914	0.031	-2.63^{***}	0.00
Getting electricity (time)	0.989	0.004	-2.73^{***}	0.00

$\ell\left(\hat{\beta}\right) = -67.78$, $\text{AIC} = 151.57$, $\mathfrak{R}^2 = 67.9\%$, $\text{ACC} = 90.1\%$

Explaining credit ratings with ESG metrics

E, S and G pillars

Table: Logit model with the ESG selected variables

Pillar	Variable	$\hat{\theta}_j$	$\hat{\sigma}\left(\hat{\theta}_j\right)$	t-student	p-value
E	Domestic regulatory framework	2.881	2.108	1.44	0.14
	Climate change vulnerability (average)	0.275	0.302	−1.17	0.24
	Water import security (average)	0.717	0.467	−0.50	0.61
	Biodiversity threatening score	1.029	0.199	0.14	0.88
S	Health expenditure per capita	0.998	0.002	−1.10	0.26
	Public dissatisfaction with water quality	1.332	0.269	1.41	0.15
	Mean years of schooling of adults	68.298	85.559	3.37***	0.00
	Base pay / value added per worker	0.000	0.000	−1.07	0.28
	Urban population change (5 years)	3.976	1.857	2.95***	0.00
	Basic food stuffs net imports per person	0.990	0.004	−2.07**	0.03
	Food import security	0.803	0.067	−2.59***	0.00
G	Government effectiveness index	1.751	0.412	2.37**	0.01
	Venture capital availability	1.099	0.035	2.93***	0.00
	Enforcing a contract (time)	0.999	0.004	−0.31	0.75
	Paying tax (process)	0.846	0.096	−1.47	0.14
	Getting electricity (time)	0.882	0.037	−2.95***	0.00

$\ell\left(\hat{\beta}\right) = -18.91$, AIC $= 71.83$, $\mathfrak{R}^2 = 91.1\%$, ACC $= 96.7\%$

Explaining credit ratings with ESG metrics

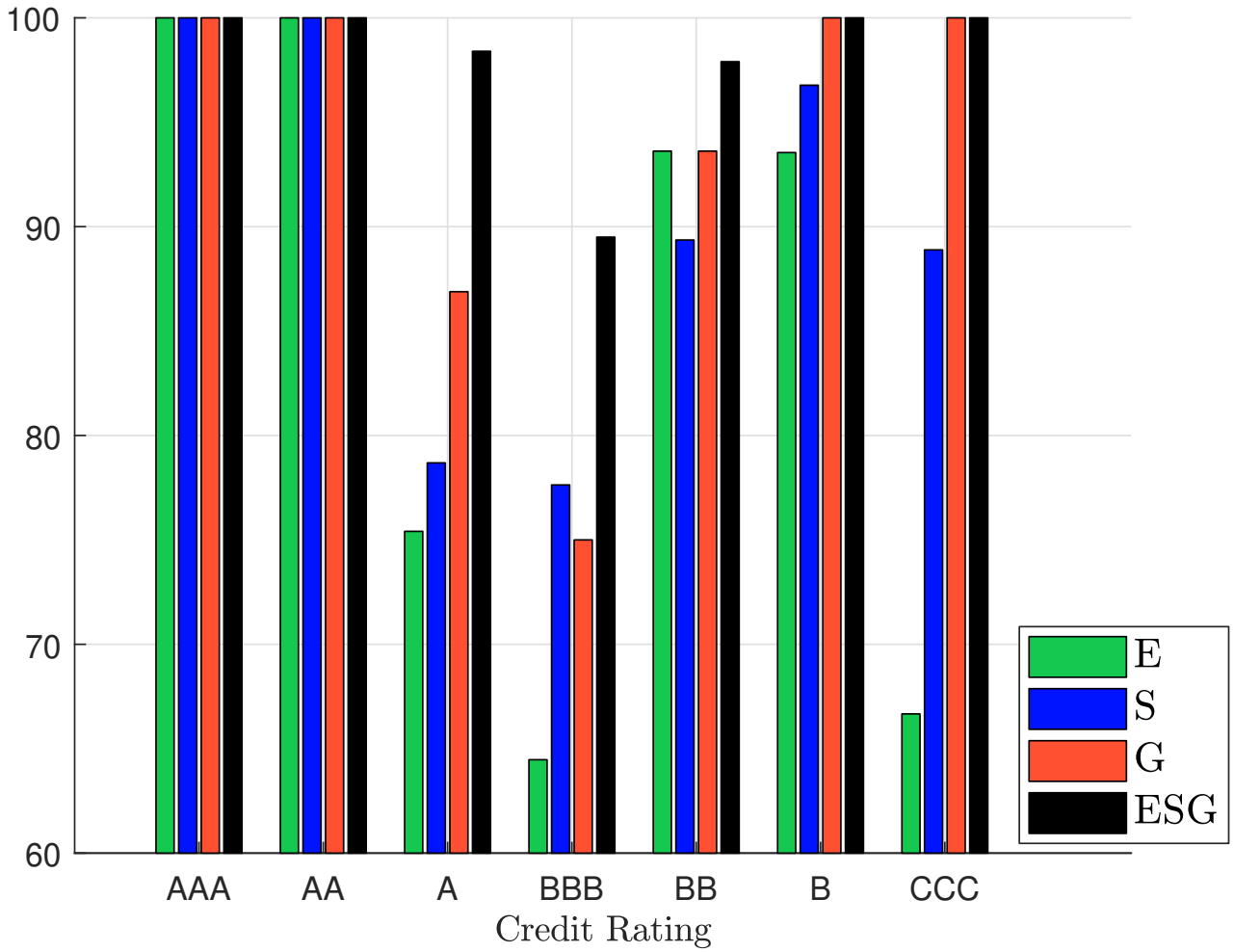
Table: Summary of the results

	***	$\mathfrak{R}^2$	Accuracy	Sensitivity	Specificity	AIC
E	4	49.1%	83.6%	82.6%	84.8%	231.19
S	7	65.6%	87.9%	88.8%	86.9%	160.83
G	5	67.9%	90.1%	87.5%	93.1%	151.57
ESG	5	91.1%	96.7%	96.8%	96.5%	71.83

$\Rightarrow$ Final model: Education, Demographics, Human rights, Government effectiveness, Business environment and R&D

Explaining credit ratings with ESG metrics

Figure: Prediction accuracy (in %) of credit ratings



ESG and sovereign risk

Table: Summary of the results

What is directly priced by the bond market?		What is indirectly priced by credit rating agencies?
E $\succ$ **G** $\succ$ **S**		**G** $\succ$ **S** $\succ$ **E**
Significant market-based ESG indicators	$\neq$	Relevant CRA-based ESG indicators
• High-income countries Transition risk $\succ$ Physical risk • Middle-income countries Physical risk $\succ$ Transition risk		**E** metrics are second-order variables: • Environmental stantards • Water management • Biodiversity • Climate change
S matters for middle-income countries, especially for Gender inequality, Working conditions and Migration		Education, Demographic and Human rights are prominent indicators for the **S** pillar
National security, Infrastructure and mobility and International relationships are the relevant **G** metrics		Government effectiveness, Business environment and R&D dominate the **G** pillar
Fundamental analysis: $\mathfrak{R}_c^2 \approx 70\%$ Extra-financial analysis: $\Delta\mathfrak{R}_c^2 \approx 13.5\%$		Accuracy $> 95\%$ AAA, AA, B, CCC $\succ$ A $\succ$ BB $\succ$ BBB

Scoring system

Table: An example of ESG criteria (corporate issuers)

Environmental	Social	Governance
• Emission & energy use	• Employment conditions	• Board independence
• Water	• Community involvement	• Audit and control
• Green cars*	• Access to medicine*	• Remuneration
• Green financing*	• Digital device*	• Shareholder' rights

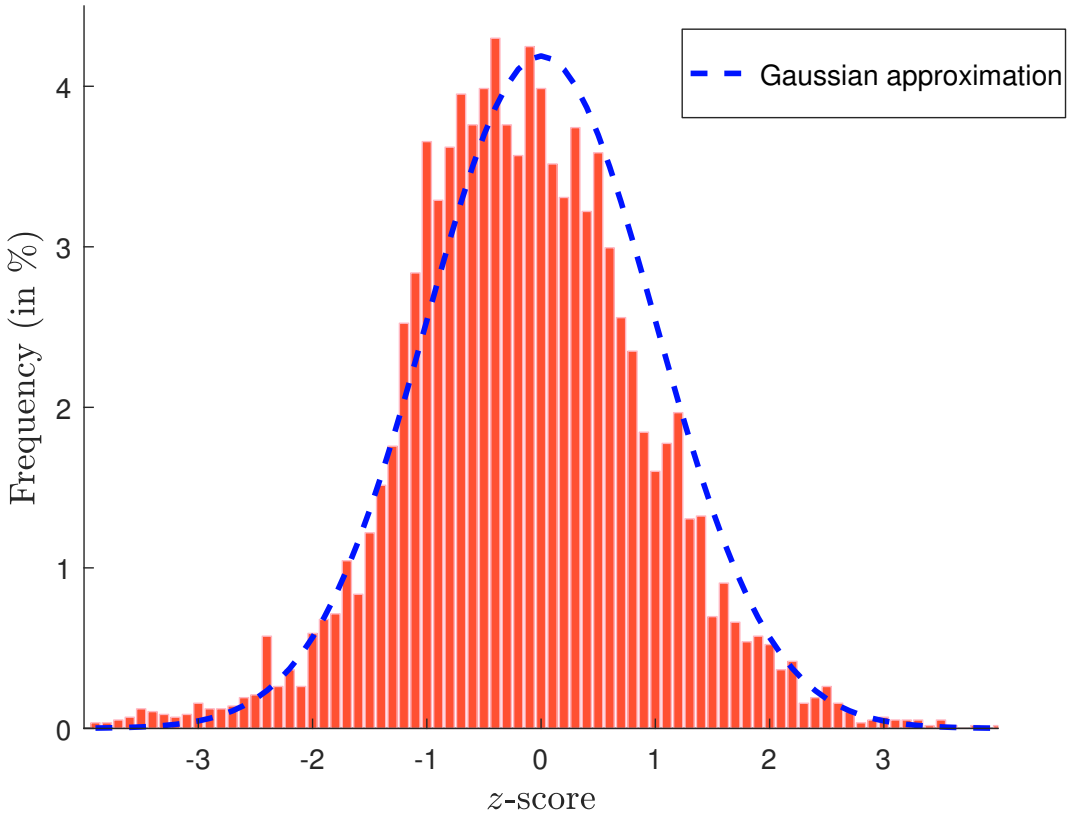
$\Rightarrow$ Weighting schemes depend on sectors

$^{(\star)}$means a specific criterion (related to one or several sectors)

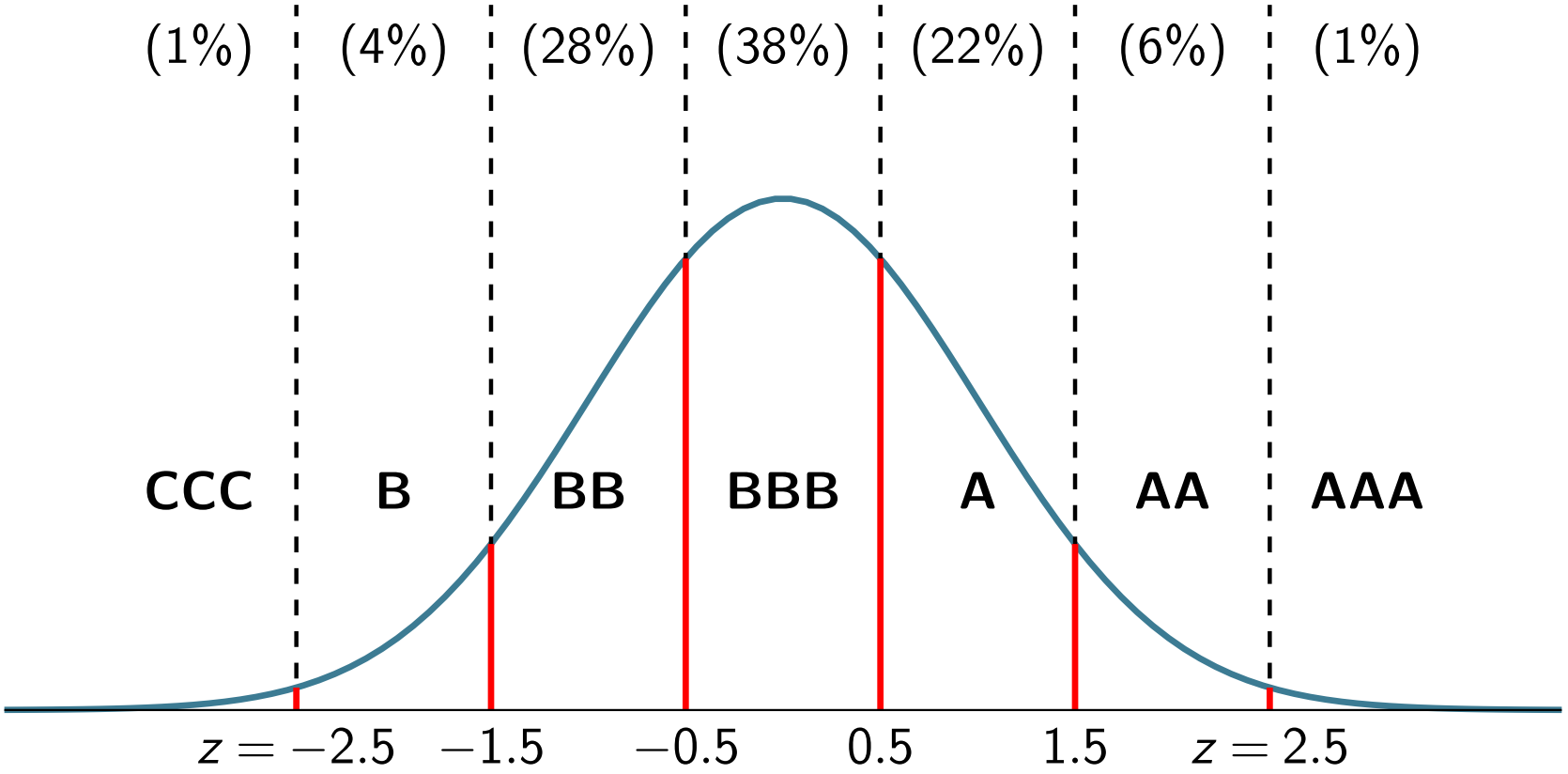
Scoring system

- Sector-neutral
- Scaling and mapping $\Leftrightarrow$ ESG ratings

Figure: Distribution of the ESG scores (z-score profile and Gaussian mapping)



From ESG scores to ESG ratings



ESG ratings versus credit ratings

The case of corporate risk

Credit rating

- What is the question?
  Measuring the 1Y PD
- Rating correlation $\geq 90\%$
  Convergence in the 1990s
- **Absolute** rating
  $\Rightarrow$ Facilitates comparison
- More stable
- Accounting standards

ESG rating

- What is the question?
  ???
- Rating correlation $\leq 40\%$
  European issuers $>$ American issuers $>$ Japanese issuers (≈ 0)
- **Relative** rating
  $\Rightarrow$ Complicates comparison
- Less stable
- ESG standardization and the issue of self-reporting

What can we anticipate? $\Rightarrow$ Strong convergence for subcomponents, (more or less) convergence for **E**, **S**, and **G** ratings, but not for **ESG** ratings

The example of Tesla!

ESG ratings versus credit ratings
The case of sovereign risk

Strong convergence between extra-financial and financial analysis

$\neq$

Medium/weak convergence between ESG ratings and credit ratings?

Puzzle!

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