Course 2021-2022 in ESG and Climate Risks
Lecture 2. ESG Investing

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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.

Agenda

- **Lecture 1: Introduction**
  - *Definition, Actors, the Market of ESG Investing* (42 slides)
- **Lecture 2: ESG Investing**
  - *ESG Scoring, ESG Ratings, Performance of ESG Investing, ESG Financing, ESG Premium* (132 slides)
- **Lecture 3: Other ESG Topics**
  - *Sustainable Financing Products, Impact Investing, Voting Policy & Engagement, ESG and Climate Accounting* (82 slides)
- **Lecture 4: Climate Risk**
  - *Definition, Global Warming, Economic Modeling, Risk Measures* (176 slides)
- **Lecture 5: Climate Investing**
  - *Portfolio Decarbonization, Net Zero Carbon Metrics, Portfolio Alignment* (164 slides)
- **Lecture 6: Mathematical Methods, Technical Tools and Exercises**
  - *Scoring System, Trend Modeling, Geolocation Data, Numerical Computations, Optimization* (150+ slides)

General information

1. **Overview**
   The objective of this course is to understand the concepts of sustainable finance from the viewpoint of asset owners and managers
2. **Prerequisites**
   M1 Finance or equivalent
3. **ECTS**
   3
4. **Keywords**
   Finance, Asset Management, ESG, Responsible Investing, Climate Change
5. **Hours**
   Lectures: 18h
6. **Evaluation**
   Project + oral examination
7. **Course website**
   `http://www.thierry-roncalli.com/SustainableFinance.html`

Class schedule

Course sessions

- Date 1 (6 hours, AM+PM)
- Date 2 (6 hours, AM+PM)
- Date 3 (6 hours, AM+PM)

Class times: Friday 9:00am-12:00pm, 1:00pm–4:00pm, Location: University of Evry

Additional materials

http://www.thierry-roncalli.com/SustainableFinance.html

- Slides
- Past examinations
- Exercises + Solutions
- LaTeX source of the slides + figures (in pdf format)
- Links to the references

Main references

Amundi publications on ESG Investing

1. Bennani *et al.* (2018), How ESG Investing Has Impacted the Asset Pricing in the Equity Market, DP-36-2018, 36 pages, November 2018
2. Drei *et al.* (2019), ESG Investing in Recent Years: New Insights from Old Challenges, DP-42-2019, 32 pages, December 2019
3. Ben Slimane *et al.* (2020), ESG Investing and Fixed Income: It's Time to Cross the Rubicon, DP-45-2019, 36 pages, January 2020
4. Roncalli, T. (2020), ESG & Factor Investing: A New Stage Has Been Reached, Amundi Viewpoint, May 2020

Available at `https://research-center.amundi.com` or `www.ssrn.com`

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Amundi publications on Climate Investing

1. Le Guenedal, T. (2019), Economic Modeling of Climate Risk, WP-83-2019, 92 pages, April 2019
2. Bouchet, V., and Le Guenedal, T. (2020), Credit Risk Sensitivity to Carbon Price, WP-95-2020, 48 pages, May 2020
3. Le Guenedal *et al.* (2020), Trajectory Monitoring in Portfolio Management and Issuer Intentionality Scoring, WP-97-2020, 54 pages, May 2020
4. Roncalli *et al.* (2020), Measuring and Managing Carbon Risk in Investment Portfolios, WP-99-2020, 67 pages, August 2020
5. Ben Slimane, M., Da Fonseca, D., and Mahtani, V. (2020), Facts and Fantasies about the Green Bond Premium, WP-102-2020, 52 pages, December 2020
6. Le Guenedal, Drobinski, P., and Tankov, P. (2021), Measuring and Pricing Cyclone-Related Physical Risk under Changing Climate, WP-111-2021, 42 pages, June 2021
7. Adenot *et al.* (2022), Cascading Effects of Carbon Price through the Value Chain and their Impacts on Firm's Valuation, WP-122-2022, 82 pages, February 2022
8. Le Guenedal *et al.* (2022), Net Zero Carbon Metrics, WP-123-2022, 82 pages, February 2022

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Amundi ESG Thema

1. Créhalet, E. (2021), Introduction to Net Zero, *Amundi ESG Thema #1*, `https://research-center.amundi.com`
2. Créhalet, E., Foll, J., Haustant, P., and Hessenberger, T. (2021), Carbon Offsetting: How Can It Contribute to the Net Zero Goal?, *Amundi ESG Thema #5*, `https://research-center.amundi.com`
3. Créhalet, E., and Talwar, S. (2021), Carbon-efficient Technologies in the Race to Net Zero, *Amundi ESG Thema #6*, `https://research-center.amundi.com`
4. Le Meaux, C., Le Berthe, T., Jaulin, T., Créhalet, E., Jouanneau, M., Pouget-Abadie, T., and Elbaz, J. (2021), How can Investors Contribute to Net Zero Efforts?, *Amundi ESG Thema #3*, `https://research-center.amundi.com`

Available at `https://research-center.amundi.com` or `www.ssrn.com`

Main references

Academic publications

1. Andersson, M., Bolton, P., and Samama, F. (2016), Hedging Climate Risk, *Financial Analysts Journal*, www.ssrn.com/abstract=2499628.
2. Ardia, D., Bluteau, K., Boudt, K., and Inghelbrecht, K. (2021), Climate Change Concerns and the Performance of Green versus Brown Stocks, *National Bank of Belgium, Working Paper*, www.ssrn.com/abstract=3717722.
3. Battiston, S., Mandel, A., Monasterolo, I., Schütze, F., and Visentin, G. (2017), A Climate Stress-test of the Financial System, *Nature Climate Change*, www.ssrn.com/abstract=2726076.
4. Berg, F. Koelbel, J.F., and Rigobon, R. (2019), Aggregate Confusion: The Divergence of ESG Ratings, *Working Paper*, www.ssrn.com/abstract=3438533
5. Berg, F., Fabisik, K., and Sautner, Z. (2021), Is History Repeating Itself? The (Un)predictable Past of ESG Ratings , *Working Paper*, www.ssrn.com/abstract=3722087
6. Bolton, P., and Kacperczyk, M. (2021), Do Investors Care about Carbon Risk?, *Journal of Financial Economics*, www.ssrn.com/abstract=3594189
7. Bolton, P., Kacperczyk, M., and Samama, F. (2021), Net-Zero Carbon Portfolio Alignment, *Working Paper*, www.ssrn.com/abstract=3922686
8. Coqueret, G. (2021), Perspectives in ESG Equity Investing, *Working Paper*, www.ssrn.com/abstract=3715753

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9. Crifo, P., Diaye, M.A., and Oueghlissi, R. (2015), Measuring the Effect of Government ESG Performance on Sovereign Borrowing Cost, *Quarterly Review of Economics and Finance*, `hal.archives-ouvertes.fr/hal-00951304v3`
10. Dennig, F., Budolfson, M.B., Fleurbaey, M., Siebert, A., and Socolow, R.H. (2015), Inequality, Climate Impacts on the Future Poor, and Carbon Prices, *Proceedings of the National Academy of Sciences*, `www.pnas.org/content/112/52/15827`
11. Engle, R.F., Giglio, S., Kelly, B., Lee, H., and Stroebel, J. (2020), Hedging Climate Change News, *Review of Financial Studies*, `www.ssrn.com/abstract=3317570`
12. Görgen, M., Jacob, A., Nerlinger, M., Riordan, R., Rohleder, M., and Wilkens, M. (2020), Carbon Risk, *Working Paper*, `www.ssrn.com/abstract=2930897`
13. Harris, J. (2015), The Carbon Risk Factor, *Working Paper*, `www.ssrn.com/abstract=2666757`
14. Karydas, C., and Xepapadeas, A. (2021), Climate Change Financial Risks: Implications for Asset Pricing and Interest Rates, *Working Paper*
15. Le Guenedal, T., and Roncalli, T. (2022), Portfolio Construction and Climate Risk Measures, *Climate Investing*, `www.ssrn.com/abstract=3999971`

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Academic publications

16. Martellini, L., and Vallée, L. (2021), Measuring and Managing ESG Risks in Sovereign Bond Portfolios and Implications for Sovereign Debt Investing, *Journal of Portfolio Management*, www.risk.edhec.edu/measuring-and-managing-esg-risks-sovereign-bond
17. Pedersen, L.H., Fitzgibbons, S., and Pomorski, L. (2021), Responsible Investing: The ESG-Efficient Frontier, *Journal of Financial Economics*, www.ssrn.com/abstract=3466417
18. Pástor, L., Stambaugh, R.F., and Taylor, L.A. (2021), Sustainable Investing in Equilibrium, *Journal of Financial Economics*, www.ssrn.com/abstract=3498354
19. Roncalli, T., Le Guenedal, T., Lepetit, F., Roncalli, T., and Sekine, T. (2021), The Market Measure of Carbon Risk and its Impact on the Minimum Variance Portfolio, *Journal of Portfolio Management*, www.ssrn.com/abstract=3772707
20. Van der Beck, P. (2021), Flow-driven ESG returns, *Working Paper*, www.ssrn.com/abstract=3929359

ESG rating agencies

Major players

- ISS ESG (Deutsche Börse)
- MSCI ESG
- Sustainalytics (Morningstar)
- Thomson Reuters (Refinitiv)
- Vigeo-Eiris (Moody's)

Other players

- Beyond Ratings (LSE)
- Bloomberg ESG
- FTSE Russell
- RobecoSAM (S&P)
- TrueValue Labs (Factset)

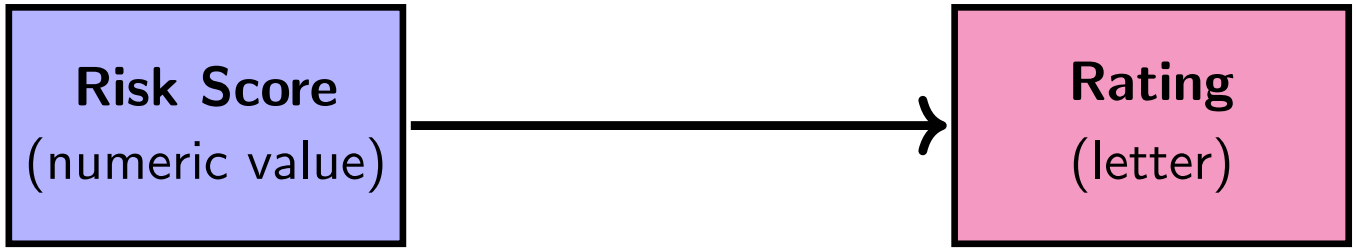
Specialized climate data providers

- CDP
- Iceberg Data Lab
- Trucost (S&P)

Specialized data providers

- EthiFinance
- Factiva
- RepRisk
- Verisk Maplecroft

The construction of ESG ratings

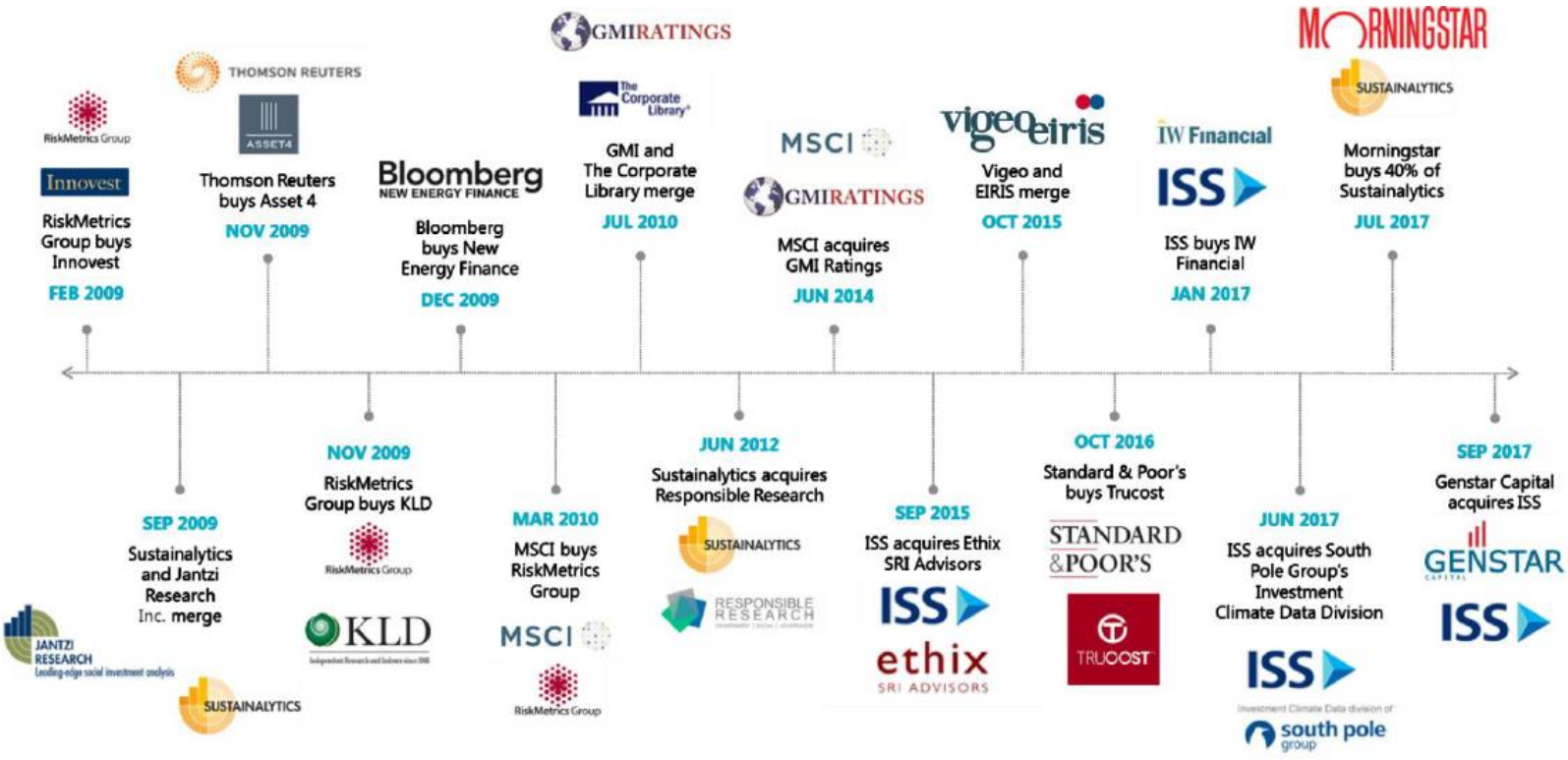


- In the case of credit risk, the estimate of the one-year probability of default is converted into credit ratings
  - For instance, a **CCC**-rated company has a 1Y PD of 25%; a **B**-rated company has a 1Y PD of 5%; a **BB**-rated company has a 1Y PD of 1%; etc.
- In the case of ESG risk, the ESG score is converted into ESG ratings
  - The best scores correspond to the best ratings
  - The worst scores correspond to the worst ratings

Examples of ESG ratings

- Amundi: -3 to $+3$ and **A** (high) to **G** (low)
- Bloomberg ESG Data Service: 0 to 100
- DowJones Sustainability Index: 0 to 100
- FTSE Russell: 0 (low) to 5 (high)
- ISS Quality Score: 1 (high) to 10 (low)
- MSCI: 0 to 10 and **AAA** (high) to **CCC** (low)
- RepRisk: **AAA** (high) to **D** (low)
- RobecoSAM: 0 to 100
- Sustainanalytics: 0 to 100 and 1 (low) to 5 -high)
- Thomson Reuters: 1 to 100 and **A+** (high) to **D-** (low)

Merger & acquisition activity



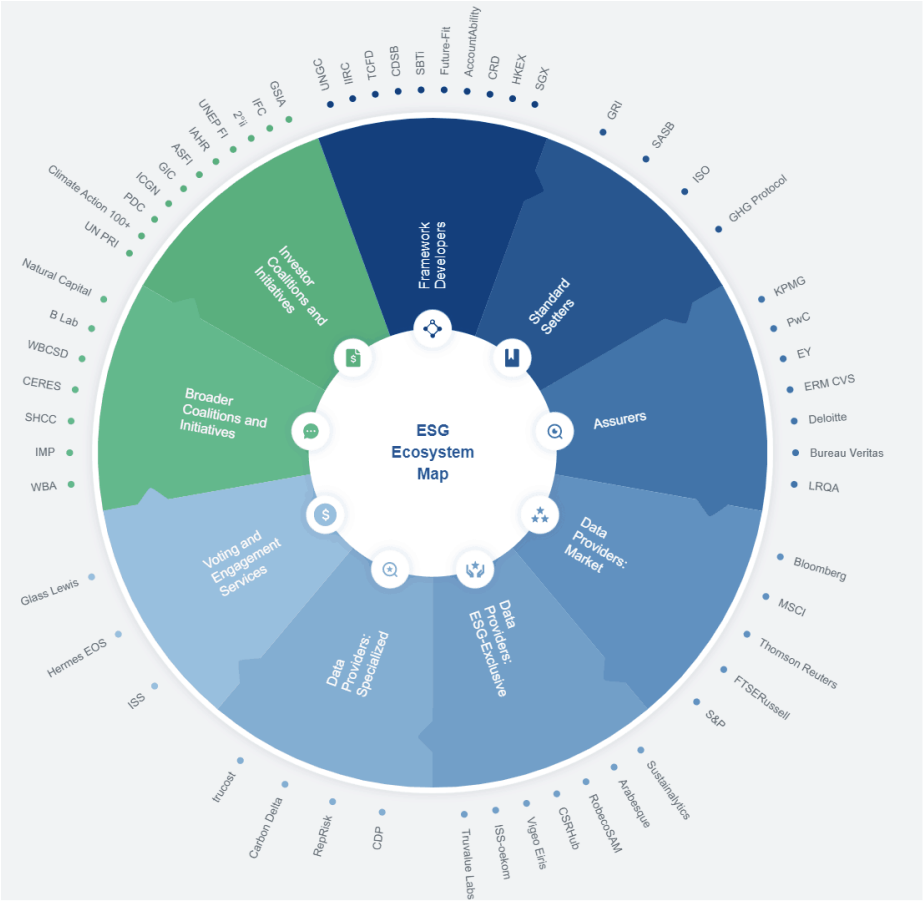
Source: Brown Flynn (2018)

Merger & acquisition activity

- 1983: Creation of Ethical Investment Research Services Ltd. (EIRIS, UK)
- 1988: Creation of KLD (US)
- 1995: Creation of Innovest (Canada) and SAM (Switzerland)
- 2002: Creation of Vigeo (France)
- At the end of 2000s: Bloomberg (US), MSCI (US) and Thomson Reuters (US)
- At the beginning of 2010s: the leading ESG rating agencies were EIRIS (UK), GMI Ratings (US), Inrate (Switzerland), oekom (Germany), Sustainalytics (Netherlands) and Vigeo (France)
- 2010s: Sustainalytics $\rightarrow$ Morningstar (2017), oekom $\rightarrow$ ISS (2018), Vigeo-EIRIS $\rightarrow$ Moody's (2019), RobecoSAM $\rightarrow$ S&P, Beyond Ratings $\rightarrow$ LSE

Ecosystem of ESG ratings

Figure 1: `https://widgets.weforum.org/esgecosystemmap`



ESG data

- ESG requires a lot of data and **alternative** data
- For example, Sustainalytics ESG Data includes 220 ESG indicators and 450 fields, and covers over 12 000 companies
- Where to find the data?
  - Public data
    - Standardized data (regulatory reporting)
    - Non-standardized data (self reporting)
  - Private data
  - Proprietary data
  - Questionnaire/survey
  - Analyst scores
  - Data from other ESG rating agencies

ESG data

Examples of data

- Corporate annual reports
- Corporate environmental and social reports
- Carbon Disclosure Project (CDP) responses
- US Bureau of Labor Statistics
- Thomson Financial
- World Bank (WB)

ESG data

The example of MSCI ESG data

MSCI data sources used to determine characteristics of a company's operations

- Annual reports
- Investor presentations
- Financial and regulatory filings

ESG data

The example of MSCI ESG data

MSCI data sources used to map macro-level risk exposure

Comprehensive Environmental Data Archive (CEDA); US Department of Energy; International Council on Clean Transportation; Lamont-Doherty Earth Observatory, Columbia University; Organization of Economic Co-Operation and Development (OECD); Canadian Industrial Water Survey; University of New Hampshire's Water Systems Analysis Group (country data); Hoekstra, A.Y. and Mekonnen, M.M. (2011); Ecorisk; World Development Indicators (WDI); Annual Change of Forest Resources Food and Agriculture Organization (FAO); World Wildlife Fund (WWF); US EPAs Toxics Release Inventory (TRI); Risk-Screening Environmental Indicators (RSEI); US Bureau of Labor Statistics (BLS); International Labour Organization (ILO); US Occupational Health & Safety Administration (OSHA); UK Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR); International Chemical Secretariat (ChemSec) Substitute It Now (SIN) List; International Monetary Fund (IMF); World Health Organization (WHO); UN Principles for Responsible Investments (UN PRI); World Resource Institute (WRI); Consultative Group to Assist the Poor (CGAP); US Census Bureau Current Population Survey Supplement; World Bank Governance Indicators (WGI); Transparency International (TI); World Bank (WB); SNL Financial; Thomson Financial;

ESG data

The example of MSCI ESG data

MSCI data sources used to assess risk management capabilities

- Corporate documents: annual reports, proxy filings, environmental and social reports, securities filings, websites and CDP responses
- Government data: central bank data, U.S. Toxic Release Inventory, Comprehensive Environmental Response and Liability Information System (CERCLIS), RCRA Hazardous Waste Data Management System, etc.
- Popular, trade, and academic journals: accessed through websites, subscriptions and searches of online databases
- News media: major news publications globally, including local-language sources across a range of markets
- Relevant organizations and professionals: reports from and interviews with trade groups, industry experts and nongovernmental organizations familiar with the companies' operations and any related controversies.

ESG data

The example of Amundi ESG scoring system

ESG data

Examples of alternative data

- Energy Data Analytics Lab research (Duke university)
  `https://energy.duke.edu/research/energy-data/resources`
- Food and Agriculture Organization (FAO)
  `http://www.fao.org`
- UK Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)
  `https://www.hse.gov.uk/riddor`
- World Health Organization (WHO)
  `https://www.who.int`
- World Bank Governance Indicators (WGI)
  `https://info.worldbank.org/governance/wgi`
- World Resources Institute (WRI)
  `https://www.wri.org`

ESG (alternative) data

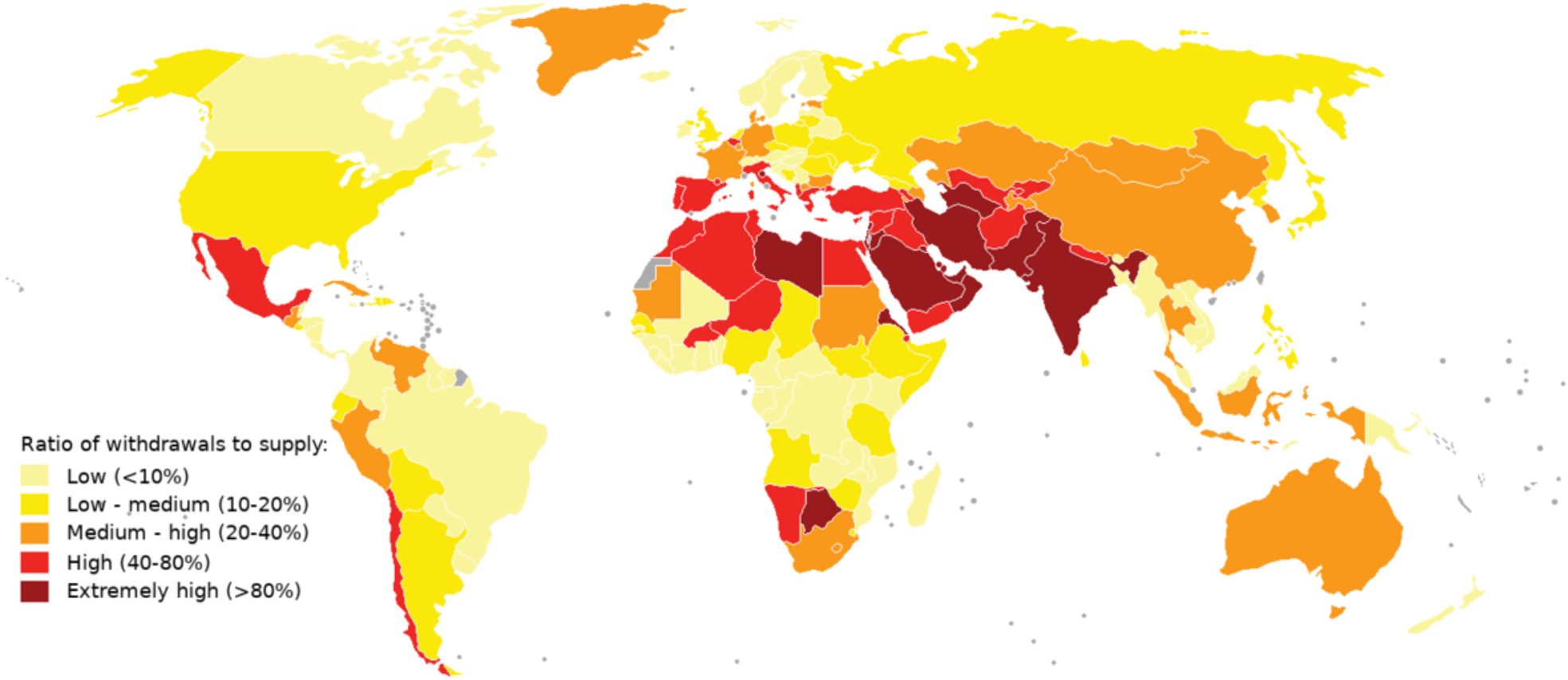


Figure 2: WRI water stress 2019

Source: World Resources Institute (WRI), `www.wri.org`

ESG (alternative) data

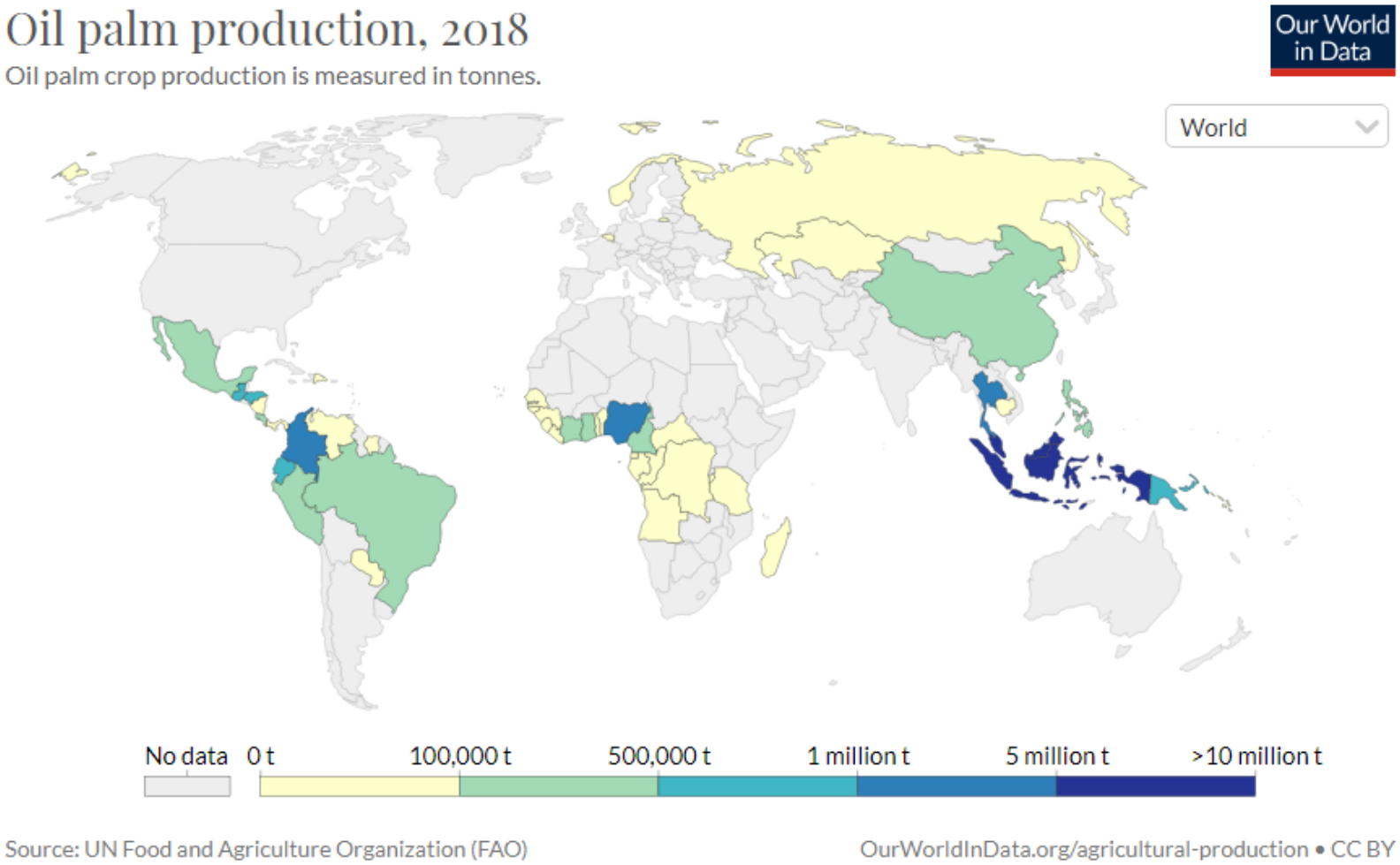


Figure 3: Oil palm production in 2018

Source: Our World in Data, `https://ourworldindata.org/grapher/palm-oil-production`

ESG (alternative) data

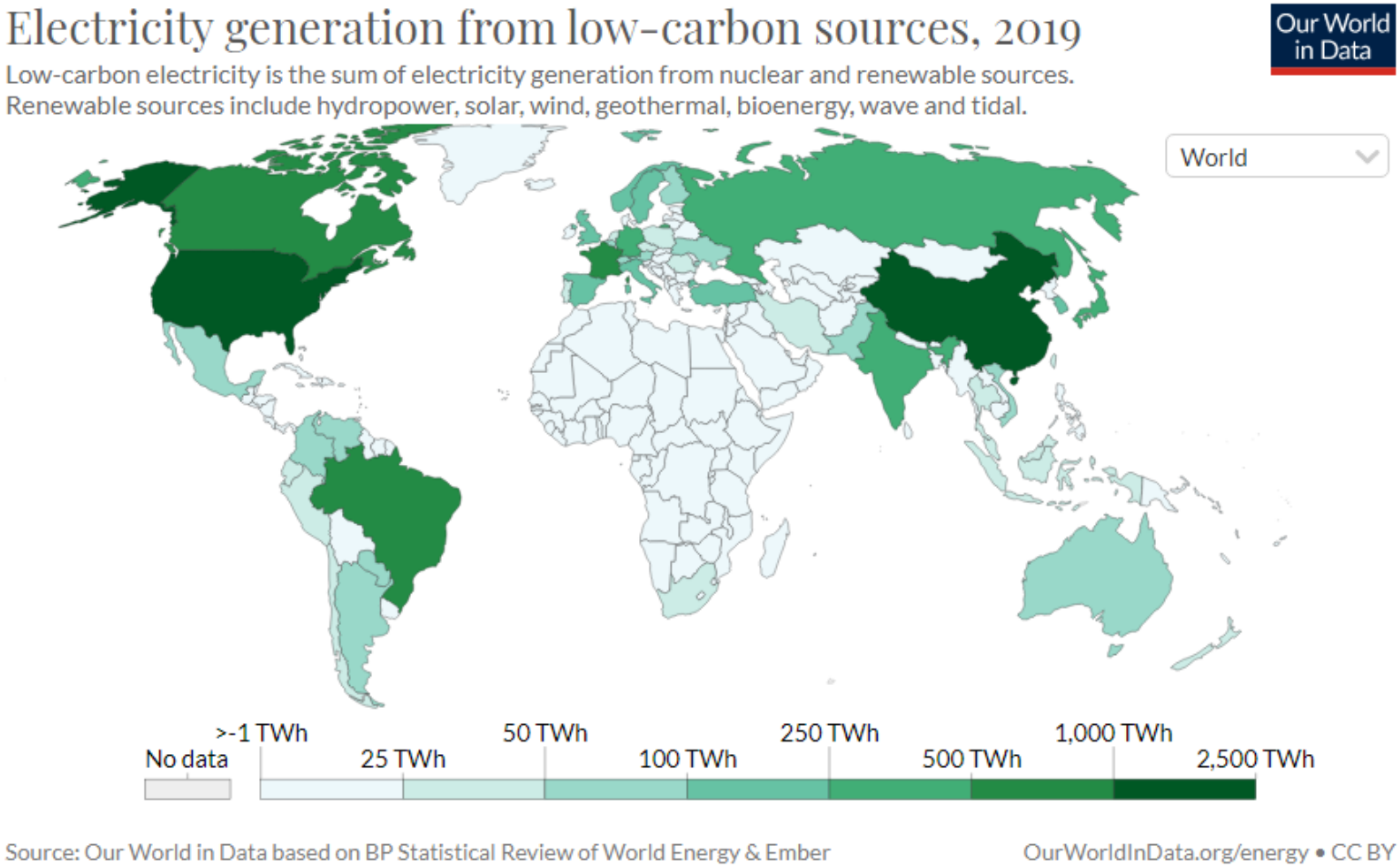


Figure 4: Electricity generation from low-carbon sources in 2019

Source: Our World in Data, `https://ourworldindata.org/grapher/low-carbon-electricity`

ESG (alternative) data

$$\text{Country} \Leftrightarrow \text{Corporate}$$

Some examples:

- Chairman of the Board $\neq$ CEO
- CO_2 emissions

ESG scoring system

Table 1: An example of ESG criteria (corporate issuers)

Environmental	Social	Governance
Carbon emissions	Employment conditions	Board independence
Energy use	Community involvement	Corporate behaviour
Pollution	Gender equality	Audit and control
Waste disposal	Diversity	Executive compensation
Water use	Stakeholder opposition	Shareholder' rights
Renewable energy	Access to medicine	CSR strategy
Green cars*		
Green financing*		

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

(Green cars $\Rightarrow$ Automobiles, Green financing $\Rightarrow$ Financials)

ESG scoring system

Table 2: An example of ESG criteria (sovereign issuers)

Environmental

- Carbon emissions
- Energy transition risk
- Fossil fuel exposure
- Emissions reduction target
- Physical risk exposure
- Green economy

Social

- Income inequality
- Living standards
- Non-discrimination
- Health & security
- Local communities and human rights
- Social cohesion
- Access to education

Governance

- Political stability
- Institutional strength
- Levels of corruption
- Rule of law
- Government and regulatory effectiveness
- Rights of shareholders

ESG scoring system

Sovereign ESG Data Framework

- World Bank
- Data may be download at the following webpage:
  `https://datatopics.worldbank.org/esg/framework.html`
- **E**: 27 variables
- **S**: 22 variables
- **G**: 18 variables

ESG scoring system

Table 3: Sovereign ESG Data Framework (World Bank)

Environmental

- Emissions & pollution (5)
- Natural capital endowment and management (6)
- Energy use & security (7)
- Environment/ climate risk & resilience (6)
- Food security (3)

Social

- Education & skills (3)
- Employment (3)
- Demography (3)
- Poverty & inequality (4)
- Health & nutrition (5)
- Access to services (4)

Governance

- Human rights (2)
- Government effectiveness (2)
- Stability & rule of law (4)
- Economic environment (3)
- Gender (4)
- Innovation (3)

ESG scoring system

- Most of ESG scoring systems are based on scoring trees
- Raw data are normalized in order to obtain features $X_1, \ldots, X_m$
- Features $X_1, \ldots, X_m$ are aggregated to obtain sub-scores $\mathcal{S}_1, \ldots, \mathcal{S}_n$:

$$\mathcal{S}_i = \sum_{j=1}^{m} \omega_{i,j}^{(1)} X_j$$

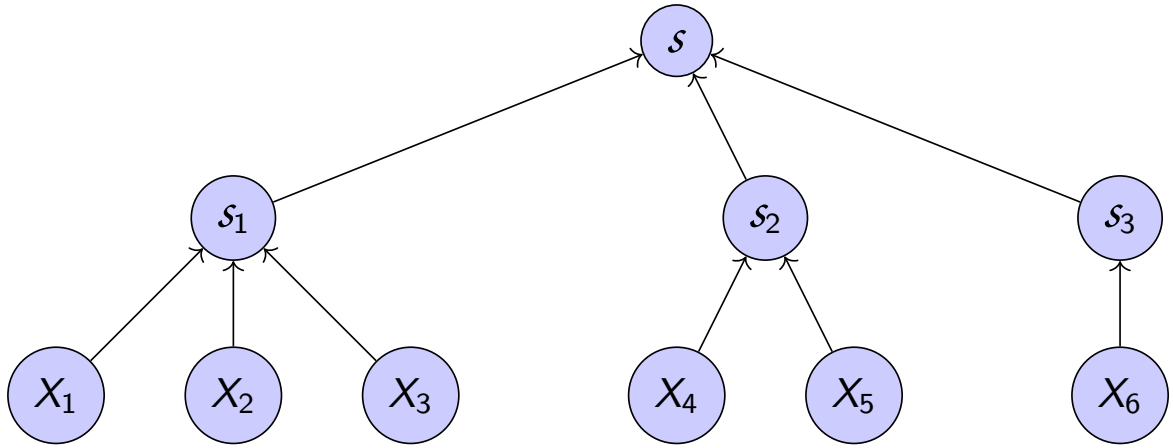
- Sub-scores $\mathcal{S}_1, \ldots, \mathcal{S}_n$ are aggregated to obtain the final score $\mathcal{S}$:

$$\mathcal{S} = \sum_{i=1}^{n} \omega_i^{(2)} \mathcal{S}_i$$

The two-level tree structure can be extended to multi-level tree structures
For example, in the case of a three-level tree structure, we have:

Raw data $\Rightarrow$ features $\Rightarrow$ sub-sub-scores $\Rightarrow$ sub-scores $\Rightarrow$ final score

ESG scoring system



We assume that:

- Level 1
  1. $\omega_{1,1}^{(1)} = 50\%$
     $\omega_{2,1}^{(1)} = 25\%$
     $\omega_{3,1}^{(1)} = 25\%$
  2. $\omega_{4,2}^{(1)} = 50\%$
     $\omega_{5,2}^{(1)} = 50\%$
  3. $\omega_{6,3}^{(1)} = 100\%$
- Level 2: $\omega_1^{(2)} = \omega_2^{(2)} = \omega_3^{(2)} = 33.33\%$

Figure 5: A two-level tree structure

ESG scoring system

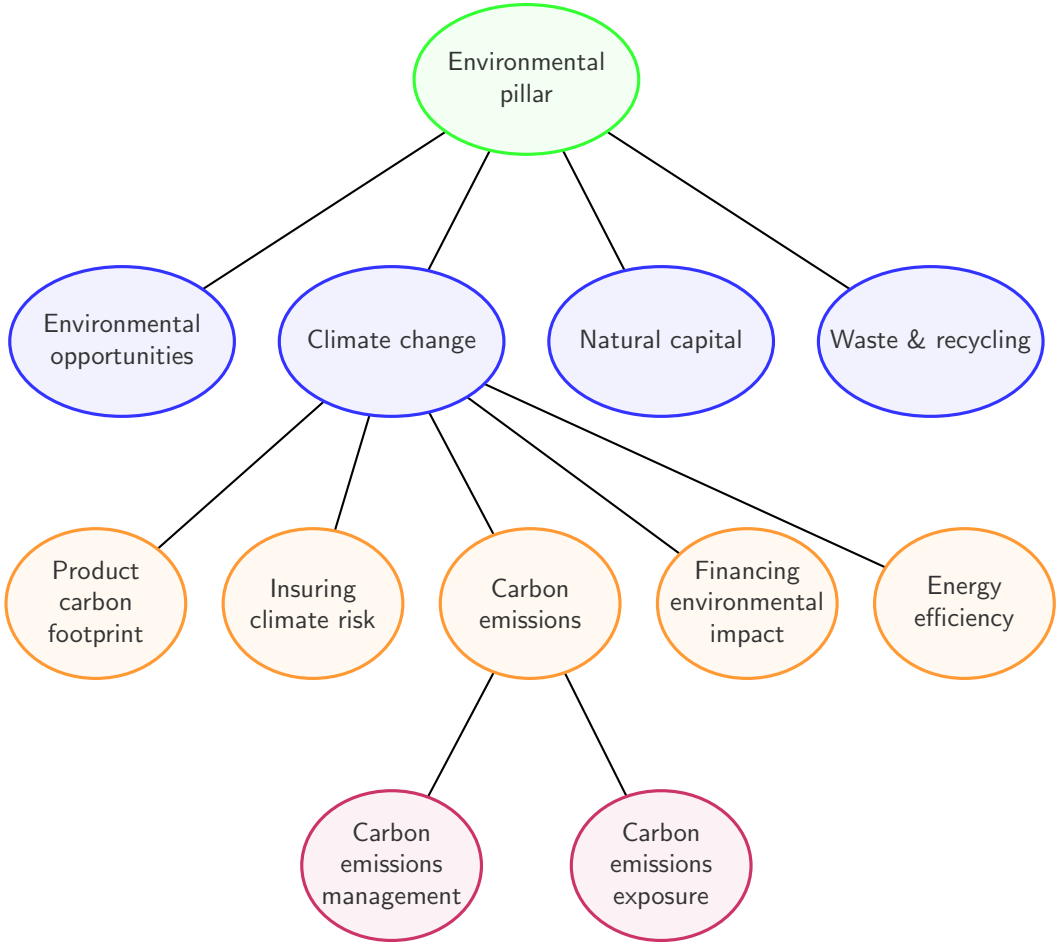


Figure 6: An example of ESG scoring tree (MSCI methodology)

Source: MSCI (2020)

ESG scoring system

Raw data have to be normalized

Why? Because to facilitate the comparison

Some examples:

- Carbon emissions $\Rightarrow$ carbon intensity $\Rightarrow$ E
- Income inequalities $\Rightarrow$ Gini index $\Rightarrow$ S
- CEO compensation $\Rightarrow$ CEO pay ratio $\Rightarrow$ G or S ?

ESG scoring system

Remark

The Dodd-Frank Act requires that publicly traded companies disclose:

1. The median total annual compensation of all employees other than the CEO
2. The ratio of the CEO's annual total compensation to that of the median employee
3. The wage ratio of the CEO to the median employee

ESG scoring system

Table 4: Examples of CEO pay ratio

Company name	Median Worker Pay (in $)	CEO Pay Ratio
Abercrombie & Fitch Co.	1 954	4,293
McDonald's Corporation	9 291	1,939
The Coca-Cola Company	11 285	1,657
The Gap, Inc.	6 177	1,558
Alphabet Inc.	258 708	1,085
Walmart Inc.	22 484	983
The Estee Lauder Companies, Inc.	30 733	697
Ralph Lauren Corporation	21 358	570
NIKE, Inc.	25 386	550
Citigroup Inc.	52 988	482
PepsiCo, Inc.	45 896	368
Microsoft Corporation	172 512	249
Apple Inc.	57 596	201

Source: https://aflcio.org (June 2021)

ESG scoring system

Table 5: Examples of CEO pay ratio

Company name	Median Worker Pay (in $)	CEO Pay Ratio
Netflix, Inc.	202 931	190
BlackRock, Inc.	133 644	182
Pfizer Inc.	98 972	181
The Goldman Sachs Group, Inc.	138 854	178
MSCI Inc.	55 857	165
Verisk Analytics, Inc.	77 055	117
Facebook, Inc.	247 883	94
Invesco Ltd.	125 282	92
The Boeing Company	158 869	90
Citrix Systems, Inc.	181 769	80
Harley-Davidson, Inc.	187 157	59
Amazon.com, Inc.	28 848	58
Berkshire Hathaway Inc.	65 740	6

Source: https://aflcio.org (June 2021)

ESG scoring system

Scores have also to be normalized

Why? Because to facilitate the aggregation process

Several normalization approaches:

- q-score normalisation:
  - $0-1$ normalization: $q_i \in [0,1]$
  - $0-10$ normalization: $q_i \in [0,10]$
  - $0-100$ normalization: $q_i \in [0,100]$

$$q_i = \hat{\mathbf{F}}(x_i)$$

where $\hat{\mathbf{F}}$ is the empirical probability distribution ($q_i \in [0,1]$)

- z-score normalisation:

$$z_i = \frac{x_i - \hat{\mu}(X)}{\hat{\sigma}(X)}$$

ESG scoring system

Let $\{x_1, x_2, \ldots, x_n\}$ be the sample. We have:

$$q_i = \hat{\mathbf{F}}(x_i) = \Pr\{X \leq x_i\} = \frac{\#\{x_j \leq x_i\}}{n_q}$$

We can use two normalization factors:

1. $n_q = n$
2. $n_q = n + 1$

For example, if $n = 4$, we have:

- $q_i \in \{0.25, 0.5, 0.75, 1\}$ if $n_q = n$
- $q_i \in \{0.2, 0.4, 0.6, 0.8\}$ if $n_q = n + 1$

Remark (probability integral transform)

The second solution is better because $q_i \in]0, 1[$. Therefore, we can transform q_i using any probability distribution $\mathbf{G}^{-1}(q_i)$

ESG scoring system

Table 6: How to make two scores comparable?

Observation	X_1	s_1	X_2	s_2
1	94.0000		−0.0300	
2	38.6000		−0.0550	
3	30.6000		0.0560	
4	74.4000		−0.0130	
5	97.1000		−0.1680	
6	57.1000		−0.0350	
7	132.4000		0.0850	
8	92.5000		−0.0910	
9	64.9000		−0.0460	
Mean	75.7333		−0.0330	
Standard deviation	31.9466		0.0746	

How to create the synthetic score $30\% \cdot X_1 + 70\% \cdot X_2$?

ESG scoring system

Table 7: Computation of q-score ($0 - 100$ normalization)

Observation	X_1	q_1	X_2	q_2
1	94.0000	70.0000	−0.0300	60.0000
2	38.6000	20.0000	−0.0550	30.0000
3	30.6000	10.0000	0.0560	80.0000
4	74.4000	50.0000	−0.0130	70.0000
5	97.1000	80.0000	−0.1680	10.0000
6	57.1000	30.0000	−0.0350	50.0000
7	132.4000	90.0000	0.0850	90.0000
8	92.5000	60.0000	−0.0910	20.0000
9	64.9000	40.0000	−0.0460	40.0000
Mean	75.7333	50.0000	−0.0330	50.0000
Standard deviation	31.9466	27.3861	0.0746	27.3861

ESG scoring system

Table 8: Computation of z-score

Observation	X_1	z_1	X_2	z_2
1	94.0000	0.5718	−0.0300	0.0402
2	38.6000	−1.1624	−0.0550	−0.2950
3	30.6000	−1.4128	0.0560	1.1933
4	74.4000	−0.0417	−0.0130	0.2682
5	97.1000	0.6688	−0.1680	−1.8101
6	57.1000	−0.5833	−0.0350	−0.0268
7	132.4000	1.7738	0.0850	1.5821
8	92.5000	0.5248	−0.0910	−0.7777
9	64.9000	−0.3391	−0.0460	−0.1743
Mean	75.7333	0.0000	−0.0330	0.0000
Standard deviation	31.9466	1.0000	0.0746	1.0000

We have $z_{1,8} = \frac{92.5 - 75.73}{31.95} = 0.5248$ and $z_{2,1} = \frac{-0.055 - (-0.033)}{0.0746} = -0.295$

ESG scoring system

Table 9: From z-score to q-score

Observation	X_1	z_1	qz_1	X_2	z_2	qz_2
1	94.0000	0.5718	71.6267	−0.0300	0.0402	51.6043
2	38.6000	−1.1624	12.2545	−0.0550	−0.2950	38.4006
3	30.6000	−1.4128	7.8861	0.0560	1.1933	88.3627
4	74.4000	−0.0417	48.3354	−0.0130	0.2682	60.5712
5	97.1000	0.6688	74.8196	−0.1680	−1.8101	3.5141
6	57.1000	−0.5833	27.9857	−0.0350	−0.0268	48.9303
7	132.4000	1.7738	96.1951	0.0850	1.5821	94.3192
8	92.5000	0.5248	70.0151	−0.0910	−0.7777	21.8383
9	64.9000	−0.3391	36.7264	−0.0460	−0.1743	43.0813

We transform the q-score:

$$qz_i = \Phi(z_i) \in [0, 1]$$

and then we normalize qz_i

ESG scoring system

Table 10: From q-score to z-score

Observation	X_1	q_1	zq_1	X_2	q_2	zq_2
1	94.0000	70.0000	0.5244	−0.0300	60.0000	0.2533
2	38.6000	20.0000	−0.8416	−0.0550	30.0000	−0.5244
3	30.6000	10.0000	−1.2816	0.0560	80.0000	0.8416
4	74.4000	50.0000	0.0000	−0.0130	70.0000	0.5244
5	97.1000	80.0000	0.8416	−0.1680	10.0000	−1.2816
6	57.1000	30.0000	−0.5244	−0.0350	50.0000	0.0000
7	132.4000	90.0000	1.2816	0.0850	90.0000	1.2816
8	92.5000	60.0000	0.2533	−0.0910	20.0000	−0.8416
9	64.9000	40.0000	−0.2533	−0.0460	40.0000	−0.2533

We normalize the q-score such that $q_i \in [0, 1]$, and then we have:

$$zq_i = \Phi^{-1}\left(q_i\right) \in [-3, 3]$$

ESG scoring system

Table 11: Score aggregation: $30\% \cdot s_1 + 70\% \cdot s_2$

Observation	X_1	X_2	q_{12}	qz_{12}	z_{12}	zq_{12}
1	94.0000	−0.0300	63.0000	57.6110	0.1997	0.3347
2	38.6000	−0.0550	27.0000	30.5568	−0.5552	−0.6196
3	30.6000	0.0560	59.0000	64.2197	0.4115	0.2047
4	74.4000	−0.0130	64.0000	56.9005	0.1752	0.3671
5	97.1000	−0.1680	31.0000	24.9058	−1.0664	−0.6446
6	57.1000	−0.0350	44.0000	42.6469	−0.1938	−0.1573
7	132.4000	0.0850	90.0000	94.8820	1.6396	1.2816
8	92.5000	−0.0910	32.0000	36.2913	−0.3869	−0.5131
9	64.9000	−0.0460	40.0000	41.1748	−0.2237	−0.2533
Mean	75.7333	0.0000	50.0000	49.9099	0.0000	0.0000
Standard deviation	31.9466	1.0000	20.6034	21.3591	0.7592	0.6207

We have $q_{12} = 0.3 \cdot q_1 + 0.7 \cdot q_2$, $qz_{12} = 0.3 \cdot qz_1 + 0.7 \cdot qz_2$, $z_{12} = 0.3 \cdot z_1 + 0.7 \cdot z_2$ and $zq_{12} = 0.3 \cdot zq_1 + 0.7 \cdot zq_2$

ESG scoring system

Sector neutrality

- Most of ESG scoring systems are sector neutral
- The normalization is done at the sector level, not at the universe level
- ESG scores are then **relative** (with respect to a sector), not **absolute**
- **Best-in-class/worst-in-class issuers** $\neq$ best/worst issuers

Example

- Corporate A: (E) $= +2$ vs Corporate B: (E) $= +1$
- If A and B belong to the same sector, we have $A \succ B$ (A is more green than B)
- If A and B belong to the two different sectors, we can have $A \succ B$ or $B \succ A$

ESG rating system

We need a mapping function $\mathcal{M}_{\text{apping}}$ to transform the ESG score s into an ESG rating $\mathcal{R}$

MSCI methodology

$$\begin{array}{rccl} \mathcal{M}_{\text{apping}}: & [0,10] & \longrightarrow & \{\text{AAA}, \text{AA}, \text{A}, \text{BBB}, \text{BB}, \text{B}, \text{CCC}\} \\ & s & \longmapsto & \mathcal{R} = \mathcal{M}_{\text{apping}}(s) \end{array}$$

- If $s \in \left[0, \frac{10}{7}\right]$, $\mathcal{M}_{\text{apping}}(s) = \textbf{CCC}$
- If $s \in \left[\frac{10}{7}, \frac{2\times10}{7}\right]$, $\mathcal{M}_{\text{apping}}(s) = \textbf{B}$
- If $s \in \left[\frac{2\times10}{7}, \frac{3\times10}{7}\right]$, $\mathcal{M}_{\text{apping}}(s) = \textbf{BB}$
- If $s \in \left[\frac{3\times10}{7}, \frac{4\times10}{7}\right]$, $\mathcal{M}_{\text{apping}}(s) = \textbf{BBB}$
- If $s \in \left[\frac{4\times10}{7}, \frac{5\times10}{7}\right]$, $\mathcal{M}_{\text{apping}}(s) = \textbf{A}$
- If $s \in \left[\frac{5\times10}{7}, \frac{6\times10}{7}\right]$, $\mathcal{M}_{\text{apping}}(s) = \textbf{AA}$
- If $s \in \left[\frac{6\times10}{7}, 10\right]$, $\mathcal{M}_{\text{apping}}(s) = \textbf{AAA}$

ESG rating system

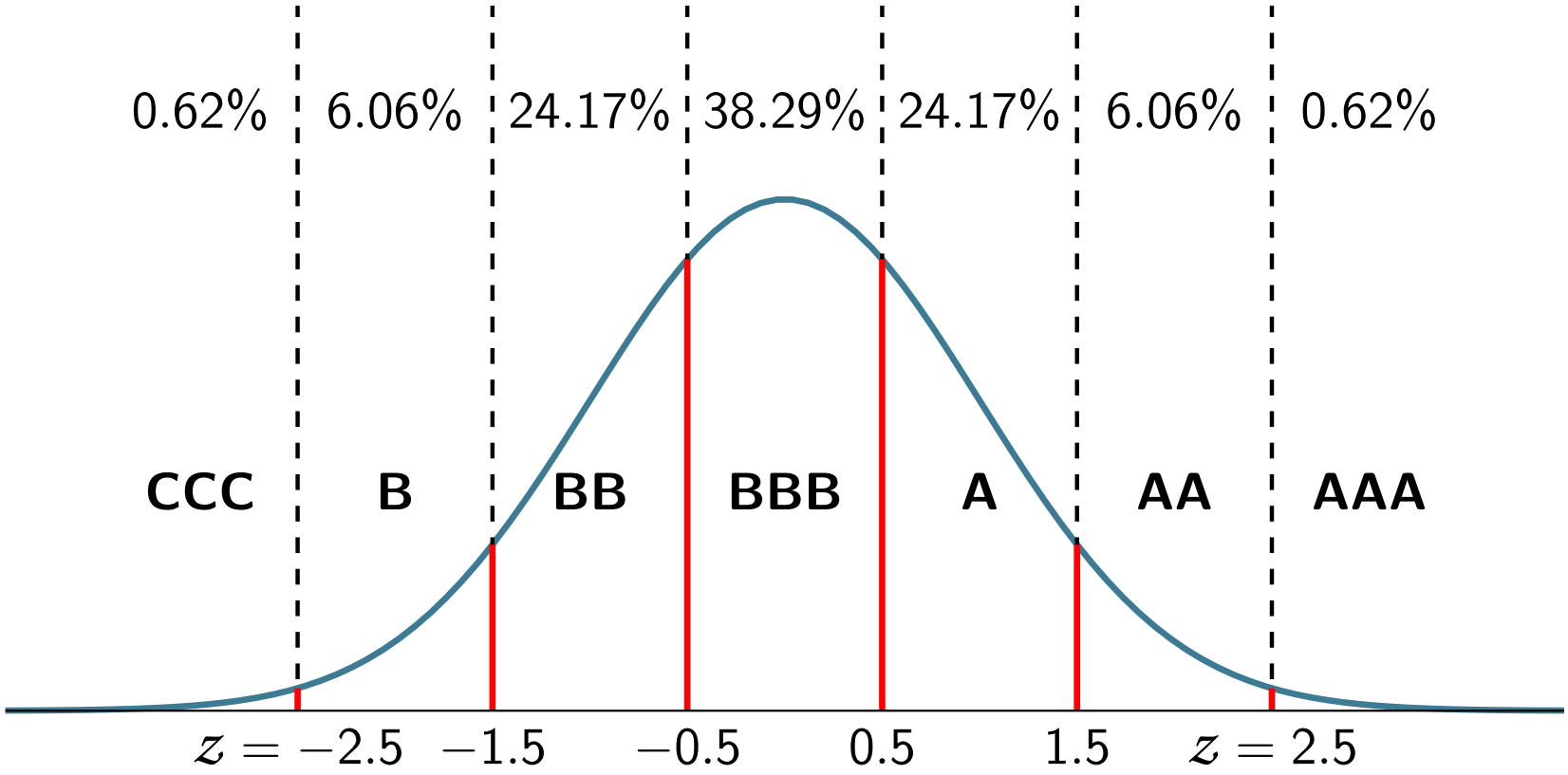
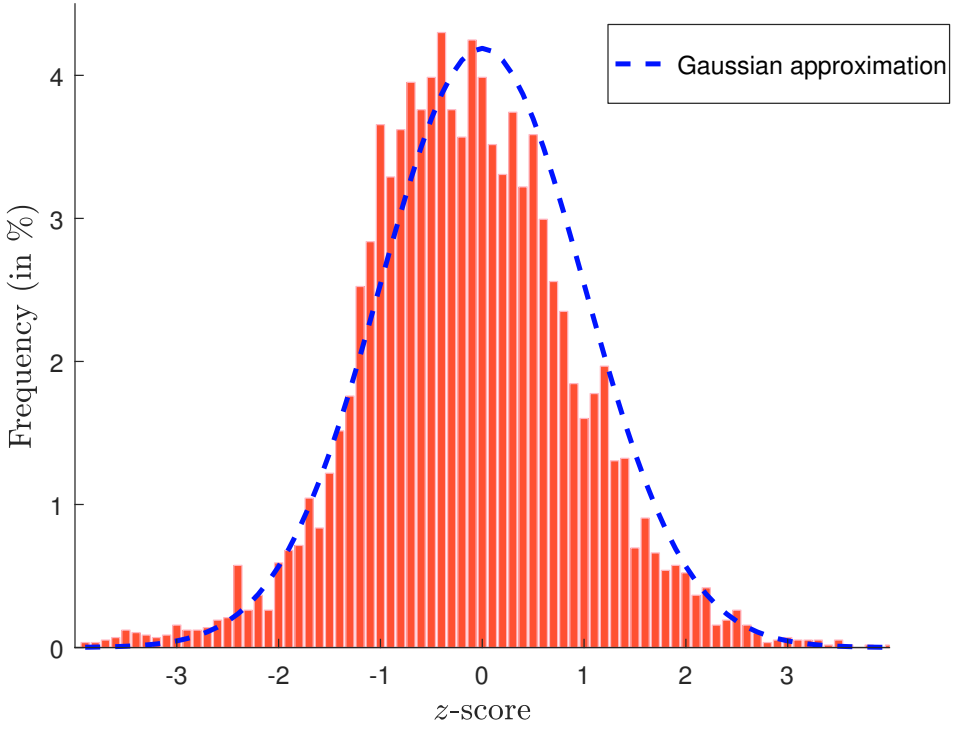


Figure 7: From ESG scores to ESG ratings (Gaussian mapping* of the z-score)

*We have $\Phi(-2.5) = 0.62\%$, $\Phi(-1.5) - \Phi(-2.5) = 6.06\%$, $\Phi(-0.5) - \Phi(-1.5) = 24.17\%$, $\Phi(0.5) - \Phi(-0.5) = 38.29\%$, $\Phi(1.5) - \Phi(0.5) = 24.17\%$, $\Phi(2.5) - \Phi(1.5) = 6.06\%$ and $1 - \Phi(2.5) = 0.62\%$

ESG rating system

Figure 8: Distribution of Amundi ESG scores (December 2018)



Source: Amundi ESG Research (2018)

Table 12: Empirical frequencies of Amundi ESG ratings

	Frequencies	
Rating	Theoretical	Empirical
A	0.62%	1%
B	6.06%	4%
C	24.17%	28%
D	38.29%	38%
E	24.17%	22%
F	6.06%	6%
G	0.62%	1%

Source: Amundi ESG Research (2018)

ESG rating system

Why?

Because ESG analyst can modify
the systematic rating deduced from the quantitative score

ESG rating system

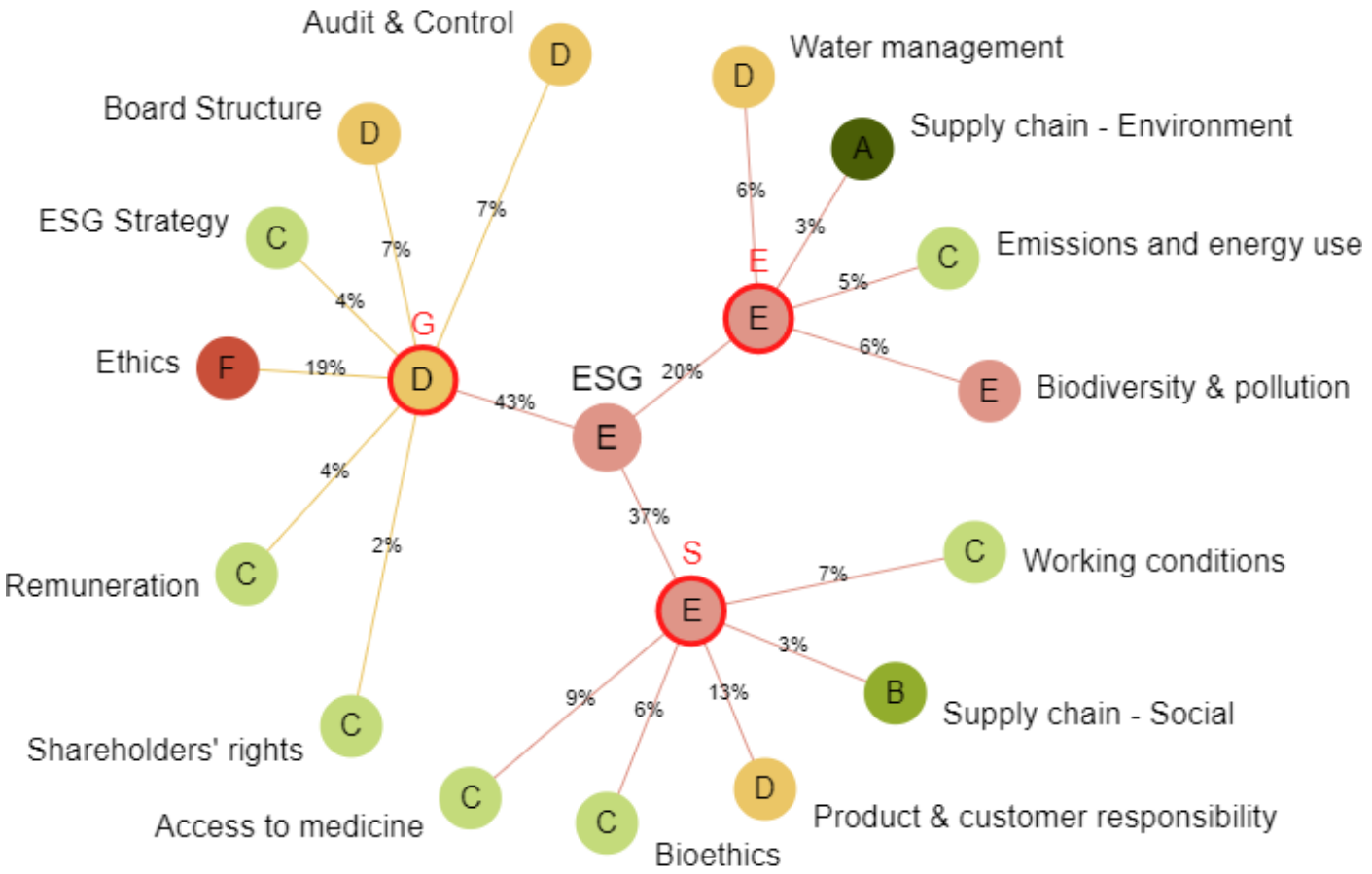


Figure 9: ESG rating tree of Company **B** (Amundi, May 2021)

Source: Amundi ALTO* SRI (2021)

ESG rating system

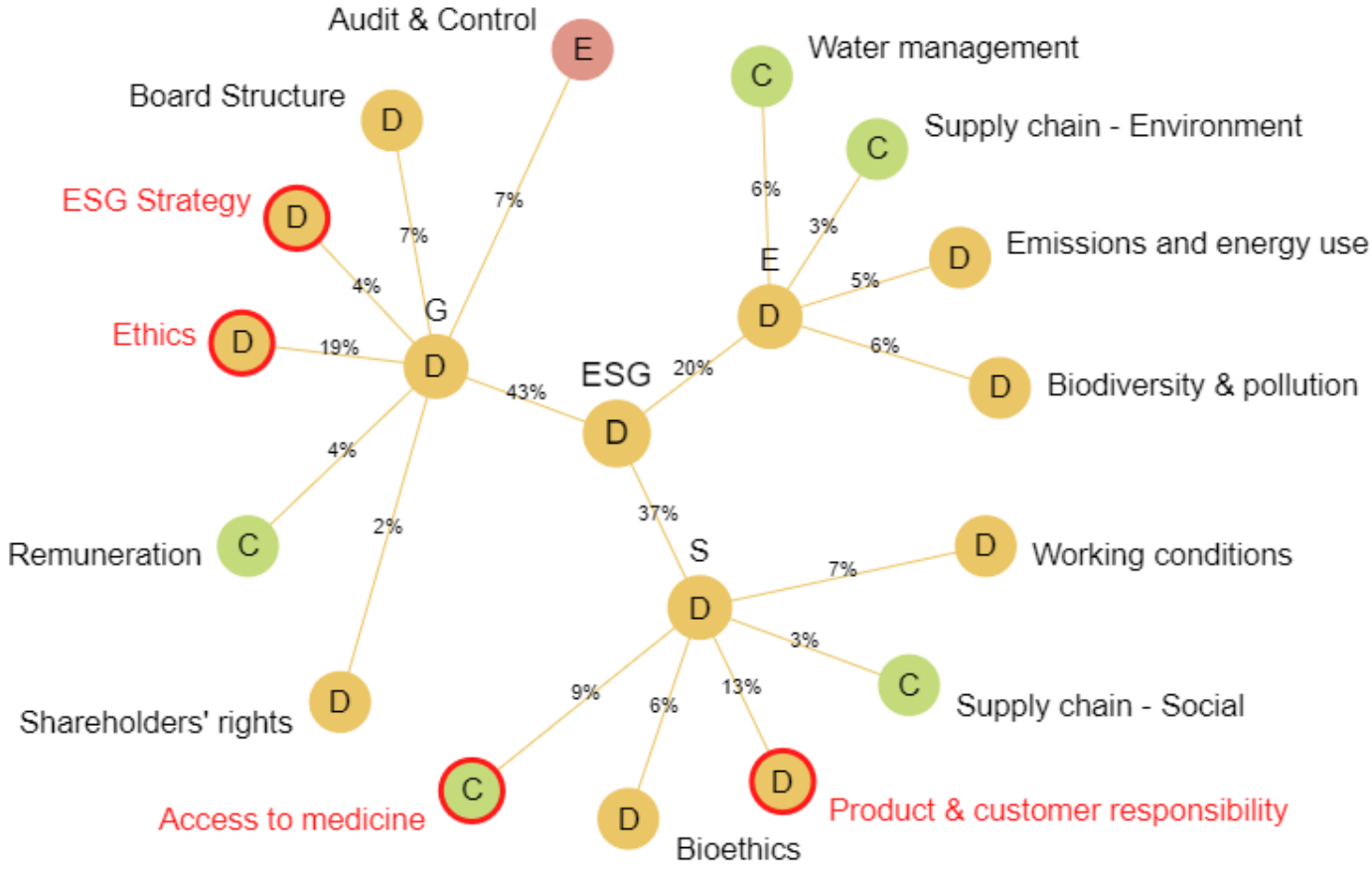


Figure 10: ESG rating tree of Company **P** (Amundi, May 2021)

Source: Amundi ALTO* SRI (2021)

ESG scores, ESG ratings and ESG strategies

Beating the benchmark

- The goal is to have a portfolio, whose ESG score is greater than that of the benchmark index
- Two ways to improve a global ESG score:
  - Overweight issuers with the best ESG scores
  - Underweight or remove issuers with the worst ESG scores

ESG Score

SRI strategy

- The goal is to systematically exclude issuers, whose rating is too bad
- For example, we can exclude:
  - Ratings **CCC**
  - Ratings **B**

ESG Rating

ESG ratings versus credit ratings

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!

The divergence of ESG ratings

Berg, F., Koelbel, J.F., and Rigobon, R. (2019), Aggregate Confusion: The Divergence of ESG Ratings, MIT Sloan School of Management, `www.ssrn.com/abstract=3438533`

Three sources of divergence

1. Weights divergence (3%)
   Rating agencies take different views on the relative importance of attributes
2. Scope divergence (44%)
   Ratings agencies rely on a different set of attributes
3. Measurement divergence (53%)
   Rating agencies measure the same attribute using different indicators
   Rater Effect accounts for one fifth of the variation

The robustness of ESG ratings

How to measure the robustness of ratings?

1. Backtesting
2. Probabilistic properties of the rating migration matrix

$\Rightarrow$ These two tools are extensively used in credit scoring models and credit ratings

What is a good ESG rating system?

The robustness of ESG ratings

Table 13: An example of rating migration matrix (in %)

	AAA	AA	A	BBB	BB	B	CCC
AAA	80%	3%	2%	5%	5%	5%	
AA	5%	85%	3%	3%	2%	2%	
A		5%	90%	5%			
BBB		5%	5%	80%	5%	5%	
BB				7%	85%	8%	
B				1%	9%	80%	9%
CCC				5%	8%	20%	67%

Do you think that it is a good or bad rating system?

$\Rightarrow$ A rating migration matrix must satisfy a lot of mathematical properties (Markov property, time-consistency, lack-of-memory, stationarity, etc.)

The mapping function is key!

What is the performance of ESG investing?

Academic findings

- Relationship between shareholder rights and "*higher firm value, higher profits, higher sales growth, lower capital expenditures, and [...] fewer corporate acquisitions*" (Gompers *et al.*, 2003)
- Positive relation between high corporate social responsibility and low cost of equity capital (El Ghoul *et al.*, 2011): "*Employee Relations, Environmental Policies, Product Strategies lower the firms' cost of equity*"
- Corporate financial performance is a U-shape function of corporate social performance (Barnett and Salomon, 2012)
- Cultural differences explain the diversity and differences in intentions ('Value' or 'Values' oriented) of the currently available ESG data (Eccles and Stroehle, 2018)
- Negative/neutral impact: Schröder (2007), Hong and Kacperczyk (2009)

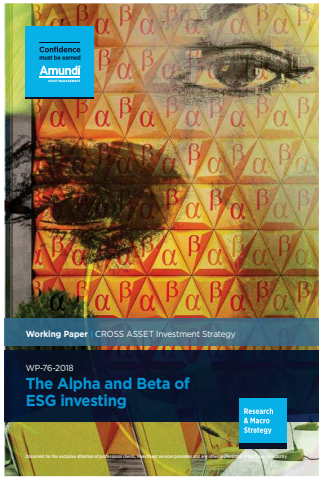
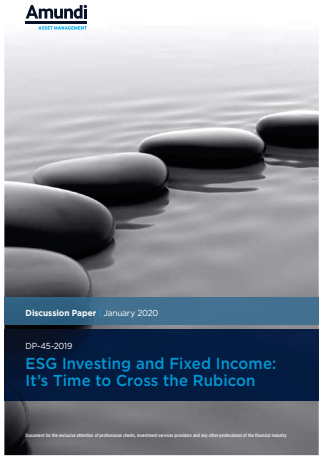
Mixed results

What is the performance of ESG investing?

- Generally, academic studies that analyze the relationship between ESG and performance are based on long-term historical data, typically the last 20 years or the last 30 years.
- Two issues:
  1. ESG investing was marginal 15+ years ago
  2. ESG data are not robust or relevant before 2010
- The relationship between ESG and performance is dynamic
- Sometimes, ESG may create performance, but sometimes not
- Few academic research on corporate bonds

What is the performance of ESG investing?

Amundi findings

2010 – 2017 Equity		2018 – 2019 Equity	2010 – 2019 Fixed-income	
				
DP	WP	DP	DP	WP

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 is a risk factor (or a beta strategy) in the Eurozone, whereas it is an alpha strategy in North America

Active management
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)

Performance of ESG active management (2010 – 2017)

North America

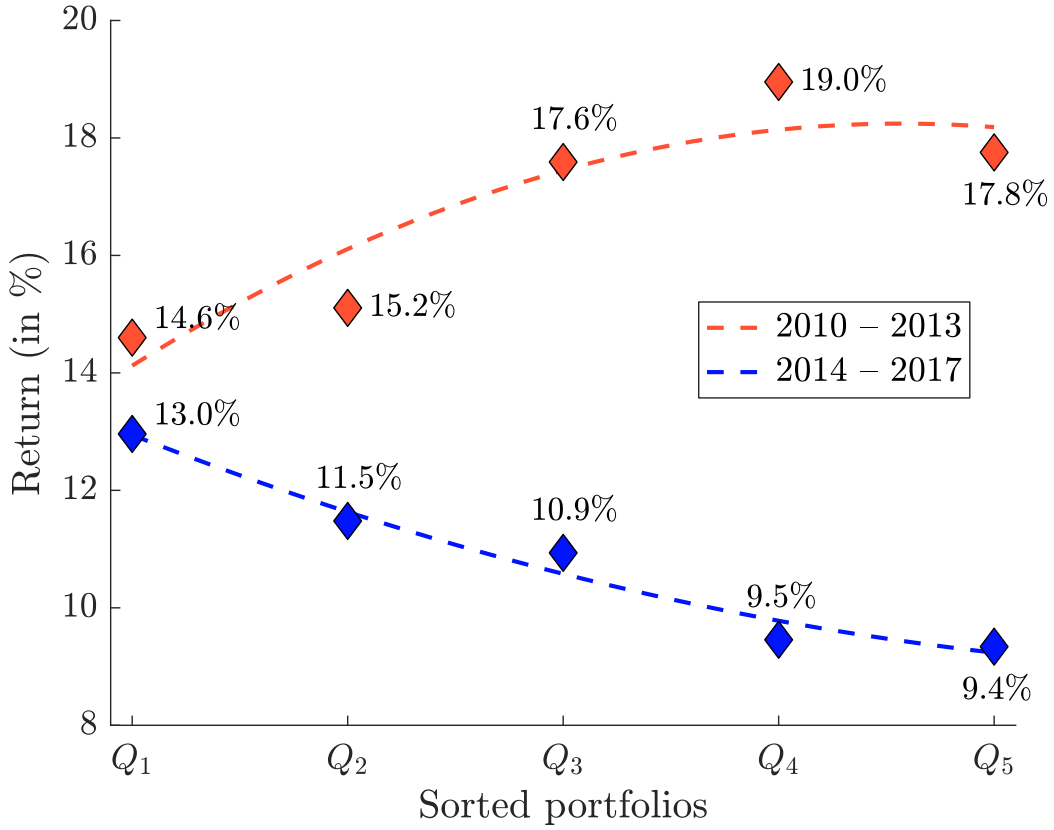


Figure 11: Annualized return of **ESG** sorted portfolios (North America)

Source: Amundi Quantitative Research (2018)

Performance of ESG active management (2010 – 2017)

Eurozone

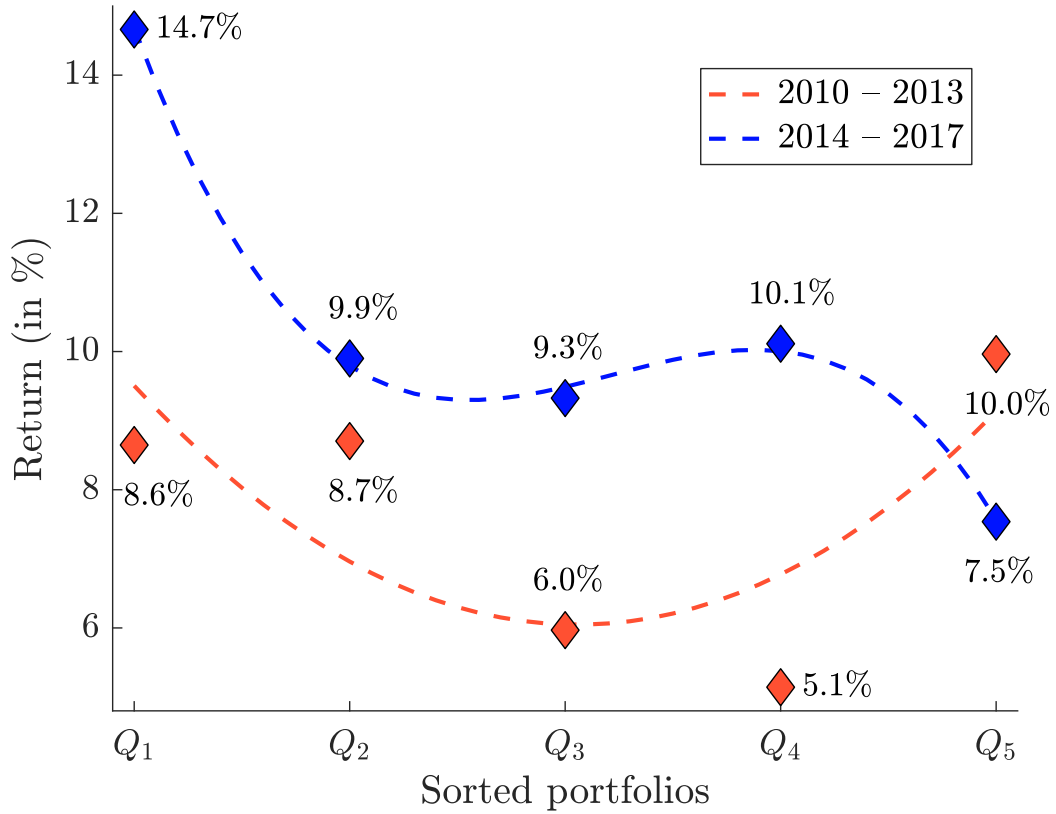


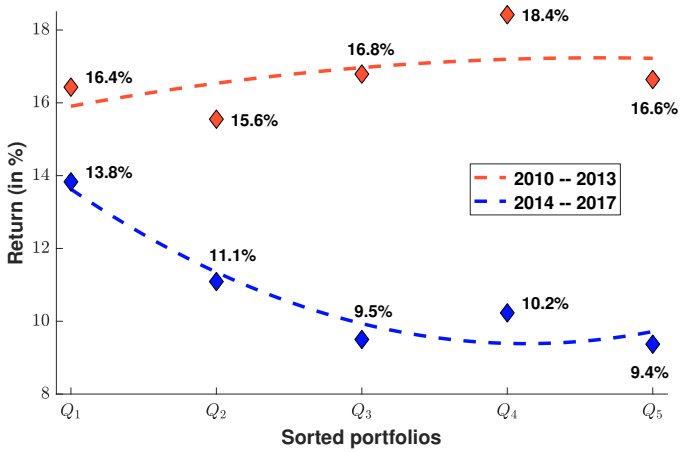
Figure 12: Annualized return of **ESG** sorted portfolios (Eurozone)

Source: Amundi Quantitative Research (2018)

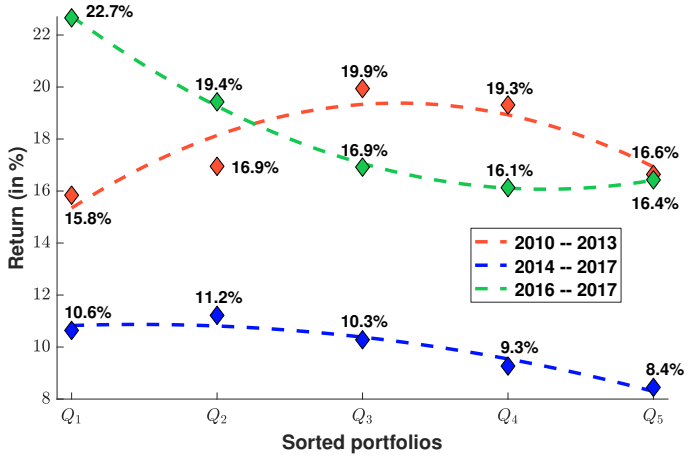
Performance of ESG active management (2010 – 2017)

North America

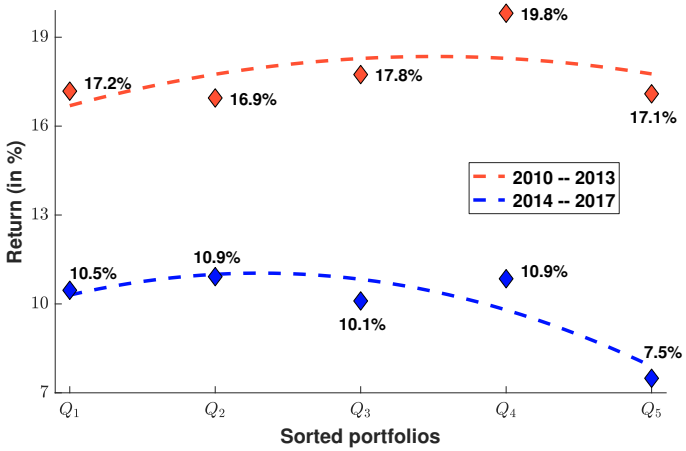
Environmental



Social



Governance

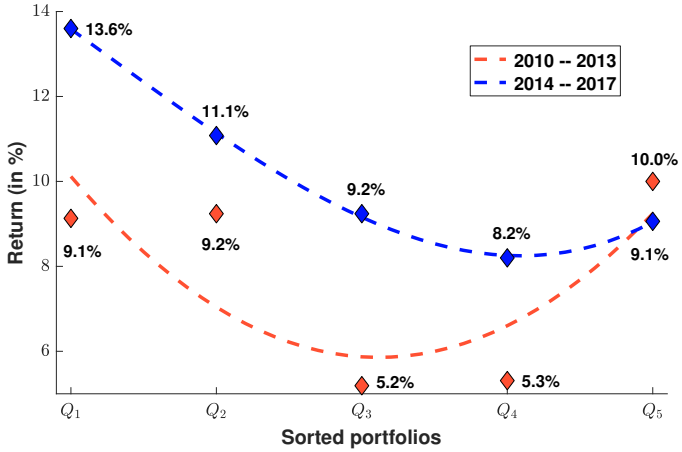


Source: Amundi Quantitative Research (2018)

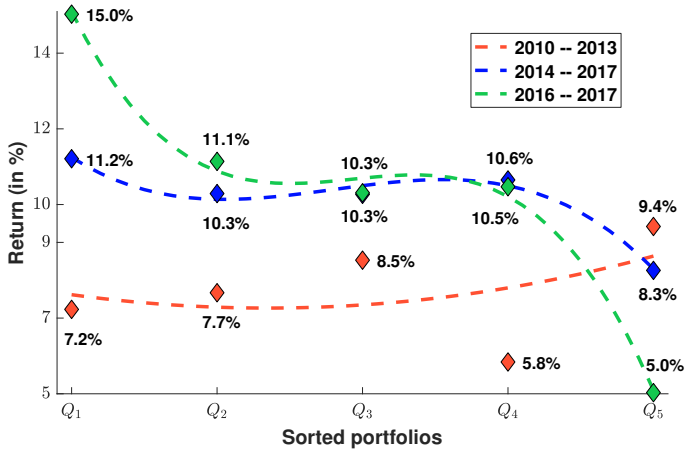
Performance of ESG active management (2010 – 2017)

Eurozone

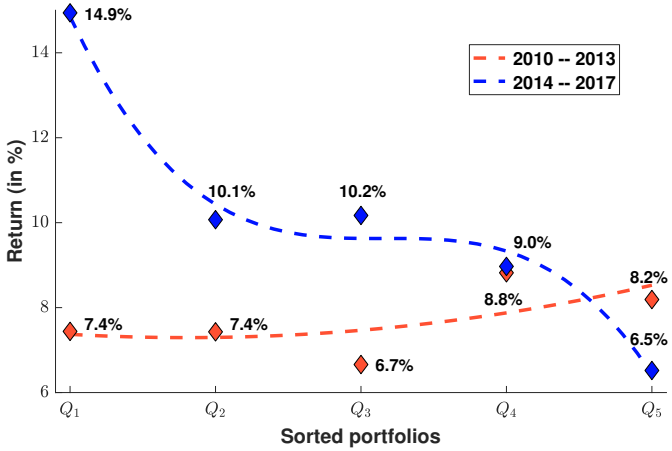
Environmental



Social



Governance



Source: Amundi Quantitative Research (2018)

Performance of ESG active management (2010 – 2017)

The 2014 break

Table 14: Summary of the results

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**	+	++

Source: Amundi Quantitative Research (2018)

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 $\Rightarrow$ Asset pricing

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

   Investment flows matter!

The steamroller of ESG for institutional investors

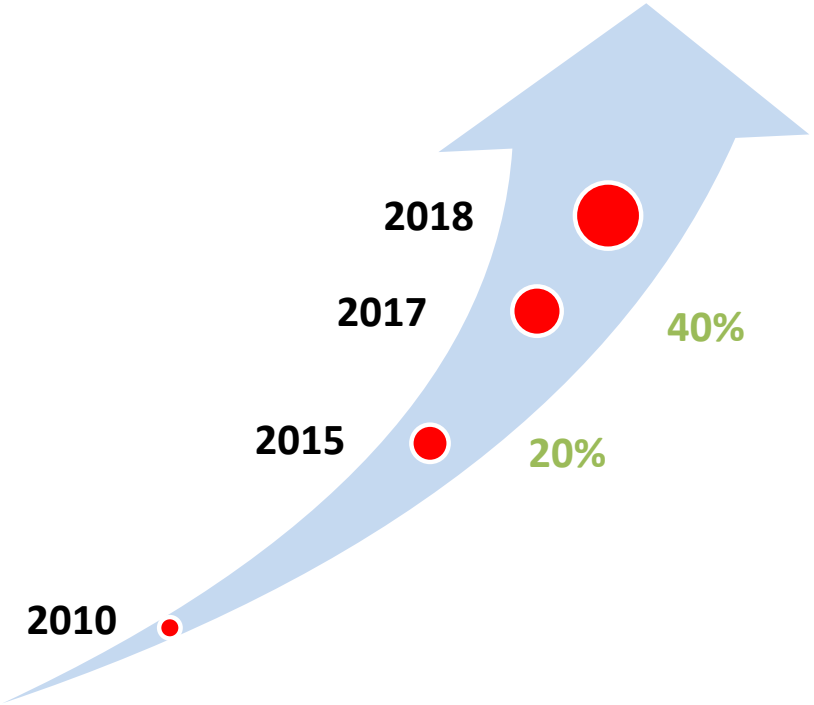


Figure 13: Frequency of institutional RFPs that require ESG filters

- 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)

Source: Based on RFPs received at Amundi.

Passive management (optimized portfolios)

Portfolio optimization with a benchmark

We consider the following optimization problem[2]:

$$x^\star(\gamma) = \arg\min \frac{1}{2}\sigma^2(x \mid b) - \gamma s(x \mid b)$$

where $\sigma(x \mid b)$ is the ex-ante tracking error (TE) of Portfolio x with respect to the benchmark b:

$$\sigma(x \mid b) = \sqrt{(x-b)^\top \Sigma (x-b)}$$

and $s(x \mid b)$ is the excess score (ES) of Portfolio x wrt the benchmark b:

$$\begin{aligned} s(x \mid b) &= (x-b)^\top s \\ &= s(x) - s(b) \end{aligned}$$

[2]We note b the benchmark, s the vector of scores and Σ the covariance matrix.

Passive management (optimized portfolios)

Portfolio optimization with a benchmark

The objective is to find the optimal portfolio with the minimum TE for a given ESG excess score

This is a standard γ-problem where the expected returns are replaced by the ESG scores

Performance of ESG passive management (2010-2017)

Arbitrage between ESG and TE

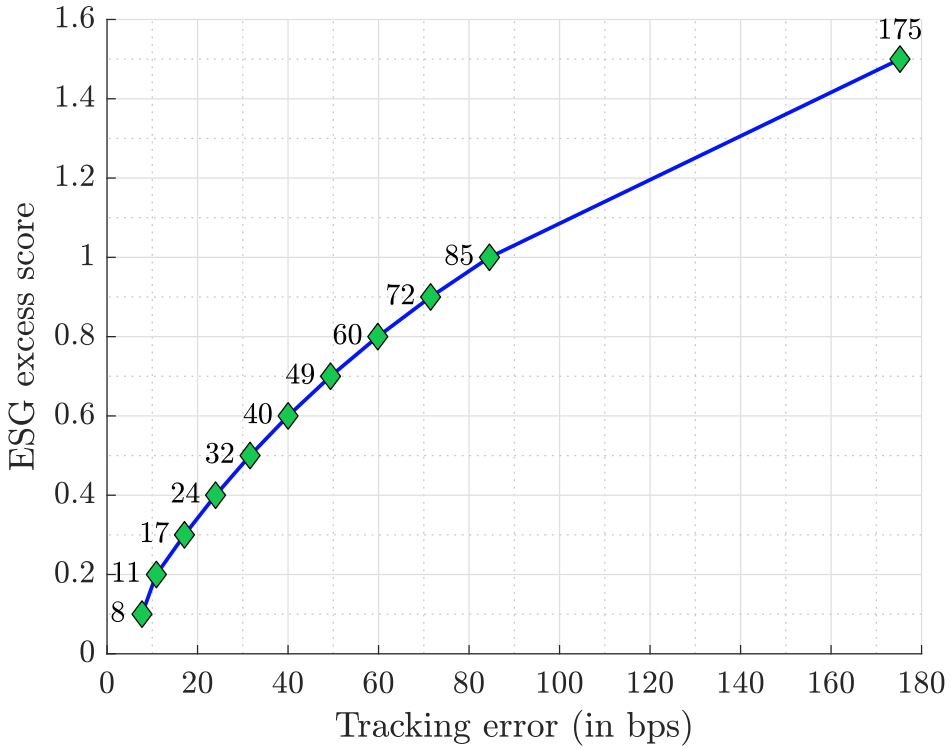


Figure 14: Efficient frontier of **ESG** optimized portfolios (World DM)

Source: Amundi Quantitative Research (2018)

No free lunch: **ESG investing implies to take a tracking-error risk!**

Performance of ESG passive management (2010-2017)

Performance of optimized portfolios

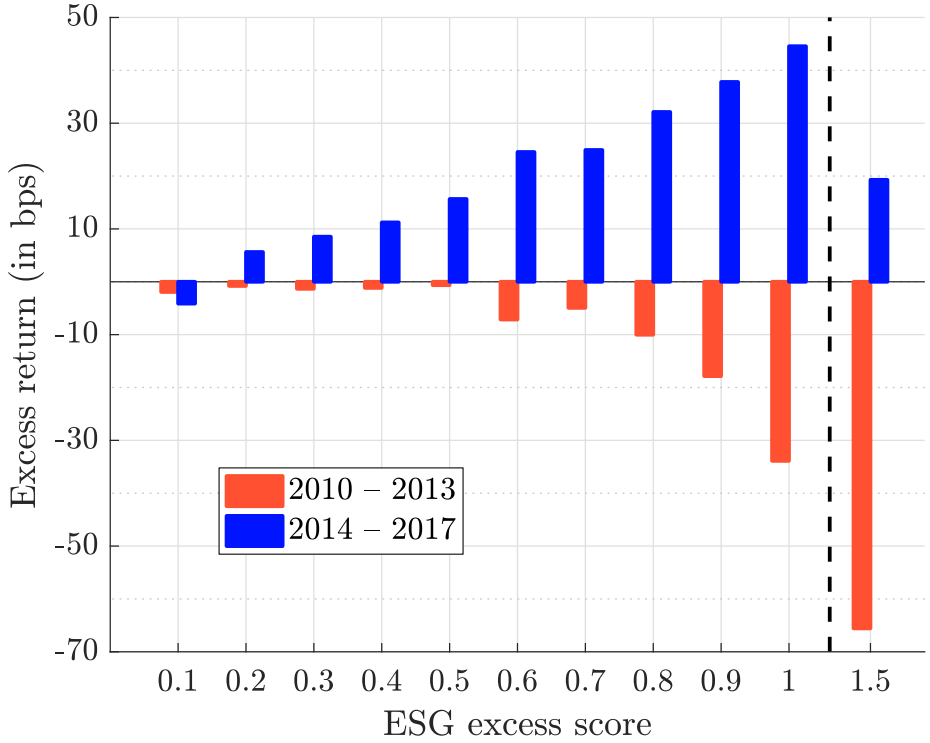


Figure 15: Annualized excess return of **ESG** optimized portfolios (World DM)

Source: Amundi Quantitative Research (2018)

ESG investing & diversification: **Mind the gap**

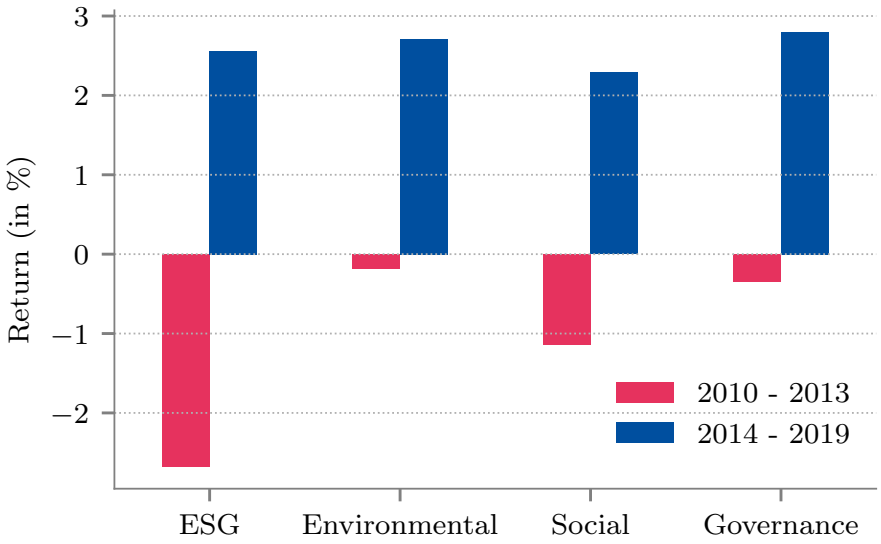
Performance of ESG active management (2018-2019)

On the road again

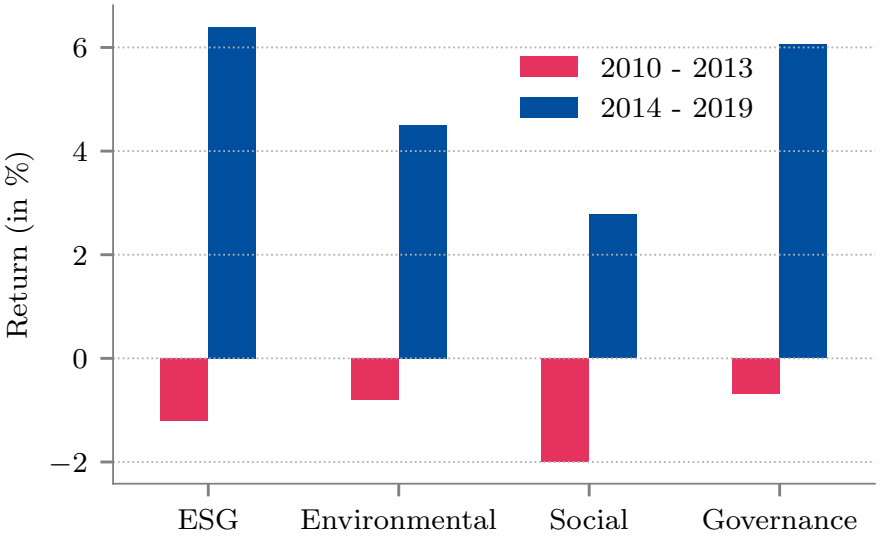
Main result

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

North America



Eurozone



Source: Amundi Quantitative Research (2020)

Performance of ESG active management (2018-2019)

New findings in the stock market

1. **The transatlantic divide**

   Eurozone $\succ$ North America

2. **Social: from laggard to leader**[3]

   S $\succ$ E, G

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

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

[3] 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**

Performance of ESG active management (2018-2019)

The transatlantic divide: the case of the Eurozone

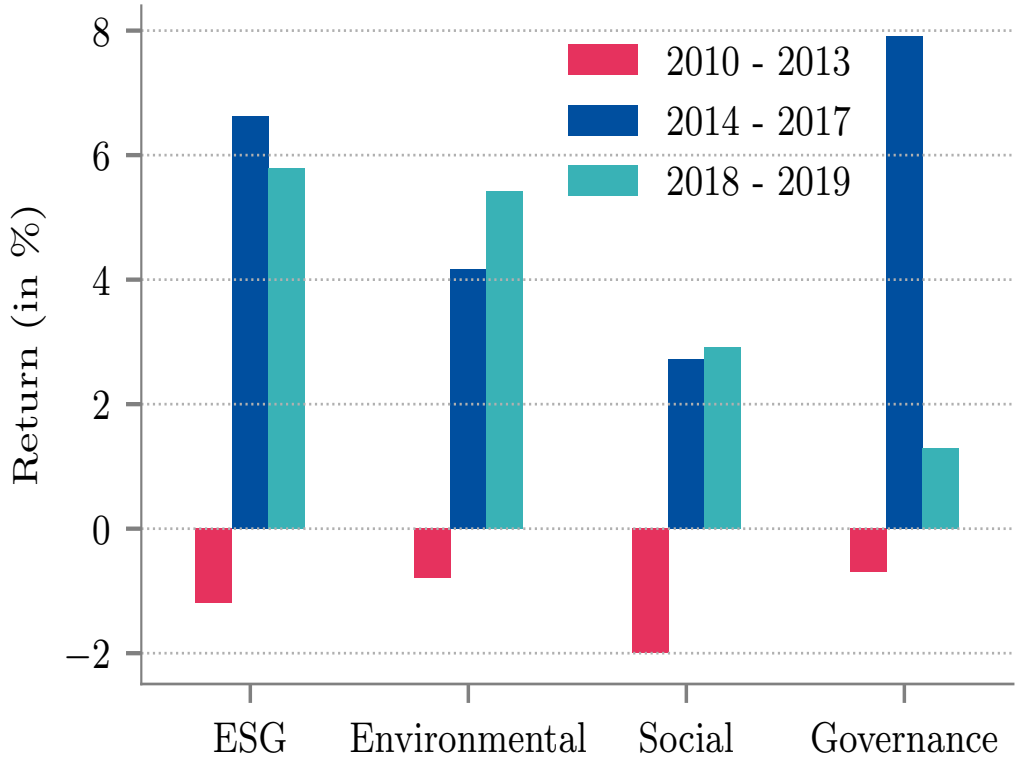


Figure 16: Annualized return of long/short $Q_1 - Q_5$ sorted portfolios

Source: Amundi Quantitative Research (2020)

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

Performance of ESG active management (2018-2019)

The transatlantic divide: the case of North America

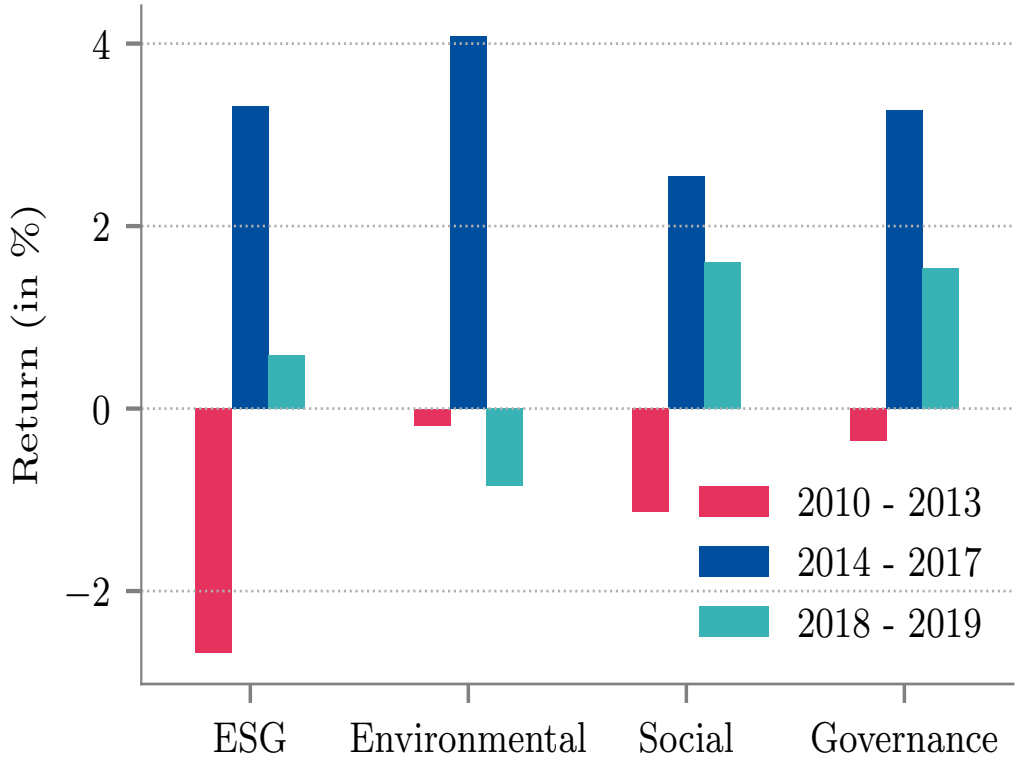


Figure 17: Annualized return of long/short $Q_1 - Q_5$ sorted portfolios

Source: Amundi Quantitative Research (2020)

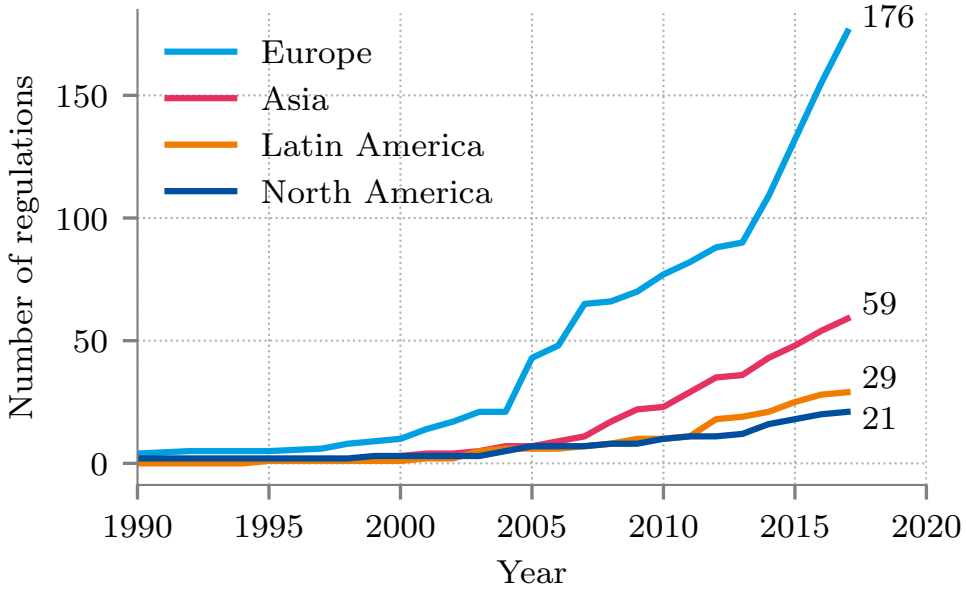
$\Rightarrow$ Performance is positive, but reduced for **S** and **G**, whereas **E** is negative

Performance of ESG active management (2018-2019)

How to explain the American setback?

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

- Trump election effect
- Regulatory environment



- ESG regulations are increasing, with a strong momentum in Europe but a weaker one in North America
- US withdrawal from Paris Climate Agreement

Figure 18: Number of ESG regulations

Source: PRI, responsible investment regulation database, 2019.

Performance of ESG active management (2018-2019)

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:
    $$\text{NBIM} \succ \text{CalPERS} + \text{CalSTRS} + \text{NYSCRF} \text{ for U.S. stocks}$$
- 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

Performance of ESG active management (2018-2019)

Social is strong in Eurozone

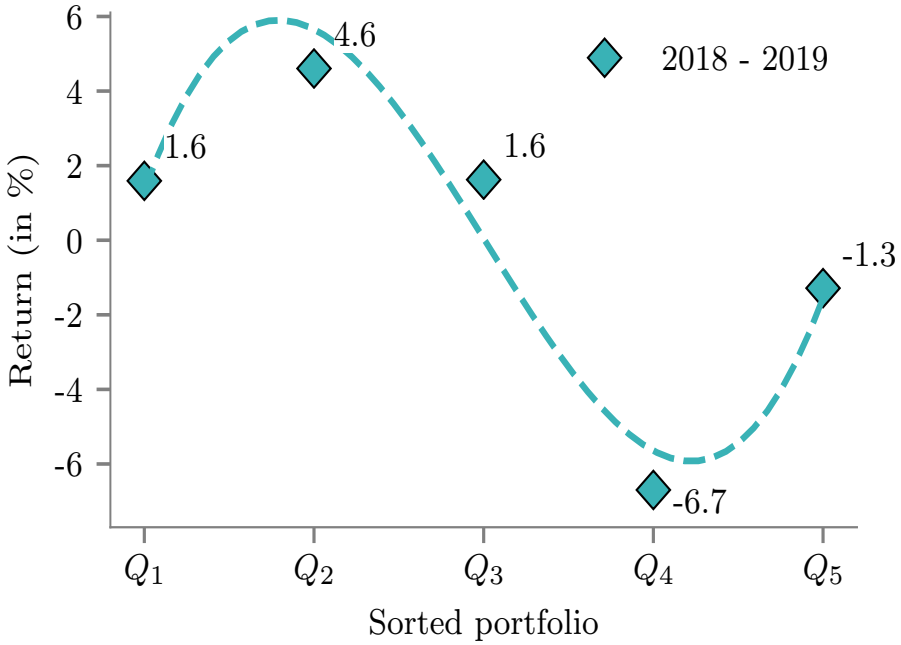


Figure 19: Sorted portfolios

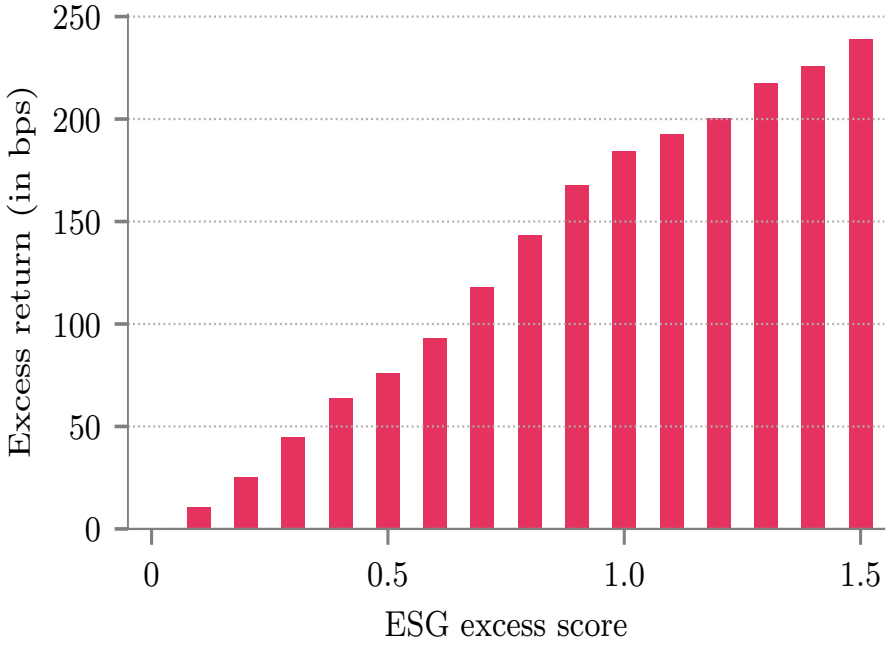


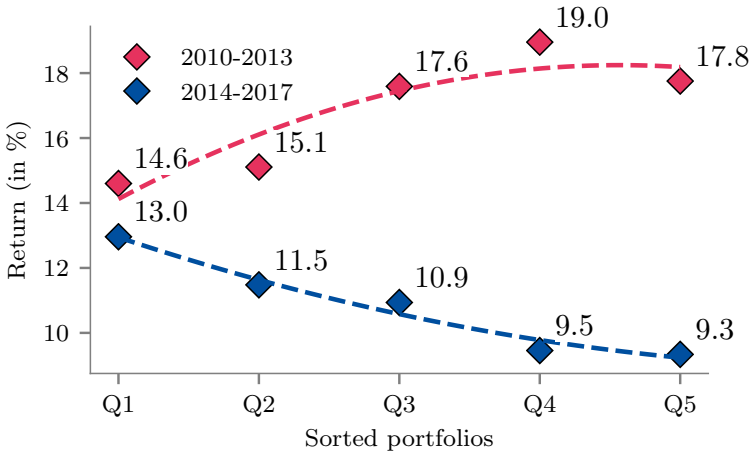
Figure 20: Optimized portfolios

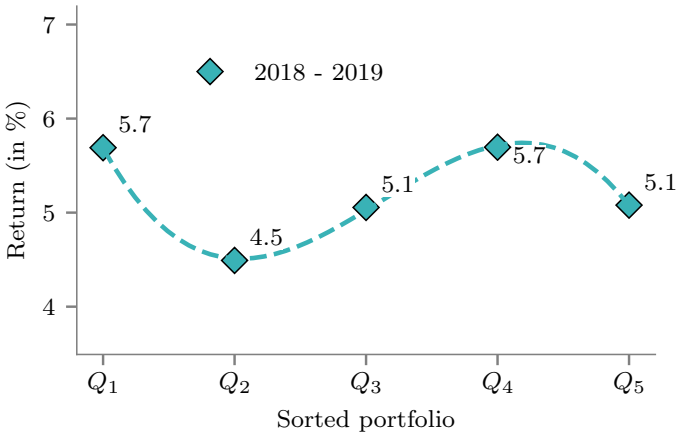
Source: Amundi Quantitative Research (2020)

Performance of ESG active management (2018-2019)

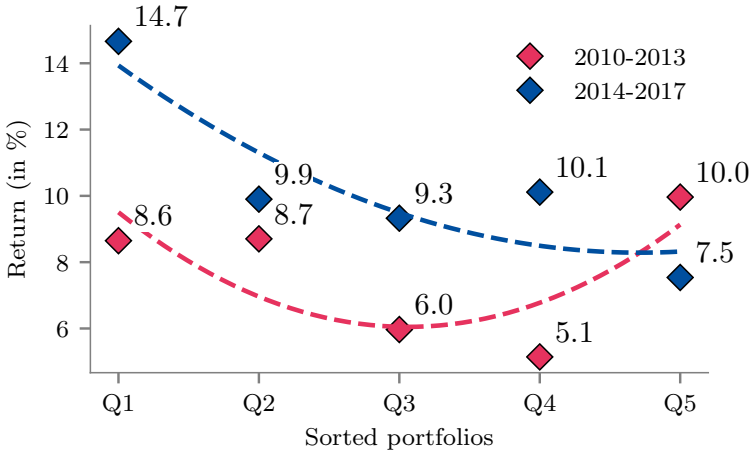
ESG investing: growing in complexity

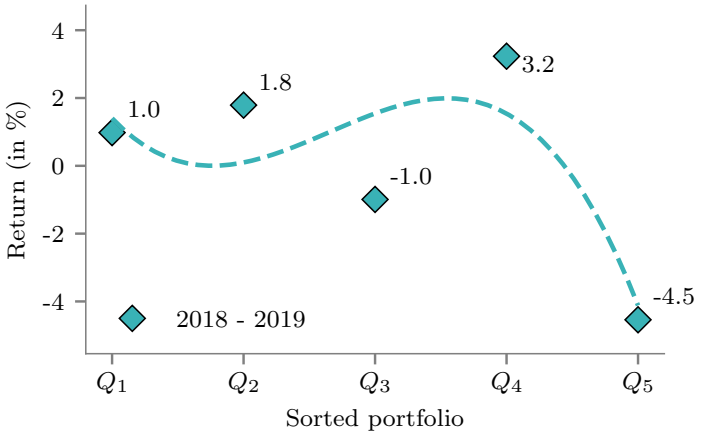
North America, **ESG**-Sorted portfolios, 2010 – 2019





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

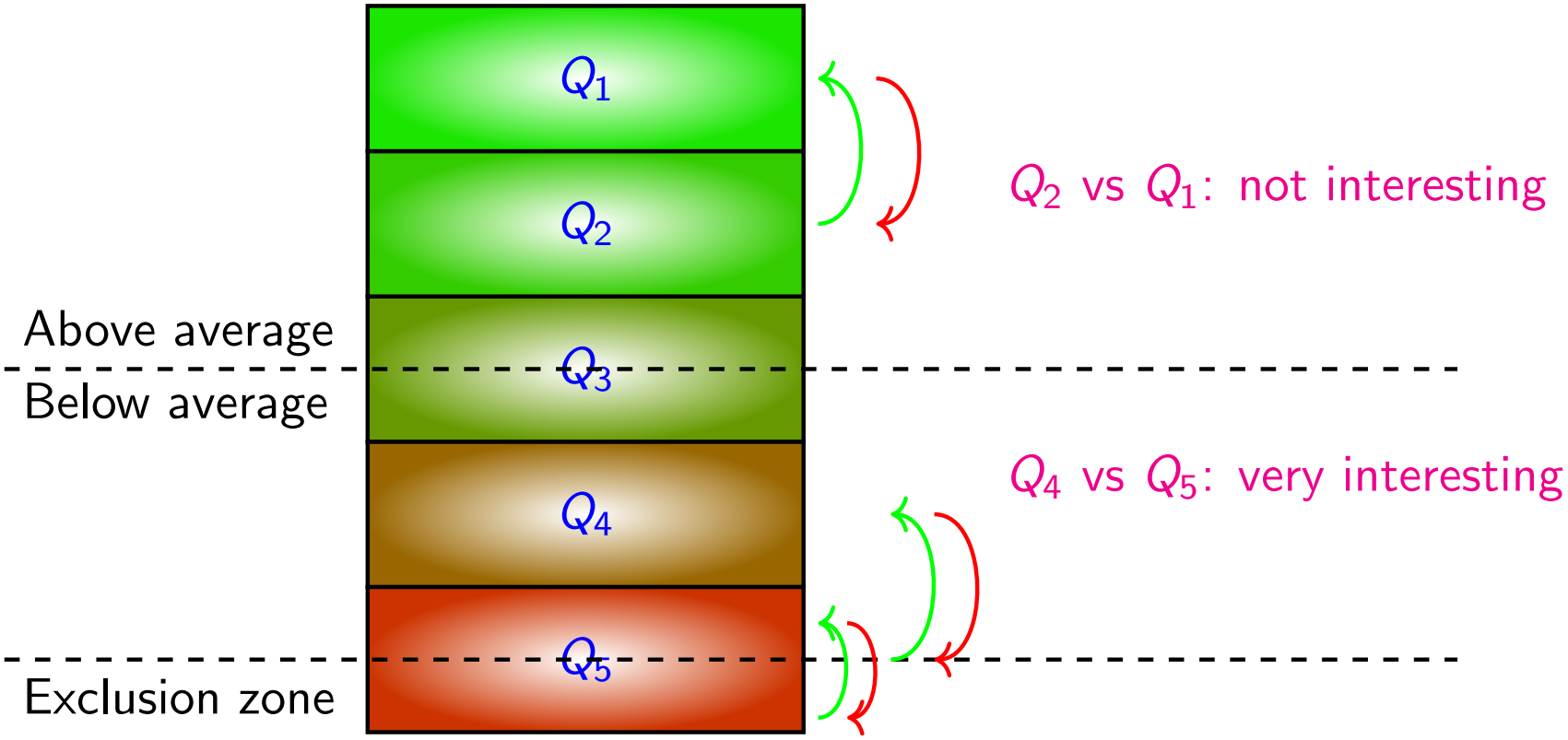




Performance of ESG active management (2018-2019)

The dynamic view of ESG investing

Figure 21: 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:

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

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

Single-factor model

Table 15: 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:

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

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

Multi-factor model

Table 16: Results of cross-section regressions with long-only risk factors (average R^2)

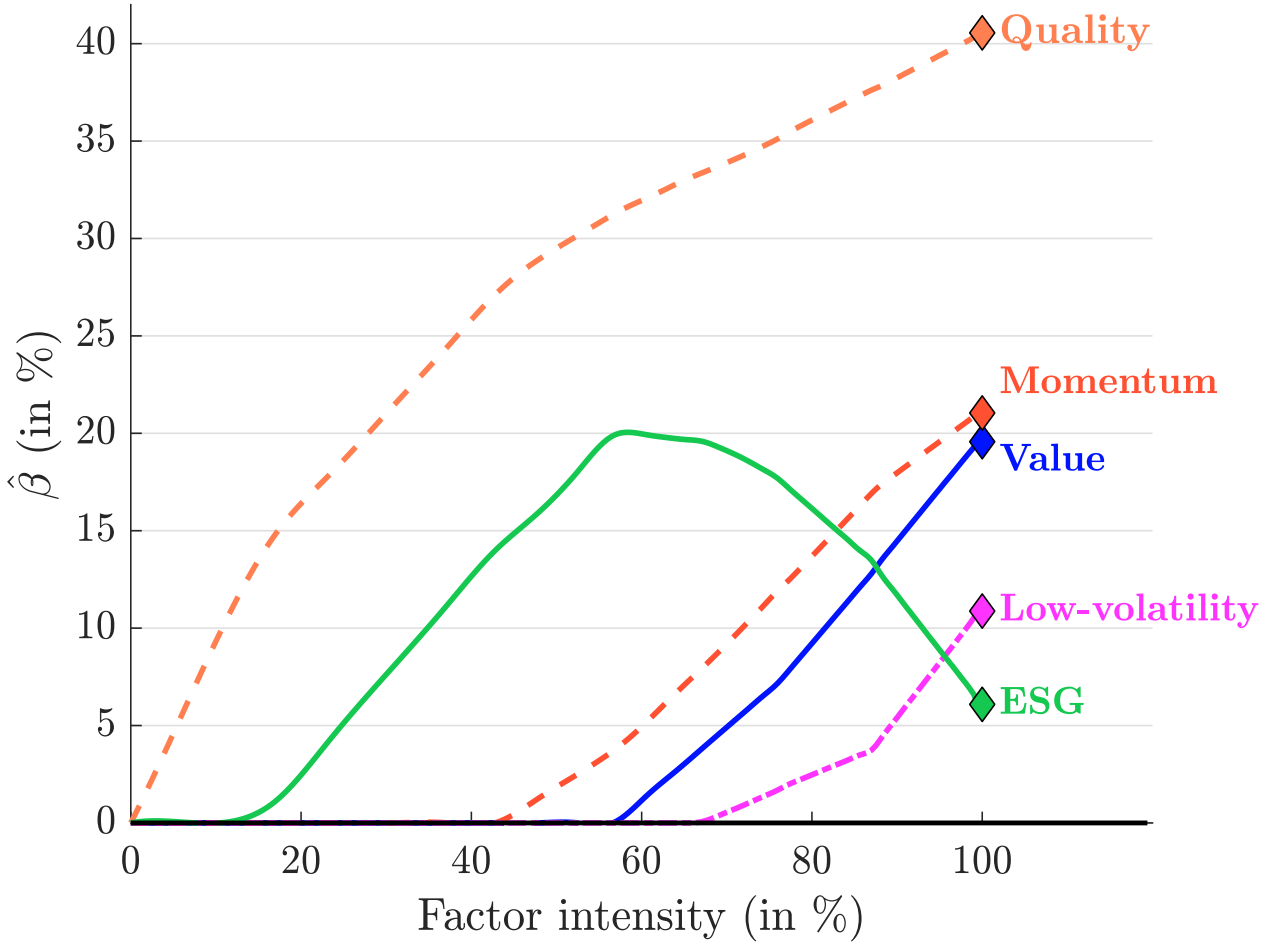
Factor	North America		Eurozone	
	2010 – 2013	2014 – 2019	2010 – 2013	2014 – 2019
Market	40.8%	28.6%	42.8%	36.3%
5F model	46.1%	38.4%	49.5%	45.0%
6F model (5F + ESG)	46.7%	39.7%	50.1%	45.8%

***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

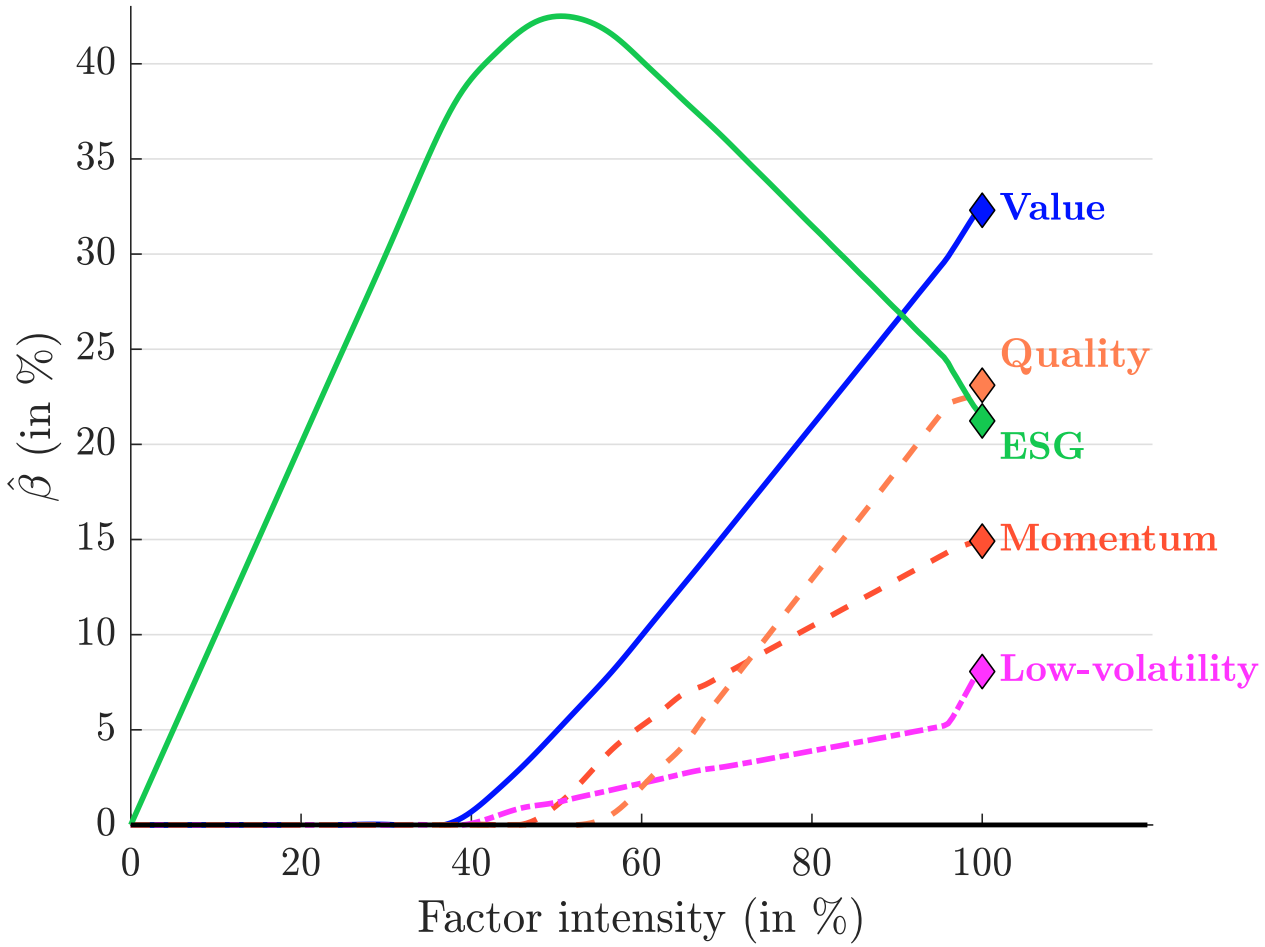
Figure 22: North America



Source: Amundi Quantitative Research (2020)

Factor selection

Figure 23: Eurozone



Source: Amundi Quantitative Research (2020)

What is the difference between alpha and beta?

α or β?

"[...] When an alpha strategy is massively invested, it has an enough impact on the structure of asset prices to become a risk factor.
[...] Indeed, an alpha strategy becomes a common market risk factor once it represents a significant part of investment portfolios and explains the cross-section dispersion of asset returns" (Roncalli, 2020)

- ESG remains an alpha strategy in North America
- ESG becomes a beta strategy (or a risk factor) in Europe
- Forward looking, ESG will be a beta strategy in North America

Is ESG a risk factor?

- Of course, **ESG is a risk factor that explains the cross-section of stock returns**
- ESG investing is correlated with Quality investing
- But ESG $\neq$ Value, Quality, Low volatility, etc.
  - The motivation of ESG Investing is not the performance
  - The motivation of Value or Quality Investing is the performance

$\Rightarrow$ Investment flows on ESG investing are more stable than investment flows on the other factors (in particular value, momentum and low volatility)

The question of the ESG risk premium is different from the question of the ESG risk factor

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 $\Rightarrow$ 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)

$\Rightarrow$ 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

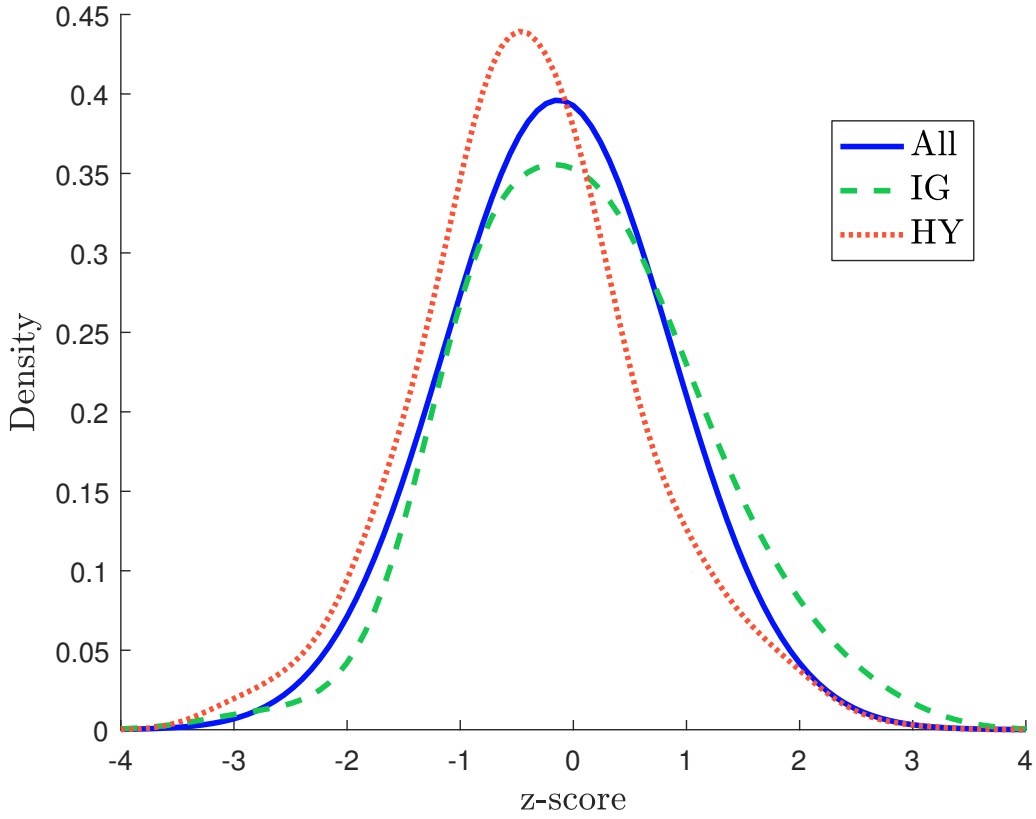
- Impact on carry (coupon effect)?
- Impact on price dynamics (credit spread/mark-to-market effect)?
- Buy-and-hold portfolios $\neq$ managed portfolios

The distinction between IG and HY bonds

- ESG and credit ratings are correlated
- There are more worst-in-class issuers in the HY universe, and best-in-class issuers in the IG universe
- Non-neutrality of the bond universe (bonds $\neq$ stocks)

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

Figure 24: Density function of the z-score



- The average z-score for IG bonds is positive
- The average z-score for HY bonds is negative

Sorted portfolio methodology

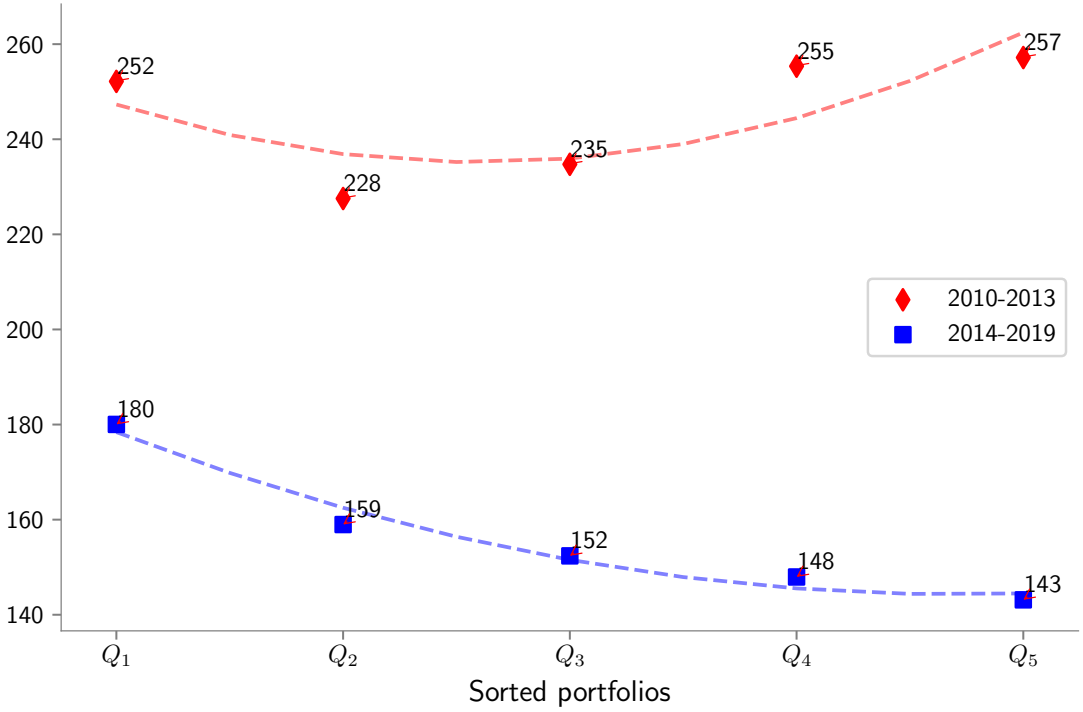
Sorted-portfolio approach

- 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

What is the performance of ESG investing?

Sorted portfolios

Figure 25: Annualized credit return in bps of **ESG** sorted portfolios (EUR IG, 2010 – 2019)



Source: Amundi Quantitative Research (2020)

Table 17: 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)

Bond portfolio optimization

We consider the following optimization problem:

$$x^\star(\gamma) = \arg\min \mathcal{R}(x \mid b) - \gamma \cdot \mathcal{S}(x \mid b)$$

where:

$$\mathcal{R}(x \mid b) = \frac{1}{2}\mathcal{R}_{\text{MD}}(x \mid b) + \frac{1}{2}\mathcal{R}_{\text{DTS}}(x \mid b)$$

and:

- $\mathcal{R}_{\text{MD}}(x \mid b)$ and $\mathcal{R}_{\text{DTS}}(x \mid b)$ are the interest rate and credit **active risk** measures wrt the benchmark b
- $\mathcal{S}(x \mid b)$ is the ESG excess score of Portfolio x wrt the benchmark b

The objective is to find the optimal portfolio minimizing interest rate and credit active risk for a given ESG excess score

What is the performance of ESG investing?

Optimized portfolios

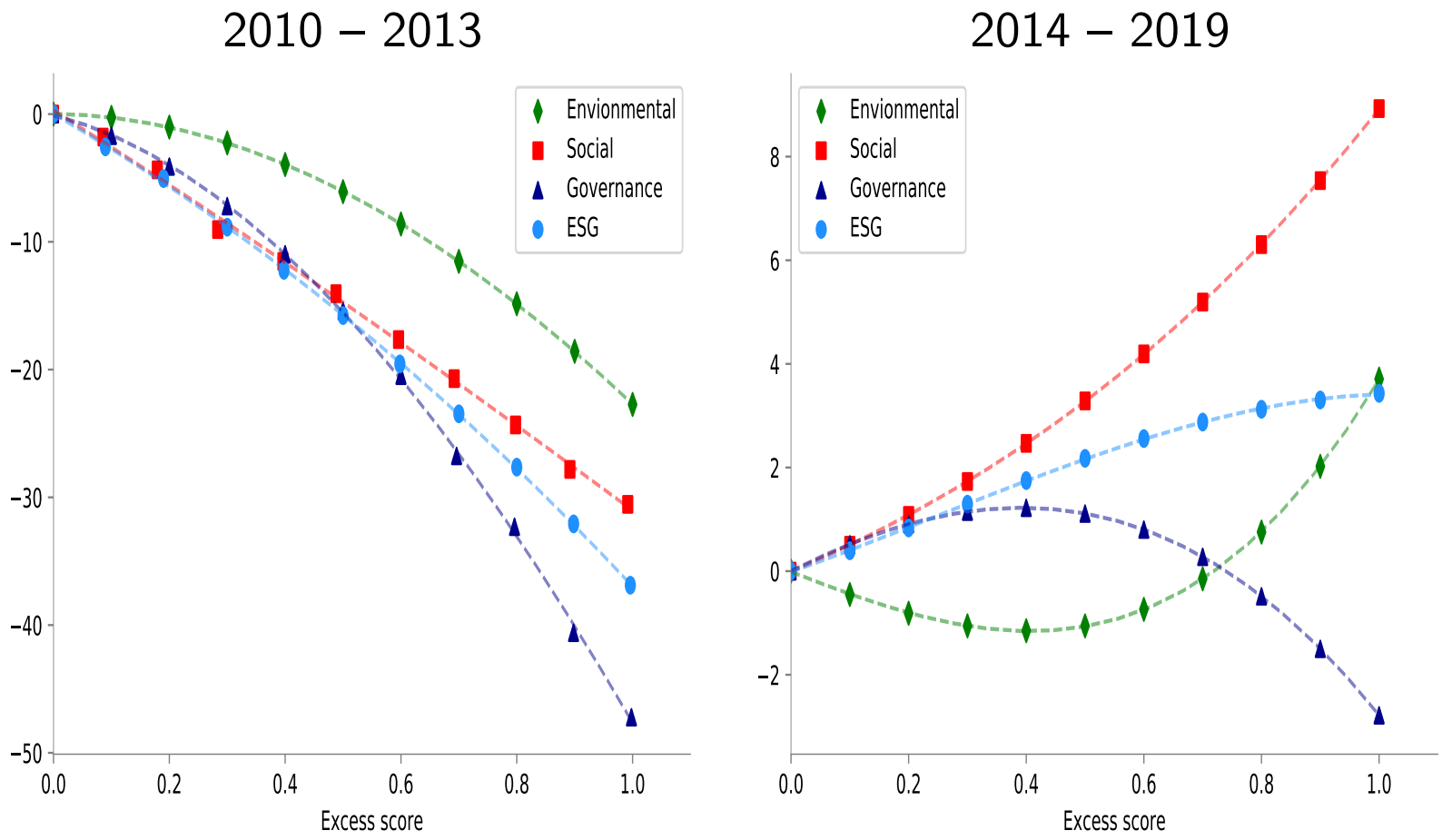


Figure 26: Excess credit return in bps of optimized portfolios (EUR IG)

Source: Amundi Quantitative Research (2020)

What is the performance of ESG investing?

Optimized portfolios

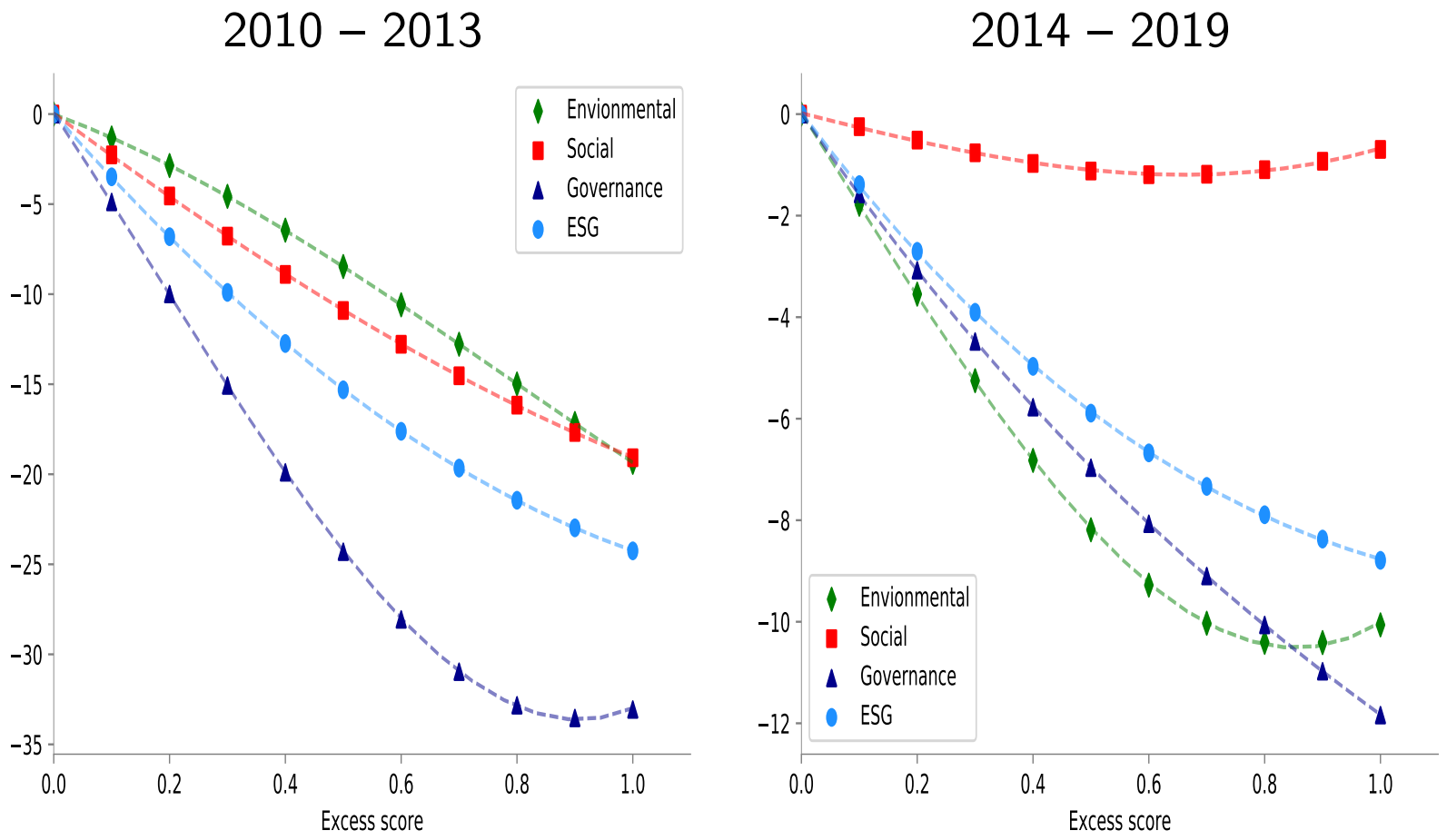


Figure 27: Excess credit return in bps of optimized portfolios (USD IG)

Source: Amundi Quantitative Research (2020)

Correlation between Credit ratings and ESG ratings

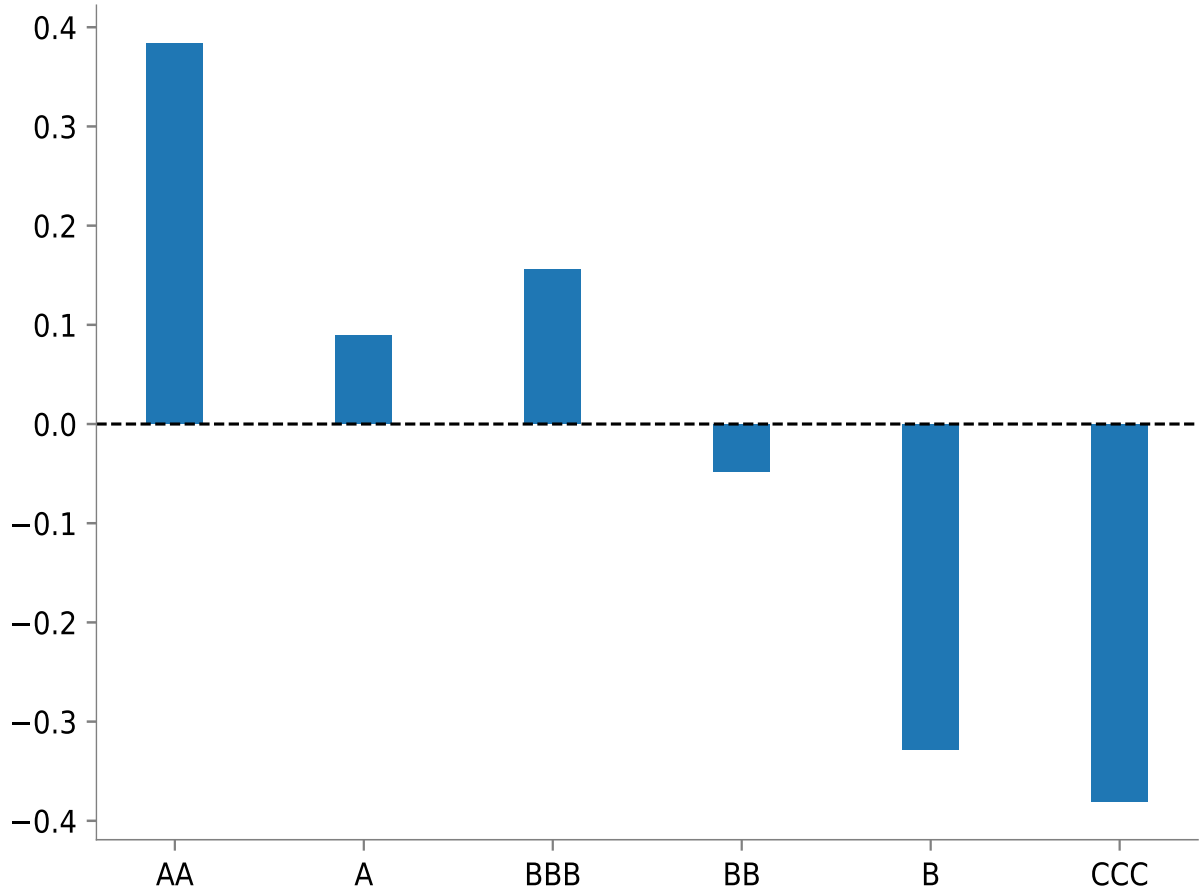


Figure 28: Average **ESG** z-score with respect to the credit rating (2010 – 2019)

Source: Amundi Quantitative Research (2020)

An integrated Credit-ESG model

We consider the following regression model:

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

where:

- $\mathcal{S}_{i,t}$ 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
- $\mathcal{S}ector_{i,t}(j)$ is a dummy variable for the j^{th} sector
- $\mathcal{R}ating_{i,t}(k)$ is a dummy variable for the k^{th} rating

An integrated Credit-ESG model

Table 18: 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

Source: Amundi Quantitative Research (2020)

The assumption $\mathcal{H}_0 : \beta_{esg} < 0$ 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 19: **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**

Source: Amundi Quantitative Research (2020)

ESG and sovereign risk

References

- Crifo, P., Diaye, M.A., and Oueghlissi, R. (2015), Measuring the Effect of Government ESG Performance on Sovereign Borrowing Cost, *Quarterly Review of Economics and Finance*, `hal.archives-ouvertes.fr/hal-00951304v3`
- Martellini, L., and Vallée, L. (2021), Measuring and Managing ESG Risks in Sovereign Bond Portfolios and Implications for Sovereign Debt Investing, *Journal of Portfolio Management*, `www.risk.edhec.edu/measuring-and-managing-esg-risks-sovereign-bond`
- Semet, R., Roncalli, T., and Stagnol, L. (2021), ESG and Sovereign Risk: What is Priced in by the Bond Market and Credit Rating Agencies?, *Working Paper*, `www.ssrn.com/abstract=3940945`

$\Rightarrow$ We present the results of Semet *et al.* (2021)

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 in by the market?
- What is the nexus between ESG analysis and credit analysis?

The economics of sovereign risk

A Tale of Two Countries

- Henry, P.B., and Miller, C. (2009), Institutions versus Policies: A Tale of Two Islands, *American Economic Review*, 99(2), pp. 261-267.
- The example of Barbados and Jamaica
- Why the economic growth of two countries with the same economic development at time t is different 10, 20 or 30 years later?

Sovereign ESG themes

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**

The economics of sovereign risk

Assessment of a country's creditworthiness

- Confidence in the country? Only financial reasons?
- Mellios, C., and Paget-Blanc, E. (2006), Which Factors Determine Sovereign Credit Ratings?, *European Journal of Finance*, 12(4), pp. 361-377 $\Rightarrow$ credit ratings are correlated to the corruption perception index
- Country default risk cannot be summarized by only financial figures!
- Why some rich countries have to pay a credit risk premium?
- How to explain the large differences in Asia?

ESG and sovereign risk

Summary of the results

What is directly priced in by the bond market?		What is indirectly priced in by credit rating agencies?
E ≻ G ≻ S		G ≻ S ≻ E
Significant market-based ESG indicators	≠	Relevant CRA-based ESG indicators
High-income countries ⇒ Transition risk ≻ Physical risk, Middle-income countries ⇒ Physical risk ≻ Transition risk, S only matters for middle-income countries		Government effectiveness, Business environment and R&D for the G pillar, Education, Demographic and Human rights for the S pillar
Fundamental analysis: $\mathfrak{R}_c^2 \approx 70\%$ Extra-financial analysis: $\Delta\mathfrak{R}_c^2 \approx 13.5\%$		Accuracy $> 95\%$ Good and Bad ratings ≻ XO ratings

Single-factor analysis
Data

Endogenous variable

10Y sovereign bond yield

Explanatory variables

- 269 ESG variables grouped into 26 ESG thematics
- 183 indicators come from Verisk Maplecrof database, the 86 remaining metrics were retrieved from the World Bank, ILO, WHO, FAO, UN...
- 6 control variables: GDP Growth, Net Debt, Reserves, Account Balance, Inflation and **Credit Rating**

Panel dimensions

- 67 countries
- 2015–2020

Single-factor analysis

Regression model

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

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

and:

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

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 $\mathcal{R}_{i,t}$ is the credit rating

Single-factor analysis
Results

Table 20: 7 most relevant indicators of the single-factor analysis per pillar

Pillar	Thematic	Indicator	$\Delta\mathfrak{R}_c^2$	F-test	Rank
	Climate change	Climate change vulnerability (acute)	5.51%	57.19	1
	Climate change	Climate change exposure (extreme)	4.80%	48.60	2
	Water management	Agricultural water withdrawal	4.02%	47.10	3
E	Climate change	Climate change sensitivity (acute)	3.95%	38.79	4
	Biodiversity	Biodiversity threatening score	3.53%	35.32	5
	Climate change	Climate change exposure (acute)	3.39%	32.95	6
	Climate change	Climate change vulnerability (average)	3.11%	31.16	7
	Human rights	Freedom of assembly	8.74%	89.58	1
	Human rights	Extent of arbitrary unrest	8.04%	80.10	2
	Human rights	Extent of torture and ill treatment	7.63%	75.48	3
S	Labour market standards	Severity of working time violations	7.21%	70.46	4
	Labour market standards	Forced labour violations (extent)	6.10%	54.40	5
	Labour market standards	Child labour (extent)	5.83%	54.68	6
	Migration	Vulnerability of migrant workers	5.83%	53.76	7
	National security	Severity of kidnappings	6.80%	64.49	1
	Business environment and R&D	Ease of access to loans	6.77%	73.57	2
	Infrastructure and mobility	Roads km	6.45%	63.66	3
G	Business environment and R&D	Capacity for innovation	5.65%	58.58	4
	Business environment and R&D	Ethical behaviour of firms	5.37%	55.14	5
	National security	Frequency of kidnappings	5.27%	48.49	6
	Infrastructure and mobility	Physical connectivity	4.94%	50.76	7

Single-factor analysis
Results

Table 21: 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

Regression model

We consider the following multi-factor regression model:

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

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 (correlation greater than 80%) in each ESG theme
3. We perform a lasso regression to retain the seven most relevant variables within each ESG pillar
4. We perform a multi-factor analysis: (a) Lasso estimation to rank the seven E, S and G variables ($m = 21$) and (b) Panel estimation to estimate the final model ($m = 7$)

Multi-factor analysis

The collinearity issue

Table 22: Example of variables exhibiting high correlations

Variable	$\Delta\mathfrak{R}_c^2$	Correlation$_{i,j}$					
Climate change exposure (average)	2.12%	1.00	0.74	0.80	0.48	**0.92**	0.77
Climate change exposure (acute)	3.89%	0.74	1.00	0.65	0.51	0.73	**0.89**
Climate change exposure (extreme)	4.80%	**0.80**	0.65	1.00	0.54	0.79	0.71
Climate change sensitivty (average)	3.95%	0.48	0.51	0.54	1.00	0.76	**0.81**
Climate change vulnerability (average)	3.11%	**0.92**	0.73	0.79	0.76	1.00	0.89
Climate change vulnerability (acute)	5.51%	0.77	0.89	0.71	0.81	**0.89**	1.00

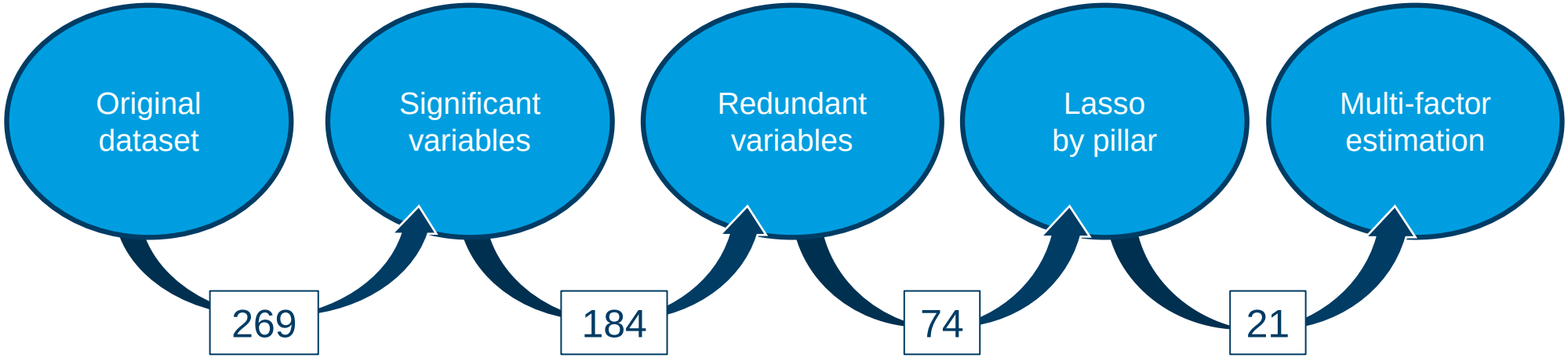
Selecting the variables

1. For each variable, we identify the highest pairwise correlation
2. Among each couple, we retain the variable showing the highest $\Delta\mathfrak{R}_c^2$
3. Among these variables, we select the variable with the lowest correlation

Multi-factor analysis

The collinearity issue

Figure 29: Filtering process



Multi-factor analysis

Results

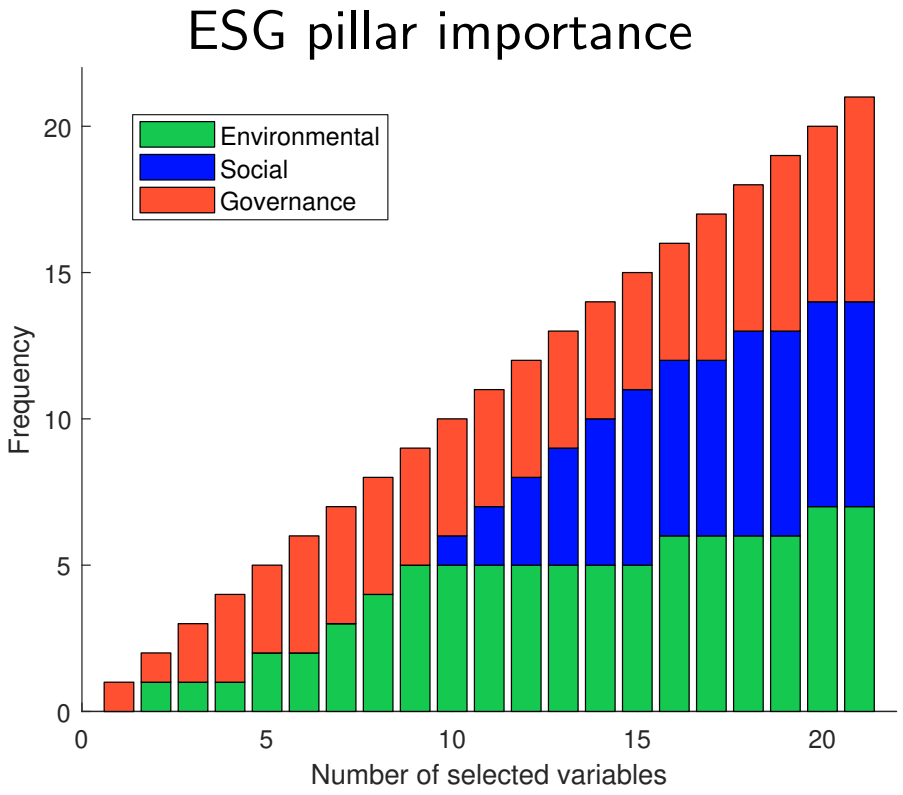
Table 23: Results after Step 3 : Lasso regression pillar by pillar

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 - Lasso regression on the three pillars

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

Global analysis

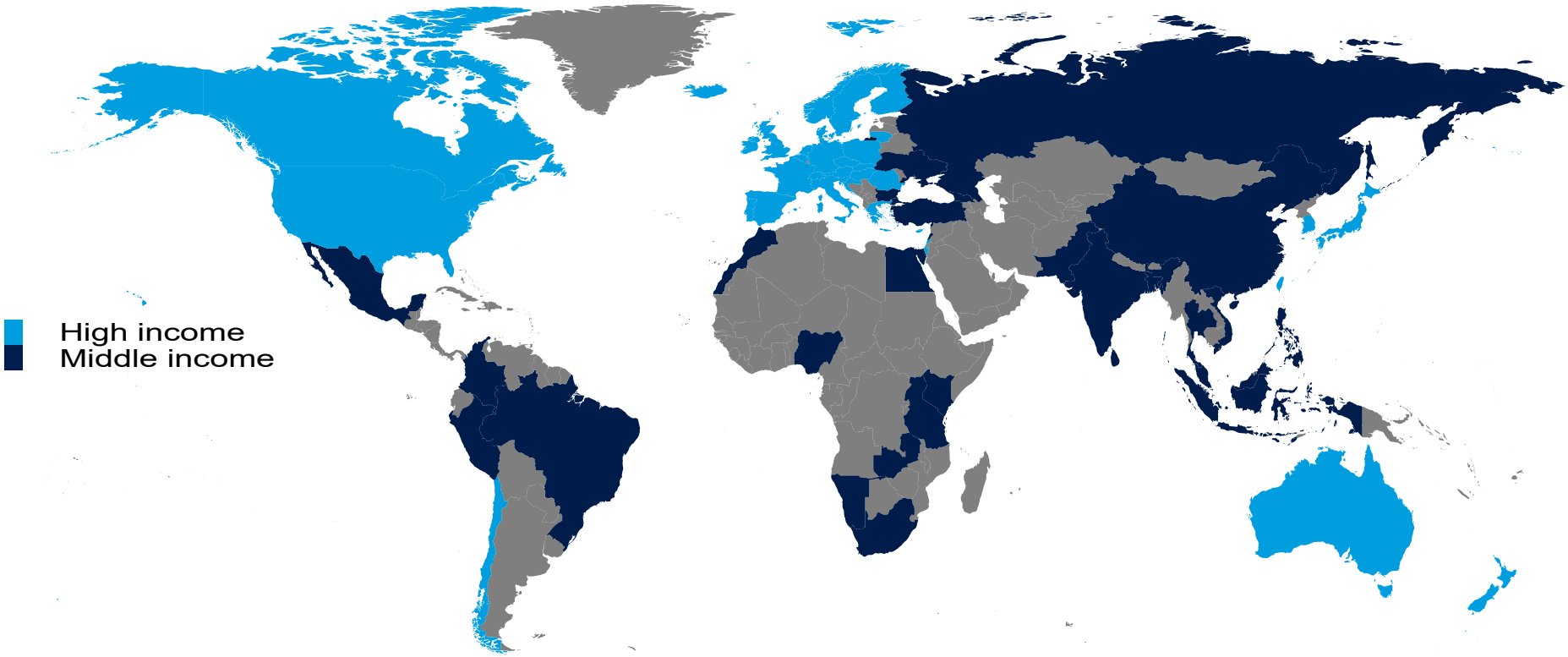
Table 24: Final multi-factor model

	Variable	$\hat{\beta}$	$\hat{\sigma}\left(\hat{\beta}\right)$	t-student	p-value
Financial	Intercept α	2.834	0.180	15.72^{***}	0.00
	GDP growth $g_{i,t}$	0.017	0.012	1.37	0.17
	Inflation $\pi_{i,t}$	0.048	0.007	6.64^{***}	0.00
	Debt ratio $d_{i,t}$	-0.001	0.001	-1.71^{*}	0.08
	Current account balance $ca_{i,t}$	-0.012	0.005	-2.45^{**}	0.01
	Reserve adequacy $r_{i,t}$	0.005	0.007	0.74	0.45
	Rating score $\mathcal{R}_{i,t}$	-0.013	0.001	-9.08^{***}	0.00
Extra-financial	Exporting across borders (cost)	$4.05e^{-04}$	$9.83e^{-05}$	4.11^{***}	0.00
	Severe storm hazard (absolute high extreme)	-0.015	0.009	-1.66^{*}	0.09
	Capacity for innovation	-0.004	0.001	-4.99^{***}	0.00
	Ethical behavior of firms	-0.061	0.021	-2.79^{***}	0.00
	Temperature change	-0.149	0.042	-3.50^{***}	0.00
	Severity of kidnappings	-0.032	0.007	-4.25^{***}	0.00
	Drought hazard (absolute high extreme)	$3.33e^{-08}$	$1.27e^{-08}$	2.60^{***}	0.00

$\Delta\mathfrak{R}^2_c = 13.51\%$, F-test $= 29.28^{***}$

Multi-factor analysis

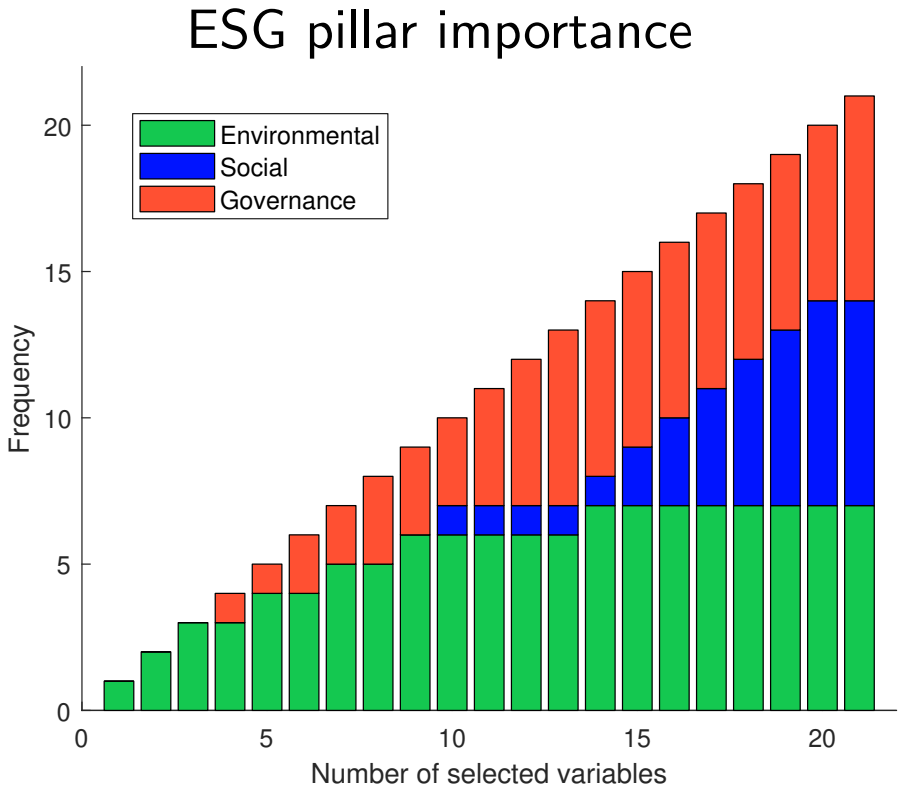
High income vs middle income countries



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

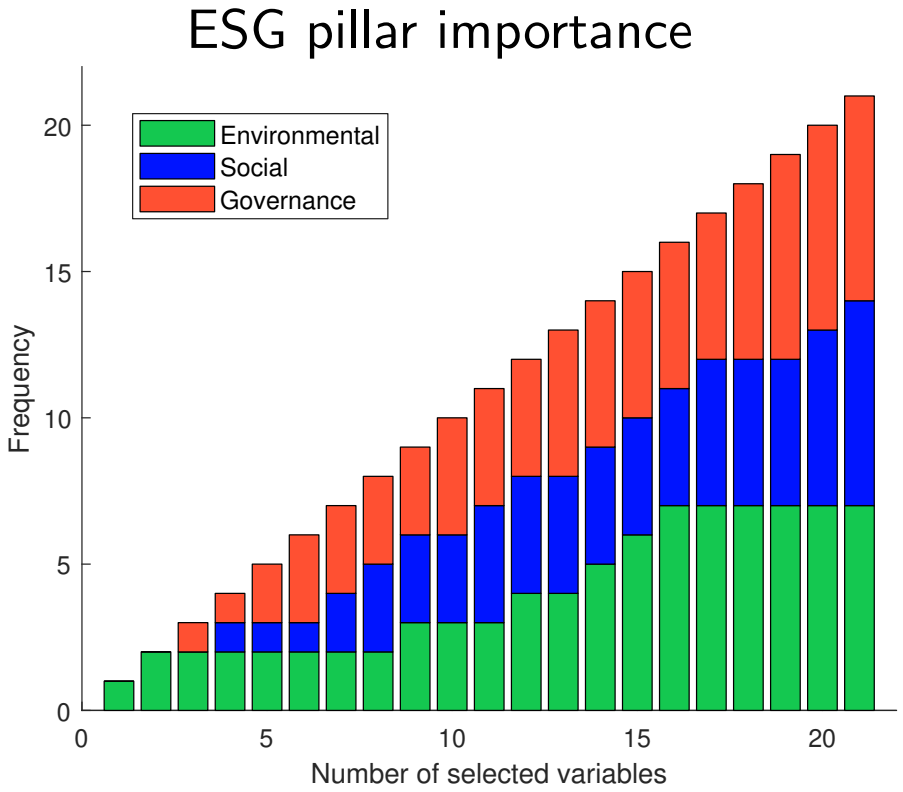


- Transition risk
- S is lagging

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
- Social issues are priced

Explaining credit ratings with ESG metrics

Statistical framework

We consider the logit model:

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

where:

- $\mathcal{G}_{i,t} = 1$ indicates if the country i is rated upper grade at time t
  - If the rating $\succeq$ A then $\mathcal{G}_{i,t} = 1$
  - if the rating $\preceq$ BBB then $\mathcal{G}_{i,t} = 0$
- $\mathbf{F}(z)$ 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

Lasso-penalized logit regression

Again, we perform a lasso regression to retain the seven most relevant variables for each ESG pillar and then we perform a multi-factor analysis

Explaining credit ratings with ESG metrics

Lasso selection process

Table 25: 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
Demographics	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 26: 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

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

Explaining credit ratings with ESG metrics

S pillar

Table 27: 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

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

Explaining credit ratings with ESG metrics

G pillar

Table 28: 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

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

Explaining credit ratings with ESG metrics

E, S and G pillars

Table 29: 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

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

Explaining credit ratings with ESG metrics

Prediction accuracy of credit ratings

Table 30: Summary of the results

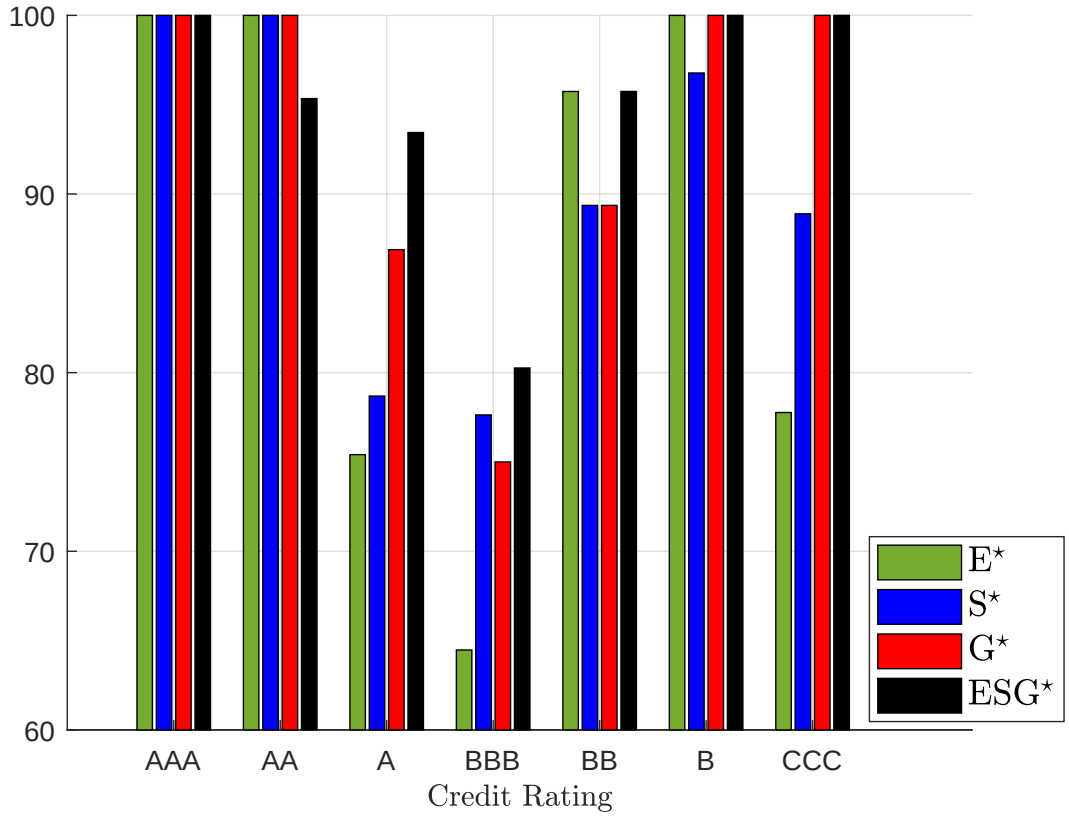
	***	$\mathfrak{R}^2$	Accuracy	Sensitivity	Specificity	AIC
E*	4	48.02%	84.97%	86.90%	83.23%	230.04
S*	7	65.60%	87.90%	88.80%	86.90%	160.83
G*	4	67.70%	89.54%	91.72%	87.58%	150.65
ESG*	7	79.02%	92.50%	93.80%	91.30%	104.80

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

Explaining credit ratings with ESG metrics

Prediction accuracy of credit ratings

Figure 30: Prediction accuracy (in %) of credit ratings



	Rating	Probabilty range
Upper-grade	AAA	83% – 100%
	AA	67% – 82%
	A	50% – 66%
Lower-grade	BBB	39% – 49%
	BB	29% – 38%
	B	11% – 28%
	C	0% – 10%

ESG and sovereign risk

Summary of the results

What is directly priced by the bond market?		What is indirectly priced by credit rating agencies?
E ≻ G ≻ S		G ≻ S ≻ E
Significant market-based ESG indicators	≠	Relevant CRA-based ESG indicators
• High-income countries Transition risk ≻ Physical risk • Middle-income countries Physical risk ≻ 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 ≻ A ≻ BB ≻ BBB

ESG risk premium
References

1. Bolton, P., and Kacperczyk, M. (2021), Do Investors Care about Carbon Risk?, *Journal of Financial Economics*, www.ssrn.com/abstract=3594189.
2. Pedersen, L.H., Fitzgibbons, S., and Pomorski, L. (2021), Responsible Investing: The ESG-Efficient Frontier, *Journal of Financial Economics*, www.ssrn.com/abstract=3466417
3. Pástor, L., Stambaugh, R.F., and Taylor, L.A. (2021), Sustainable Investing in Equilibrium, *Journal of Financial Economics*, www.ssrn.com/abstract=3498354

ESG risk premium

Asset pricing at the equilibrium

Bolton and Kacperczyk (2021)

"We study whether carbon emissions affect the cross-section of US stock returns. We find that stocks of firms with higher total carbon dioxide emissions (and changes in emissions) earn higher returns, controlling for size, book-to-market, and other return predictors. We cannot explain this carbon premium through differences in unexpected profitability or other known risk factors. We also find that institutional investors implement exclusionary screening based on direct emission intensity (the ratio of total emissions to sales) in a few salient industries. Overall, our results are consistent with an interpretation that investors are already demanding compensation for their exposure to carbon emission risk."

ESG risk premium

Asset pricing at the equilibrium

Pedersen *et al.* (2021)

"A security with a higher ESG score has

a *A higher demand from ESG investors, which lowers the expected return;*
b *Different expected future profits, which can increase the expected return if the market underreacts to this predictability of fundamentals; and*
c *Stronger flows from investors, which can increase the price in the short term."*

ESG risk premium

Asset pricing at the equilibrium

Pástor *et al.* (2021)

"We model investing that considers environmental, social, and governance (ESG) criteria. In equilibrium, green assets have low expected returns because investors enjoy holding them and because green assets hedge climate risk. Green assets nevertheless outperform when positive shocks hit the ESG factor, which captures shifts in customers' tastes for green products and investors' tastes for green holdings. The ESG factor and the market portfolio price assets in a two-factor model. The ESG investment industry is largest when investors ESG preferences differ most. Sustainable investing produces positive social impact by making firms greener and by shifting real investment toward green firms."

ESG risk premium

Asset pricing at the equilibrium

Van der Berg (2021)

"I show that the performance of ESG investments is strongly driven by price-pressure arising from flows towards sustainable funds, causing high realized returns that do not reflect high expected returns. The coefficient linking ESG flows and realized returns is the product of two factors: The deviation of green funds' portfolios from the market portfolio and a flow multiplier matrix that is the inverse of the market's demand elasticity of substitution between stocks. Empirically, withdrawing 1 dollar from the market portfolio and investing it in the representative ESG fund increases the aggregate value of high ESG-taste stocks by 2–2.5 dollars. Under the absence of flow-driven price pressure, the aggregate ESG industry would have strongly underperformed the market from 2016 to 2021. Furthermore, the positive alpha of a long-short ESG taste portfolio becomes significantly negative."

Difference between short term and long term

- In the short term, green and best-in-class ESG assets can outperform brown and worst-in-class ESG assets
  - Investment flows
  - Materiality of the risk
  - ESG bubble
- In the long run, brown and worst-in-class ESG assets must outperform green and best-in-class ESG assets
  - Skewness risk (e.g., carbon tax, regulation, business disruption)
  - Supply/demand equilibrium

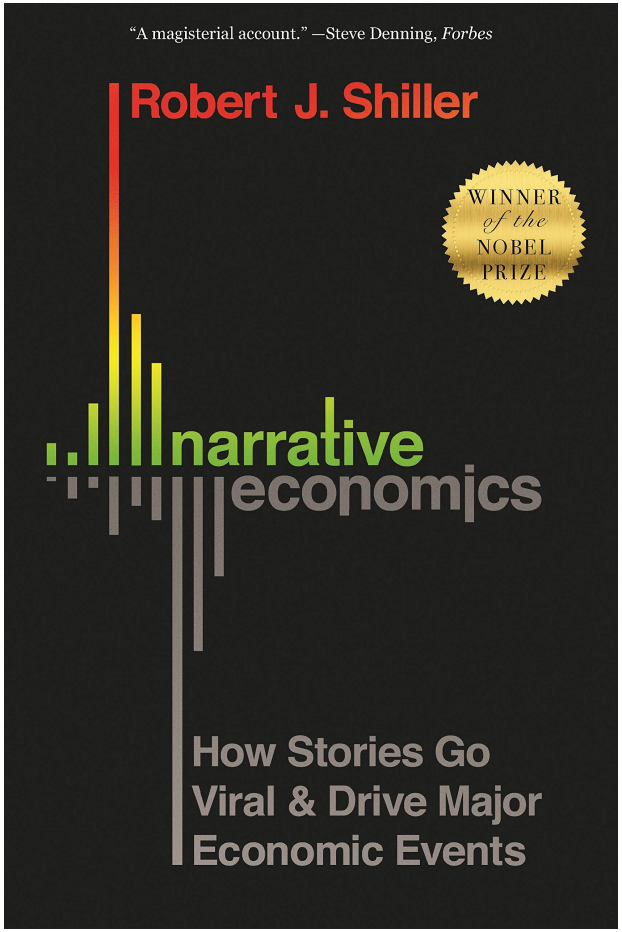
$\Rightarrow$ 2014-2020 was an exceptional period for ESG investing in terms of performance (because of investment flows)

Difference between short term and long term

- The big issue is the following:
  Are investors able to assess the carbon and ESG risks and their associated skewness risks (too optimistic)?
- What is the magnitude of the risk premium? $\Rightarrow$ too large?
- The difference between the return and the risk premium highly depends on the expectations of brown invertors and the reaction of policy markers and regulators

Narratives

Figure 31: Narrative Economics: How Stories Go Viral & Drive Major Economic Events (Robert J. Schiller)



The 'new normal' of ESG investing

- 2000's: ESG investing was motivated by values and ethics
- 2010's: ESG investing was motivated by risk management and performance
- 2020's: Back to the values and ethics?

$\Rightarrow$ The rise and the fall of best-in-class selection

Impact investing and engagement $\succ$ ESG scoring and rating systems

Difficult to assess the performance of ESG investing in this context!!!