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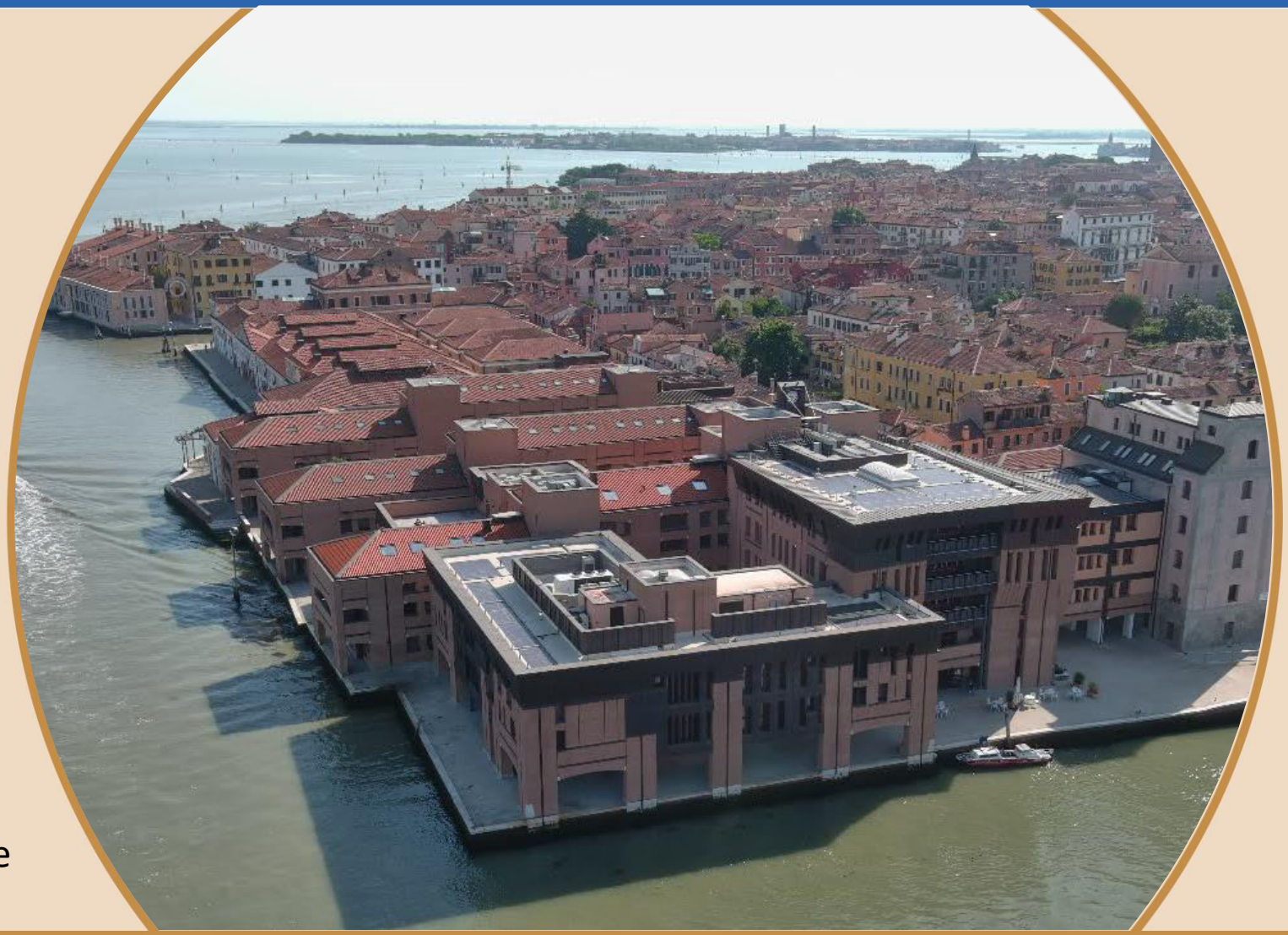
Italiadomani
PIANO NAZIONALE DI RIPRESA E RESILIENZA

UNIVERSITÀ DEGLI STUDI DI BERGAMO

Missione 4 Istruzione e Ricerca-UNIBG



Transition and physical risk exposure of the financial sector

Unibg Team: Giacometti, Cincinelli, Torri, Lauria, Bonomelli, Giacchetta

2nd Workshop on Sustainable Finance
SPOKE 4 - Venezia

Our contribution so far

Aspect of ESGness	Objectives and deliverables	Activities
A) Assessing ESGness	At a micro level, measures of «greenness», exposure to «climate shocks», and «ESG awareness» through novel indicators of «ESGness», of materiality in sustainability and of a circularity measure distilled at the company level (also based on balance sheet data).	A1: Measuring Banks' Exposure to Climate Risk (published) A2: **Transition and physical risk exposure of the financial sector** A3: ESG rating uncertainty A4: ESG performance and banks' business models
B) Exploit ESGness	Impact analysis on performances and optimal portfolio allocation, also developing axiomatic definitions of ESG-based risk and reward measures to help investors to evaluate and optimize their positions.	B1 ESG-coherent risk measures for sustainable investing (submitted and available as a pre-print on ArXiv (https://arxiv.org/abs/2309.05866). B2 ESG coherent risk measures and portfolio optimization with performance attribution constraints (expected submission: early 2024). B3 Sustanability market Implied Score (SMIS)
C) Improve ESGness	Analysis and signaling of greenwashing phenomena, also considering a law perspective input, through testable implications in terms of time-varying shares of brown, green and green-washed activities and agents (firms) will be derived and confronted with available data.	C1: methodology (submitted) C2: methodology C3: Greenwashing phenomena and Financial Stability

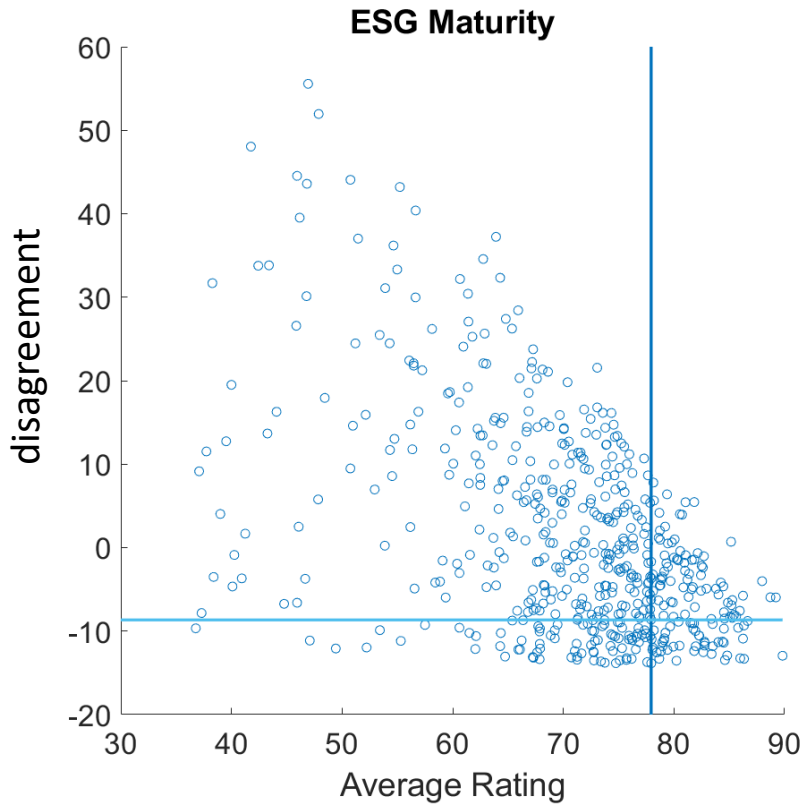
A3.1. *ESG rating uncertainty 1*

- ESG scores are provided by **multiple issuers** using different formulations and information sets; moreover, raters **update** their evaluation framework **asynchronously**.
- All of this often leads to **disagreements**.
- We propose a model for addressing the impact of ESG rating information by separating it into an "**average**" component and a "**disagreement**" one.

A3.1. *ESG rating uncertainty 1*

Given M rating agencies, for asset i (i=1..I), we define at time t (t=1..T),

- Average: $\overline{ESG(t)^i} = \frac{\sum_{j=1}^{M} ESG(t)_j^i}{M}$
- disag: $d\_ESG(t)^i = \frac{\sum_{j=1}^{M}\left(\sum_{k=1}^{M}\left(\left|ESG(t)_j^i - ESG(t)_k^i\right| - \left|\overline{ESG(t)_j - ESG(t)_k}\right|\right)\right)}{2}$
- Portfolio constraints
  - $\sum_{i=1}^{I} w_i \, 1_{\overline{ESG^i} \geq A_{\overline{ESG}}} \geq \alpha\%$
  - $\sum_{i=1}^{I} w_i \, 1_{d\_ESG^i \leq A_{dist\_ESG}} \geq \beta\%$
  - where:
  - $A_{\overline{ESG}}$ and A_{d_ESG} are percentile of the empirical distribution of $\overline{ESG(t)^i}$ and $d\_ESG(t)^i$ respectively



A3.2. *ESG rating uncertainty 2*

- If we optimize the portfolio using the ESG ratings from one agency, will the **ESG value of the resulting optimal portfolio**, when evaluated using another agency's ratings, also significantly **improve**?

- Will the **optimal weights differ**, and if so, by how much?

- Can we reduce **the ESG ambiguity** of the portfolio by applying a **Distributionally Robust Approach**?

A3.2. *ESG rating uncertainty 2*

Consider the random vector $\boldsymbol{\xi} = [\mathbf{r}, \mathbf{z}]$

- r vector of I stock returns.
- ***z*** vector of I ESG index obtained from ESG scores of different providers.
- ***w*** vector of portfolio weights.
- Data-Driven Distributionally Robust Optimization Problem [Esfahani and Kuhn 2018] :

$$\inf_{\boldsymbol{w}\in\mathbb{W}} \sup_{\mathbb{Q}\in B_\epsilon(\widehat{\mathbb{P}}_N)} \mathbb{E}^{\mathbb{Q}}\left[l(\boldsymbol{w}, \boldsymbol{\xi})\right]$$

where:

$$\mathbb{E}^{\mathbb{Q}}\left[l(\boldsymbol{w}, \boldsymbol{\xi})\right] = -\alpha\left[\lambda\mathbb{E}[\boldsymbol{w}^T\boldsymbol{z}] + (1-\lambda)\mathbb{E}[\boldsymbol{w}^T\boldsymbol{z}]\right] + (1-\alpha)CVaR_\beta(\boldsymbol{w}^T\boldsymbol{z})$$

- Empirical probability measure: $\widehat{\mathbb{P}}_N = \frac{1}{N}\sum_{n=1}^{N}\delta_{\hat{\xi}_n}$
- $B_\epsilon\left(\widehat{\mathbb{P}}_N\right)$:= Set of distributions that belong to the ball of radius ϵ around $\widehat{\mathbb{P}}_N$ with respect to the Wasserstein metric
- ESG data from Refinitiv, Morningstar, Bloomberg, S&P, Truevalue for EUROSTOXX600

A4: *ESG and banks' business models*

We use a threshold regression model (Hansen, 1999) to identify an optimal threshold level in the business models of a sample of 80 European listed banks during 2006 - 2021 time period (annual data);

$$\begin{aligned} Bus\ Model_{i,t} = & \beta_0 + \beta_1 ESG_{i,t}(Bus\ Model_{i,t-1} \leq \gamma) + \beta_2 ESG_{i,t}(Bus\ Model_{i,t-1} > \gamma) + \\ & + \beta_3 ESG_{i,t-1}(Bus\ Model_{i,t-1} \leq \gamma) + \beta_4 ESG_{i,t-1}(Bus\ Model_{i,t-1} > \gamma) + \\ & + \beta_5 ESG_{i,t-2}(Bus\ Model_{i,t-1} \leq \gamma) + \beta_6 ESG_{i,t-2}(Bus\ Model_{i,t-1} > \gamma) + \\ & + \beta_7 X_{i,t-1} + \gamma Banks_i + \delta Time_t + \varepsilon_{i,t} \end{aligned} \quad (2)$$

- $ESG_{i,t}$ is the explanatory variable expressed in terms of *Environmental*, *Social* and *Governance* scores for bank *i* at time *t*; *t-1* and *t-2;*
- $X_{i,t-1}$ is a vector which includes control variables such as: ratio between non-performing net loans and total outstanding net loans, the risk-weighted assets ratio between Tier 1 + Tier 2 capital and the total risk-weighted assets, log (total assets)
- The threshold variable, *γ*, is set to be the last period's *Bus Model* level.

Proxy for banks' business models

- *Bus Model*$_{i,t}$, is the proxy for the banks' business models (BM) for bank *i* at time *t*.
- Alternatively
  - [i] the Tier 1 + Tier 2 capital over Total Asset ratio (**BM 1**$_{i,t}$); (solvency)
  - [ii] the Loans over Total Asset ratio (**BM 2**$_{i,t}$); (type of business)
  - [iii] the Deposits over Total Asset ratio (**BM 3**$_{i,t}$); (type of business)
  - [iv] the Net-Interest Margin over the Intermediation Margin ratio (**BM 4**$_{i,t}$); (NIM/IM ratio) (type of business)

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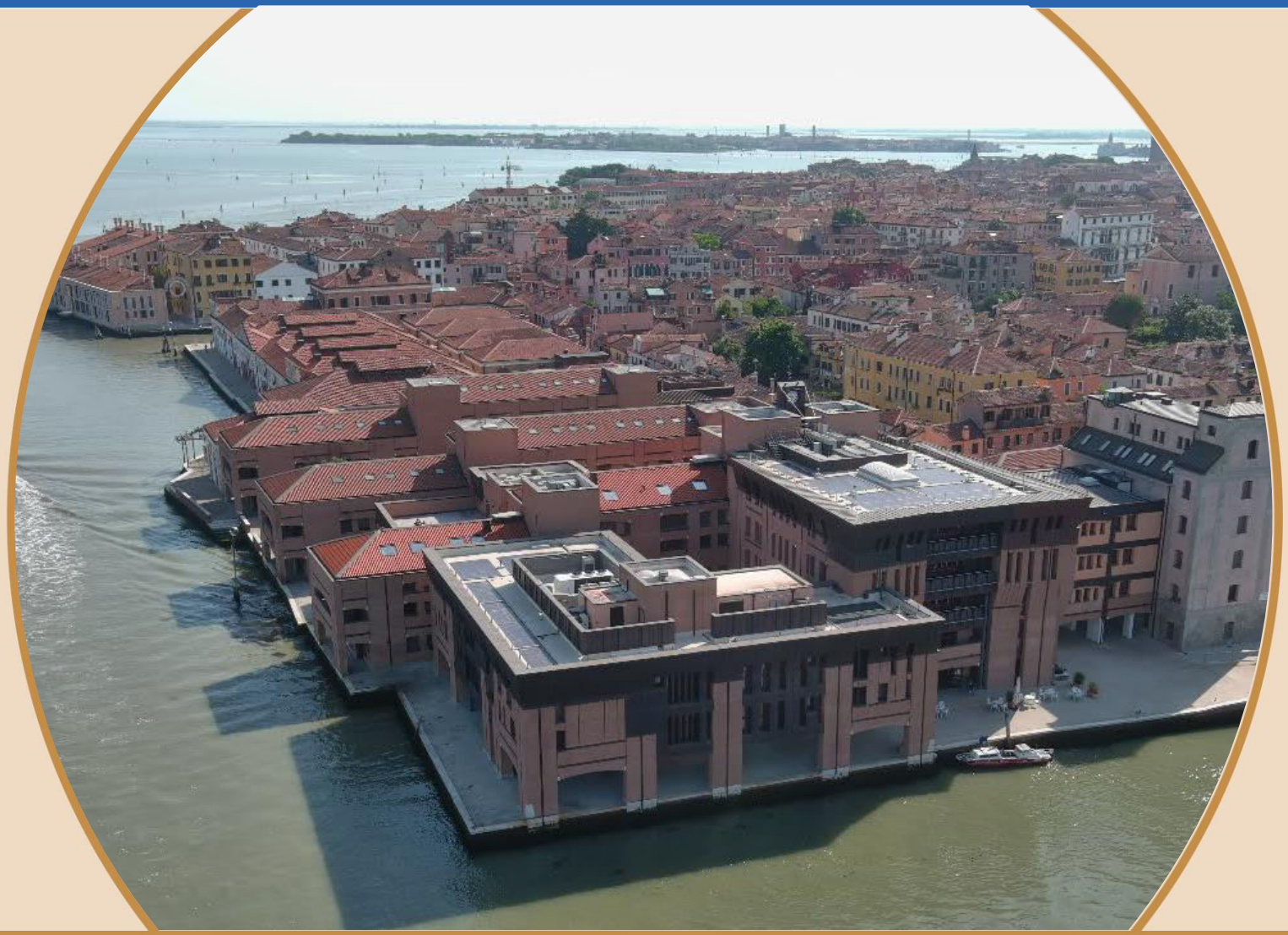
Exploit ESGness

B3: Sustanability market Implied SFDR Score



A2. *Sustanability market Implied Score (SMIS)*

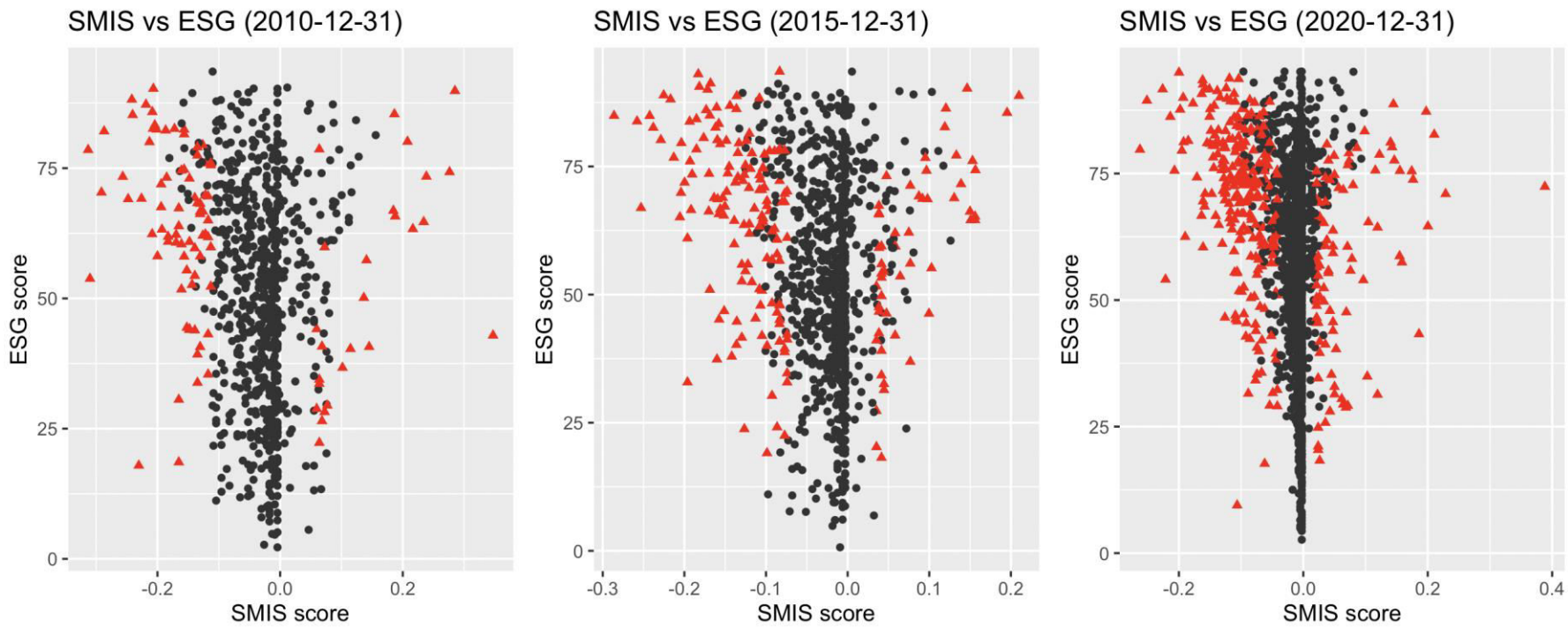
- **SFDR e ESG**

- The Sustainable Finance Disclosure Regulation (SFDR) is a set of rules introduced by the European Commission, for asset managers and other financial markets participants (e.g. funds).
- Asset managers have to classify their funds according to one of these three classes:
  - Article 9: these include funds which have sustainable investments as their objective;
  - Article 8: funds that invest in sustainable investments, but do not have sustainable investing as a core objective.
  - Article 6: funds that include a certain degree of ESG factors into their investment policy (not as restrictive as Articles 8 and 9).

A2. *Sustanability market Implied SFDR Score (SMIS)*

- We consider the constituents of different funds.
- Do ESG ratings and SFDR classification overlap?
- Is it true that asset with high ESG score are always detained by SFDR 9 funds?
- In case of negative answer, we want to extract potential information concerning those assets.
- In particular, we extract an implicit rating for the stocks based on their presence in SFDR funds.

- Dataset covers the period 2002-2023, and has quarterly frequency. The coverage of the dataset grows over time, with 108 European equity funds in 2002 and 489 in 2020. Together the funds have exposures in more than 5600 European stocks. SFDR mid 2023.



SFDR Market implied sustainability score (SMIS) vs ESG score, computed at 31/12/20210, 31/12/20215 and 31/12/2020

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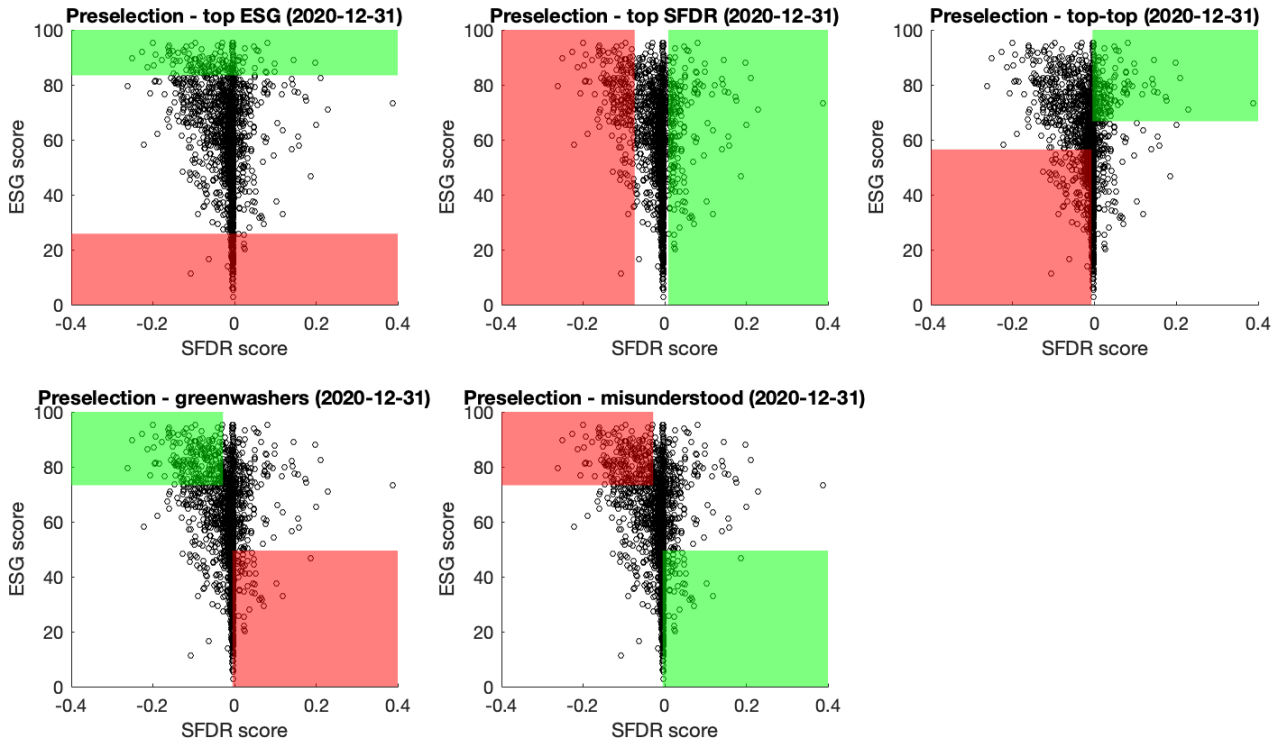
Portfolio Tilting and out of sample performance

- For 290 companies present in EUROSTOXX 600, we collect quarterly data GICS sector, Sustainability variables, Financial variables (among them Green Revenues and Total)



- Table with best and worst performers according to the SFDR market implied score (SMIS).

ranking by **implied SFDR rating**			
	name	ESG	**SMIS**
1	Schneider Electric SE	73.2	0.38
2	Kerry Group PLC	70.8	0.22
3	Kingspan Group PLC	82.3	0.21
4	Siemens Gamesa	65.3	0.20
5	Alstom SA	87.8	0.19
6	Alfen NV	46.8	0.18
...			
n-5	Carlsberg A/S	77.0	-0.20
n-4	Novartis AG	86.5	-0.21
n-3	Prosus NV	58.1	-0.22
n-2	Enel SpA	92.0	-0.22
n-1	TotalEnergies SE	89.6	-0.25
n	Rio Tinto PLC	79.5	-0.26

ranking by **ESG rating**		
name	**ESG**n	SMIS
Roche Holding AG	95.2	-0.09
AstraZeneca PLC	95.1	0.08
BNP Paribas SA	95.1	-0.19
Shell PLC	94.4	-0.16
Allianz SE	94.2	-0.04
Abb Ltd	94.0	-0.03
...		
Civitas Social Hou. PLC	7.6	-0.002
Enad Global 7 AB (publ)	6.1	-0.002
St Galler Kantonalb. AG	6.0	-0.004
Warehouse REIT PLC	5.4	-0.002
Bank of Greece	2.7	-0.002
FLEX LNG Ltd	2.1	-0.002

Honorable mentions:

name	ESG	SMIS
British American Tobacco	90.8	-0.161
ArcelorMittal SA	92.2	-0.129
Mercedes Benz Group AG	93.7	-0.162

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Aim of Research

1. Investigate the impact of Climate Transition and Physical Risk in Europe

Investigate the impact of climate transition and physical risk on the European financial system, assuming **different climate scenarios** (Ferreiro, Reboredo et al., 2022)

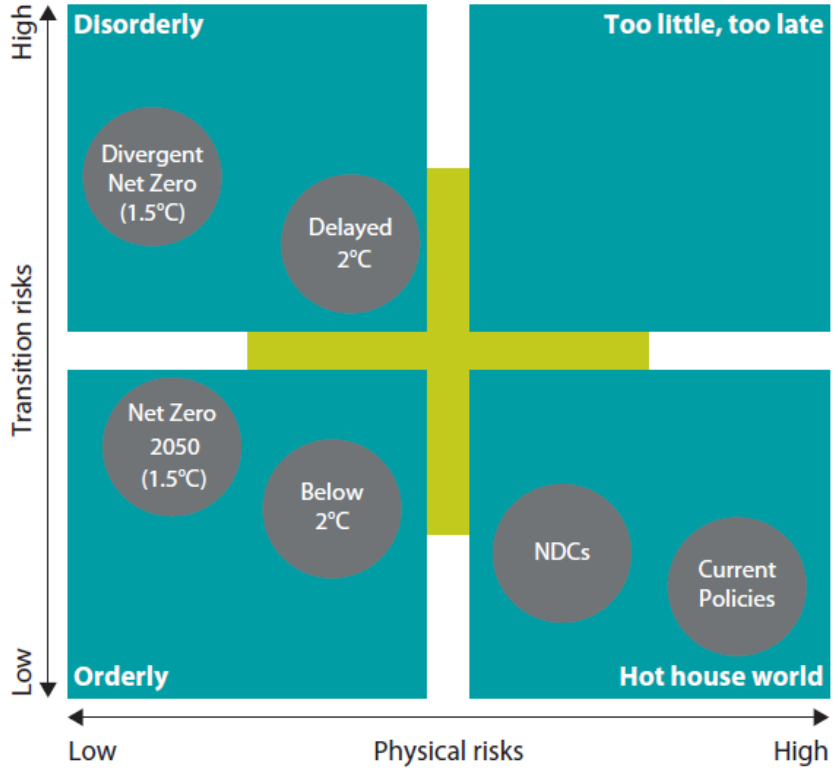
2. Computing Key Financial Risk Metrics

In each climate scenario, for each bank, we compute 4 metrics:

1. Conditional Expected Return (**C-ER**)
2. Conditional Value at Risk (**C-VaR**)
3. Conditional Expected Capital Shortfall (**C-ES**)
4. Conditional Capital at Risk (**C-RISK**)

NGFS Scenarios Framework (2022)

Figure: Physical and transition risk level of NGFS scenarios



Climate Transition Risk Factor (1/2)

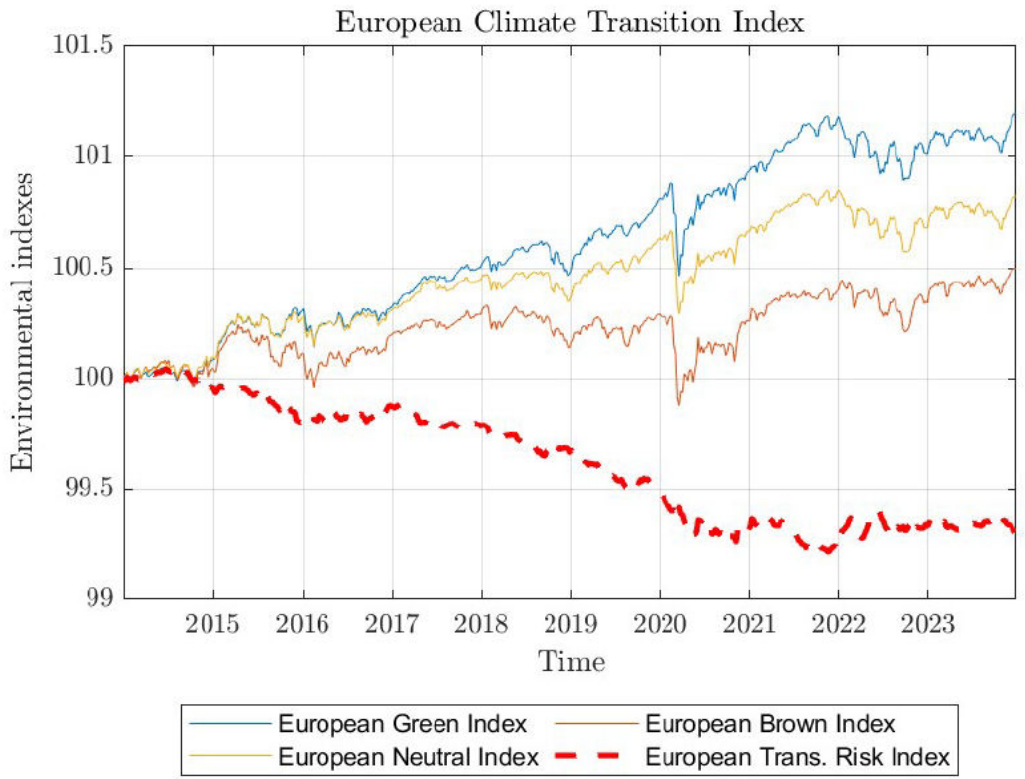
1. STOXX Europe 600 companies sorted into quintiles according to GHG Protocol Scopes 1 & 2

2. 3 clusters for **green**, **neutral** and **brown companies:**

   a) **Green companies:** average return of 1st quintile companies (GHG Scope 1 + Scope 2)
   b) **Neutral companies:** average return of 2nd, 3rd and 4th quintile companies (GHG Scope 1 + Scope 2)
   c) **Brown companies:** average return of 5th quintile companies (GHG Scope 1 + Scope 2)

Climate Transition Risk Factor (2/2)

Figure: Climate Transition Factor (CTFactor)



Climate Physical Risk Factor

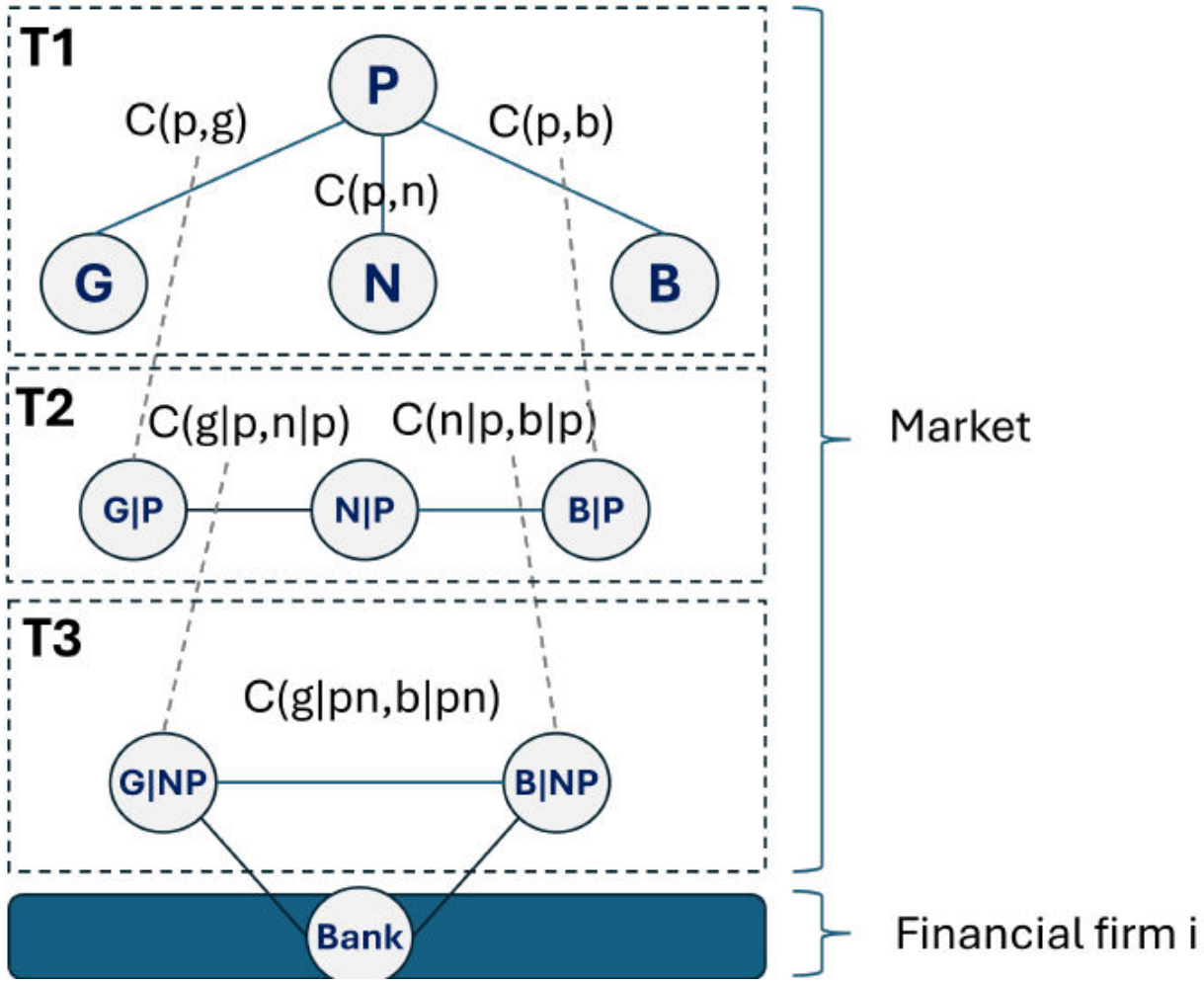
1. **European Extreme Event Climate Index (E3CI)** – 7 indicators: maximum and minimum temperatures, droughts, precipitations, winds, hails and forest fires
2. 37 European countries
3. For each of the 7 indicators, from 2013 to 2023, we computed the weighted average, using as weights the gross domestic product of the respective countries.
4. **CP-Factor has been constructed as the arithmetic mean of the 7 weighted indicators.**

Data

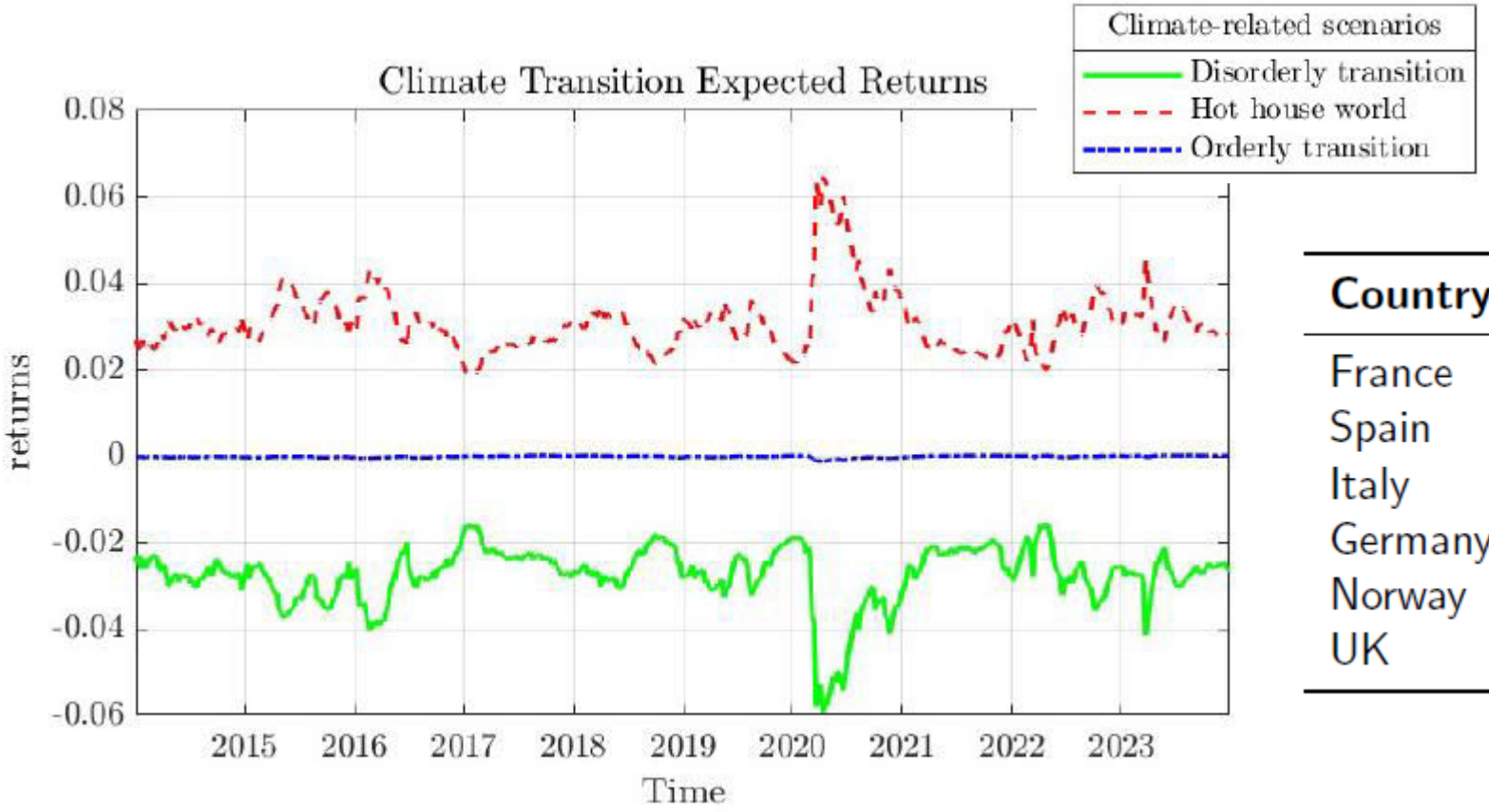
Table: Sample Composition

Country	Banks	Mkt Cap
BRITAIN	6	248.3
SPAIN	5	148.4
FRANCE	3	130.3
ITALY	8	128.0
SWITZERLAND	2	107.4
SWEDEN	3	67.0
NETHERLANDS	2	59.1
FINLAND	1	39.6
GERMANY	2	38.6
POLAND	3	35.2
DENMARK	4	30.9
NORWAY	1	29.8
AUSTRIA	3	25.9
BELGIUM	1	24.5
IRELAND	2	18.8
PORTUGAL	1	4.1
Total	47	1136.0

Vine copula


T1
P
C(p,g)
C(p,b)
C(p,n)
G
N
B
T2
C(g|p,n|p)
C(n|p,b|p)
G|P
N|P
B|P
T3
C(g|pn,b|pn)
G|NP
B|NP
Bank
Market
Financial firm i

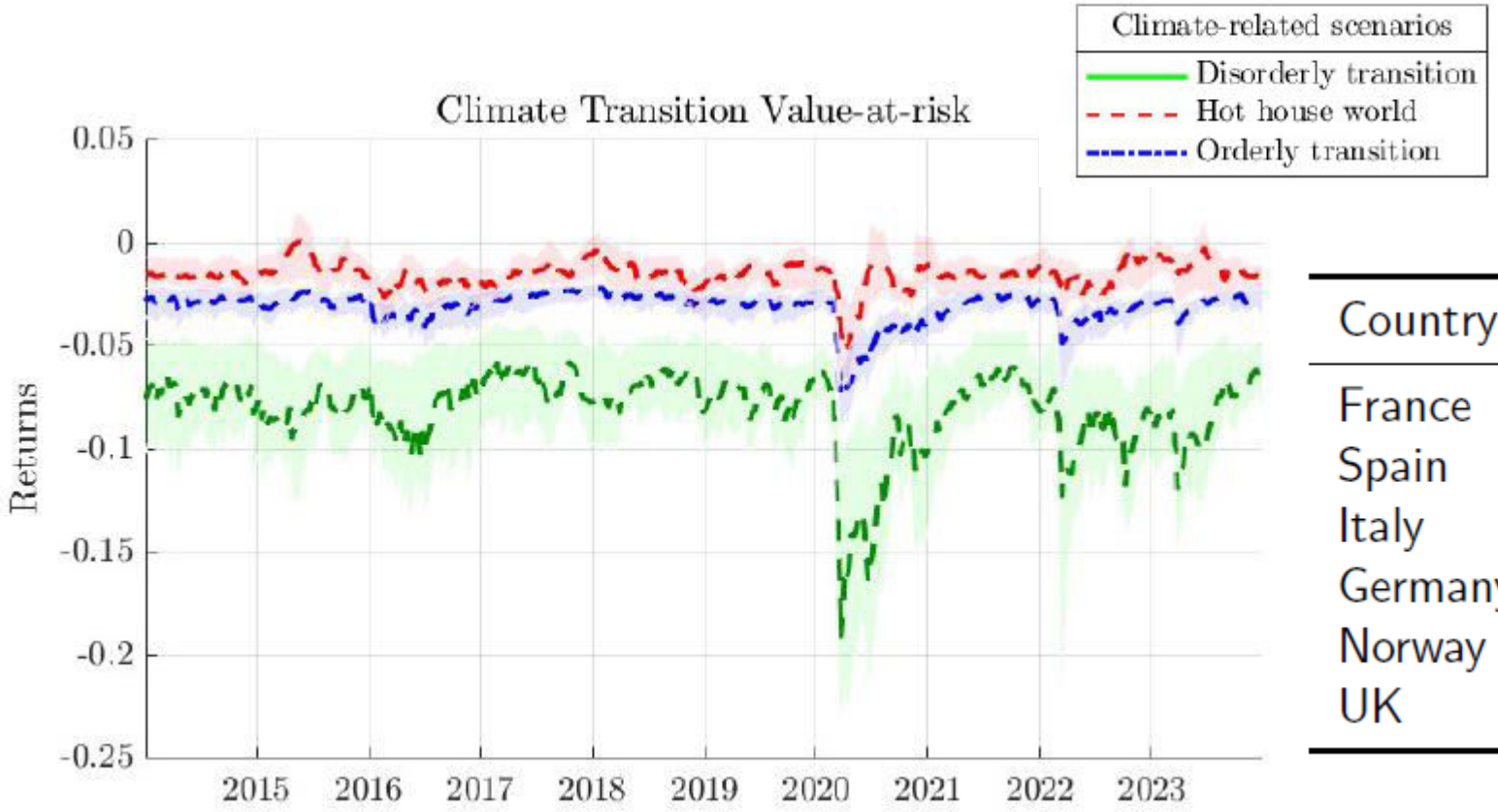
C-ER Results



Country	Dis. trans.	Ord. trans.	Hot House
France	-0.0344	0.0007	0.0297
Spain	-0.0401	-0.0002	0.0378
Italy	-0.0389	0.0007	0.0380
Germany	-0.0404	-0.0007	0.0389
Norway	-0.0229	0.0011	0.0232
UK	-0.0197	-0.0013	0.0329

C-ER is the average of C-ER of each institutions, under each scenario, weighted for market cap at December 31, 2023

C-VAR Results



Country	Dis. trans.	Ord. trans.	Hot House
France	-0.0953	-0.0278	-0.0076
Spain	-0.1045	-0.0330	-0.0062
Italy	-0.0895	-0.0413	-0.0148
Germany	-0.1064	-0.0423	-0.0194
Norway	-0.0692	-0.0287	-0.0132
UK	-0.0891	-0.0319	-0.0315

C-VAR is the median of banks' C-VAR, under each scenario.

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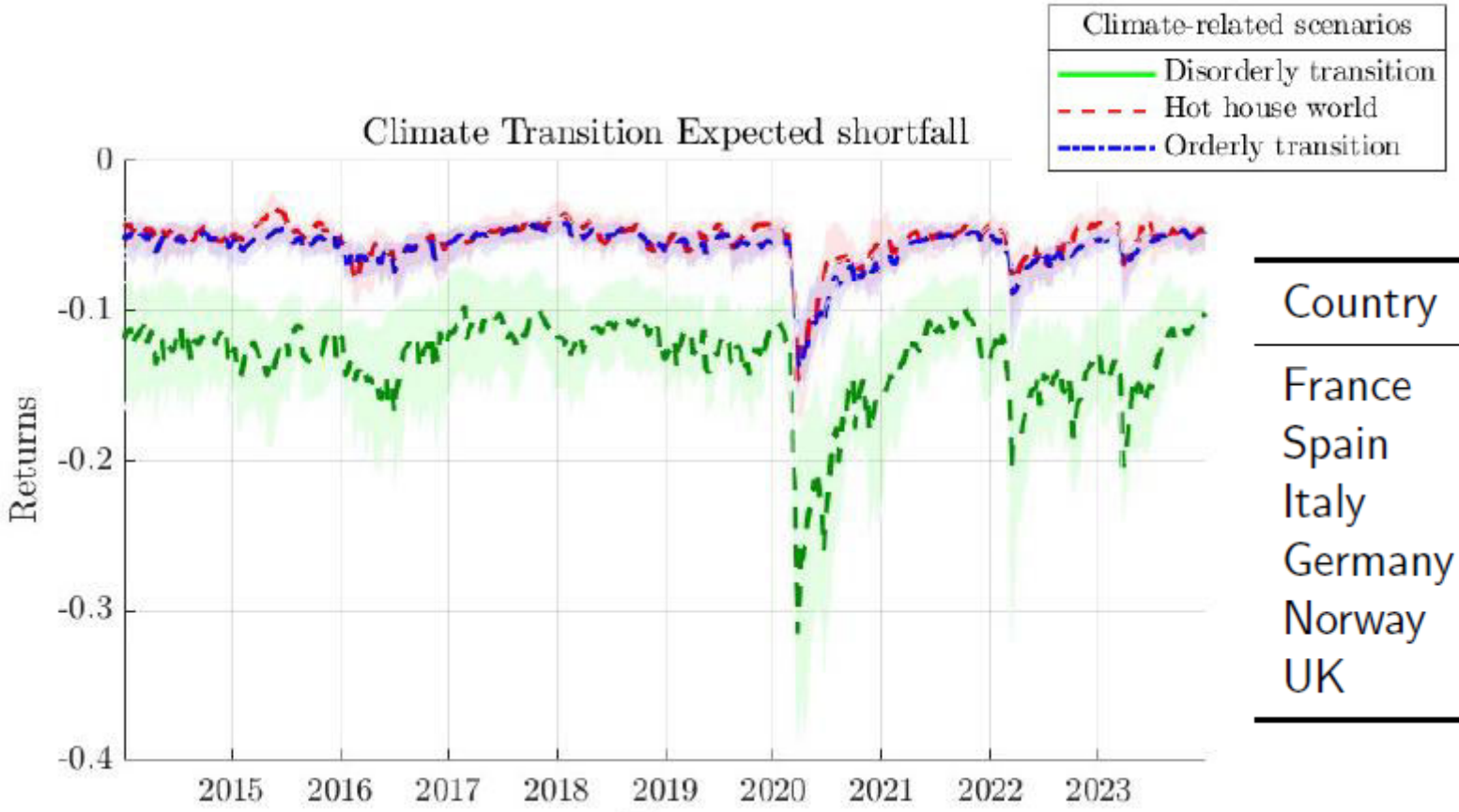
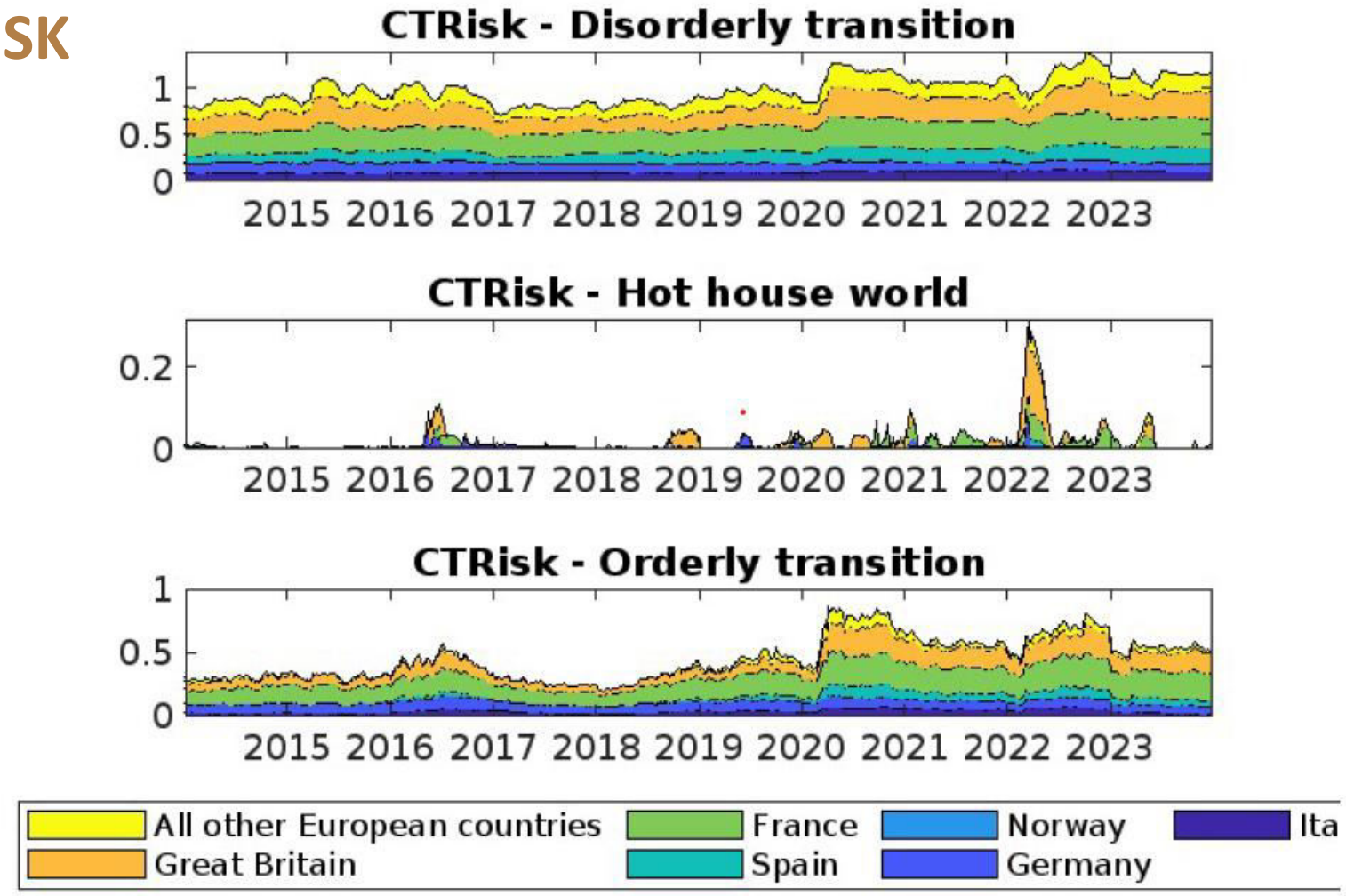
C-ES Results



Country	Dis. trans.	Ord. trans.	Hot House
France	-0.1766	-0.0586	-0.0515
Spain	-0.1632	-0.0595	-0.0434
Italy	-0.1326	-0.0738	-0.0526
Germany	-0.1572	-0.0726	-0.0609
Norway	-0.1020	-0.0520	-0.0441
UK	-0.1564	-0.0601	-0.0770

C-ES is the median of banks' C-ES, under each scenario.

C-RISK



$$CRISK_{c,t} = \sum_{i_c=1}^{n} (CTCS_{i_c,t})_+$$

Capital Shortfall

Vine copula vs DCC GJR-GARCH approach

Disorderly scenario