

Course 2022-2023 in Sustainable Finance

Lecture 9. Transition Risk Modeling

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¹The 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.

Climate transition risk

Definition

- Transition risks arise from the sudden shift towards a low-carbon economy
- Such transitions could mean that some sectors of the economy face big shifts in asset values or higher costs of doing business

“ It’s not that policies stemming from deals like the Paris Climate Agreement are bad for our economy — in fact, the risk of delaying action altogether would be far worse. Rather, it’s about the speed of transition to a greener economy — and how this affects certain sectors and financial stability” (Bank of England, 2021)

Climate transition risk

The carbon footprint approach assumes that the climate-related market risk of a company is measured by its current carbon intensity

...But the market perception of the climate change may be different

Climate transition risk

Fundamental-based analysis

- Carbon footprint and pathway are measured by CO₂ emissions
- They are fundamental data

Market-based analysis

- Financial market's perception of the potentially reduced impact of climate policies' on securities issued by corporations
- These carbon risk metrics use market data
- How an increase in carbon prices and taxes influences the credit risk of the issuer?
- How sensitive the asset price is to a carbon market factor?

Carbon price

Two main pricing systems:

- 1 Carbon tax
- 2 Emissions trading system (ETS)

Underlying idea

- A high carbon tax impacts the creditworthiness of corporates
- This impact is different from one issuer to another one
- Identifying for each company the carbon price that would lead the default probability in the Merton model to exceed a certain threshold

Carbon price

Based on the assumptions that the enterprise value V is proportional to the earnings before interest, taxes, depreciation, and amortization (EBITDA) and that the debt D remains constant, we can define the carbon price margin as²:

$$\text{CPM}_i = \left(1 - \exp \left(\sigma_i \sqrt{\tau} \Phi(-\theta) - \left(r + \frac{1}{2} \sigma_i^2 \right) \tau \right) \frac{D_i}{V_i} \right) \frac{\text{EBITDA}_i}{\mathcal{CE}_{i,1}}$$

where σ_i is the volatility of the enterprise value, τ is the maturity and r is the risk-free rate

²The parameter θ is the threshold of default probability

Carbon tax

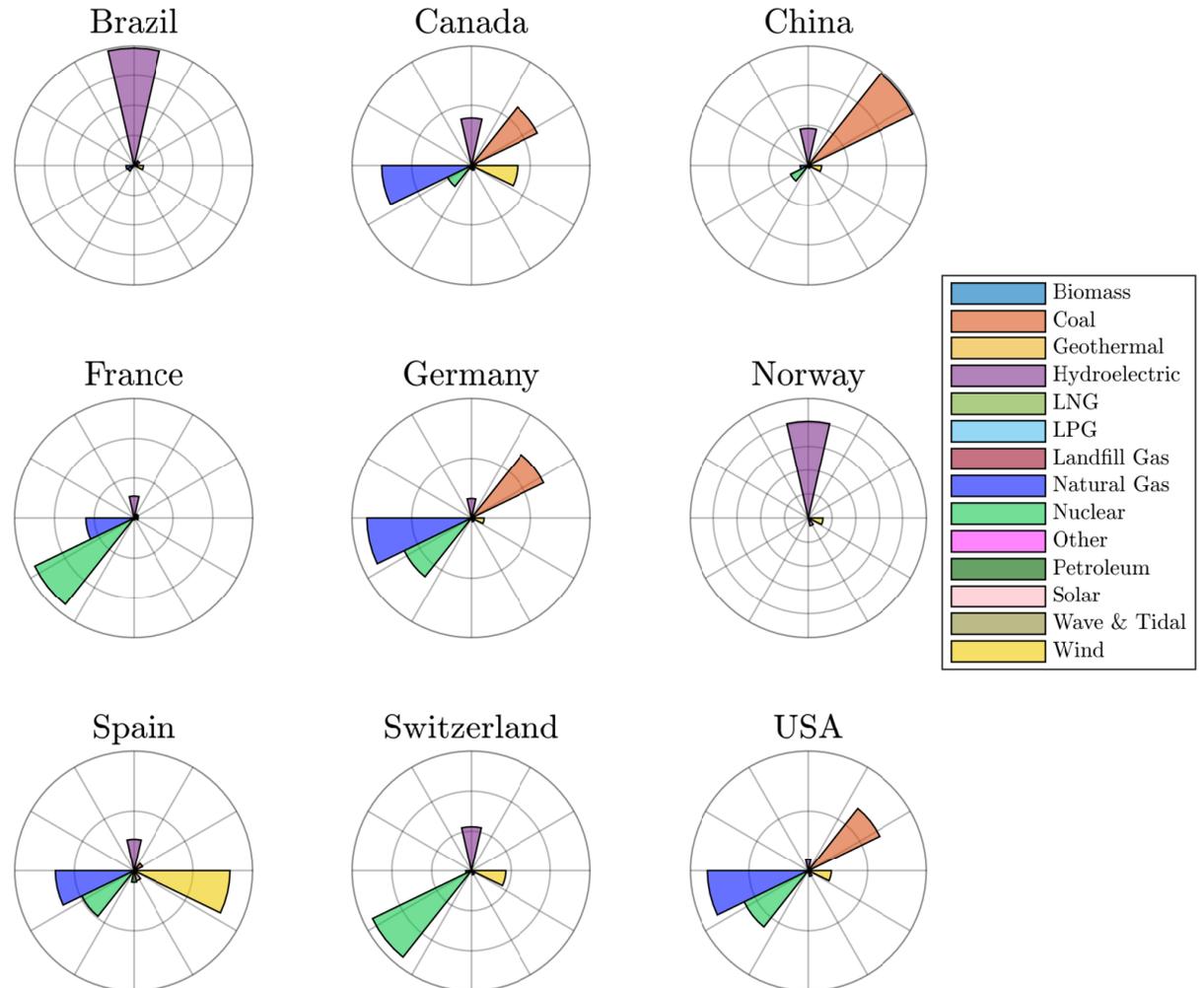
Stranded assets

Energy mix

- How to measure the environmental performance of an utility company?
- How to measure the environmental performance of a country?
- How to assess a company located in a country with a bad energy mix?

Bottom up energy mix^(*) (in %)

This figure presents the energy generation breakdown for some countries. We can distinguish countries that rely on hydroelectric power (Brazil, Norway), nuclear (France, Switzerland) and mixed solutions (Canada, Germany, Spain, USA)



(*) Each grid circle represents 20% of energy generation. The scale of the radar chart is then 40% for Canada, Germany, Spain and USA, 60% for China, France and Switzerland, 80% for Brazil and 100% for Norway

Implied temperature rating

Carbon beta

- Introduced by Harris (2015) and Görgen *et al.* (2019)
- The underlying idea of the carbon beta is to estimate the sensitivity of the stock return with respect to a carbon/climate risk factor
- Climate risk is not only an idiosyncratic risk for the issuer, but also a systematic risk factor like the Fama-French-Carhart market factors

Carbon beta

Cross-section factor

- Long/short portfolio
- Long on stocks highly exposed to carbon risk
- Short on stocks lowly exposed to carbon risk
- The value of the factor is the return of the L/S portfolio
- High carbon beta = highly exposed to carbon risk

Time-series factor

- Synthetic index that represents the financial perception of climate risk
- Textual analysis of climate change-related news published by newspapers and media
- High carbon beta = highly exposed to carbon risk

Risk measure = carbon beta

Carbon beta

Let $R_i(t)$ be the return of stock i at time t . We assume that:

$$R_i(t) = \alpha_i(t) + \beta_{i,\text{mkt}}(t) R_{\text{mkt}}(t) + \sum_{j=1}^m \beta_{i,\mathcal{F}_j}(t) R_{\mathcal{F}_j}(t) + \beta_{i,\text{Carbon}}(t) R_{\text{Carbon}}(t) + \varepsilon_i(t)$$

where $R_{\text{mkt}}(t)$ is the return of the market risk factor, $R_{\mathcal{F}_j}(t)$ is the return of the j^{th} alternative risk factor, $R_{\text{Carbon}}(t)$ is the return of the carbon risk factor and $\varepsilon_i(t)$ is a white noise process

Remark

The carbon risk factor corresponds to a long/short portfolio between “green” and “brown” stocks

Climate beta

Engle *et al.* (2020) proposed a related approach where the carbon risk factor is replaced by a climate risk news index $\mathcal{I}_{\text{Climate}}$:

$$R_i(t) = \alpha_i(t) + \beta_{i,\text{mkt}}(t) R_{\text{mkt}}(t) + \sum_{j=1}^m \beta_{i,\mathcal{F}_j}(t) R_{\mathcal{F}_j}(t) + \beta_{i,\text{Climate}}(t) \mathcal{I}_{\text{Climate}}(t) + \varepsilon_i(t)$$

Remark

The climate index $\mathcal{I}_{\text{Climate}}$ corresponds to a time series that measures the sentiment about the climate change. It is built using text mining and natural language processing (NLP)

Carbon beta

The carbon risk factor approach

Goal

The main objective is to define a **market** measure of carbon risk

Three-step approach

- Defining a brown green score (BGS) for each stock (scoring model)
- Building a brown minus green factor (Fama-French approach)
- Estimating the carbon beta of a stock with respect to the BMG factor (Multi-factor regression analysis)

Carbon beta = **market** measure of carbon risk

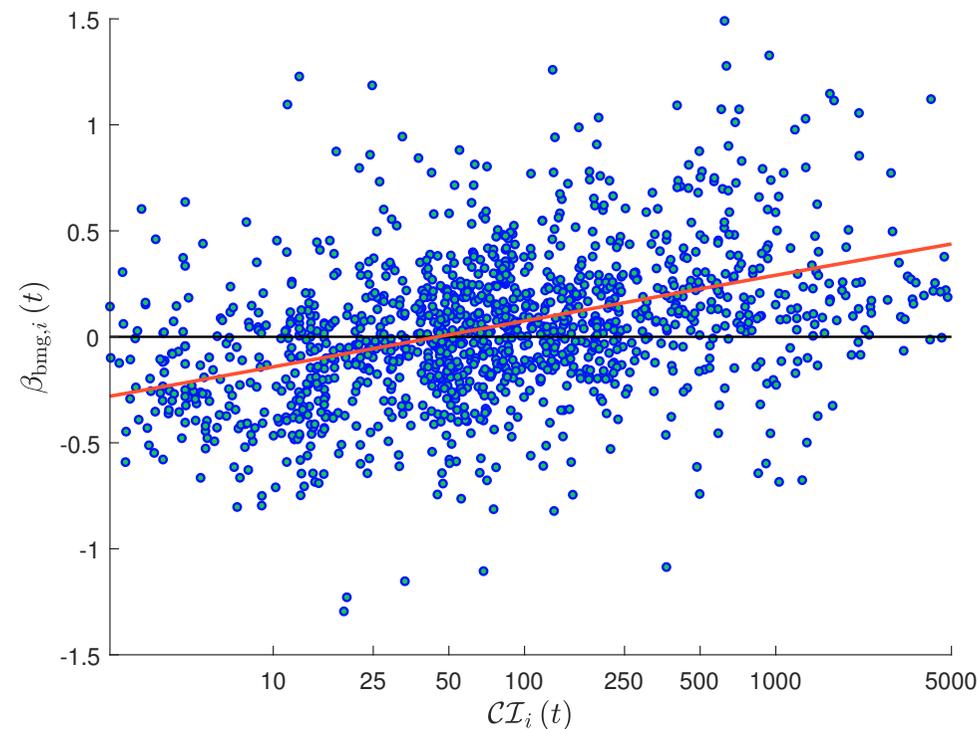
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Carbon intensity = **fundamental** measure of carbon risk

Carbon beta

The carbon risk factor approach

Figure 1: Market-based vs fundamental-based measures of carbon risk



Source: Roncalli *et al.* (2021).

⇒ The market perception of a carbon risk measure depends on several dimensions: sector, country, etc.

Carbon beta

The carbon risk factor approach

Systematic carbon risk

- Common risk
- Carbon beta

Market measure (\approx general carbon risk exposure, e.g. market repricing risk)

Idiosyncratic carbon risk

- Specific risk
- Carbon intensity

Fundamental measure (\approx specific carbon risk exposure, e.g. reputational risk)

Carbon beta

The carbon risk factor approach

	Green	Neutral	Brown
Small	SG	SN	SB
Big	BG	BN	BB

The BMG factor return $R_{\text{bmng}}(t)$ is derived from the Fama-French method:

$$R_{\text{bmng}}(t) = \frac{1}{2} (R_{\text{SB}}(t) + R_{\text{BB}}(t)) - \frac{1}{2} (R_{\text{SG}}(t) + R_{\text{BG}}(t))$$

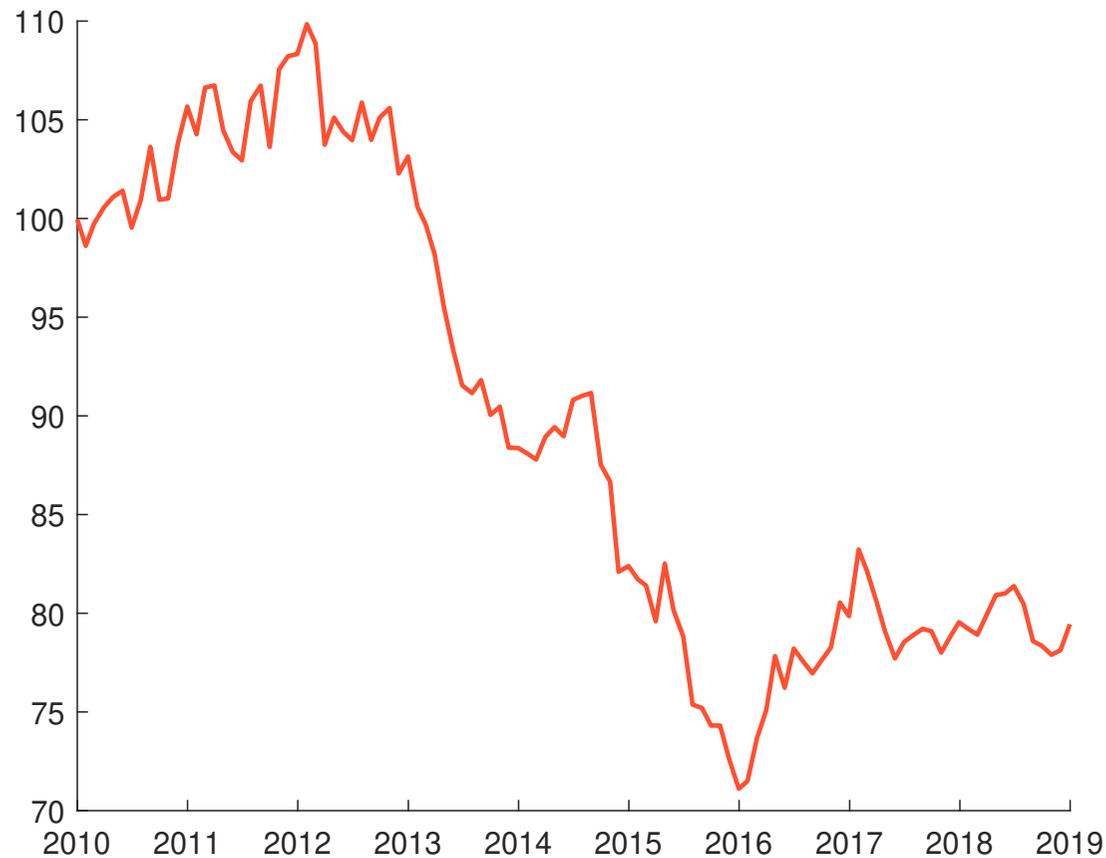
where the returns of each portfolio $R_j(t)$ (small green SG, big green BG, small brown SB, big brown BB) is value-weighted by the market capitalisation

⇒ The BMG factor is a Fama-French risk factor based on a scoring system (brown green score or BGS)

Carbon beta

The carbon risk factor approach

Figure 2: Cumulative performance of the BMG factor

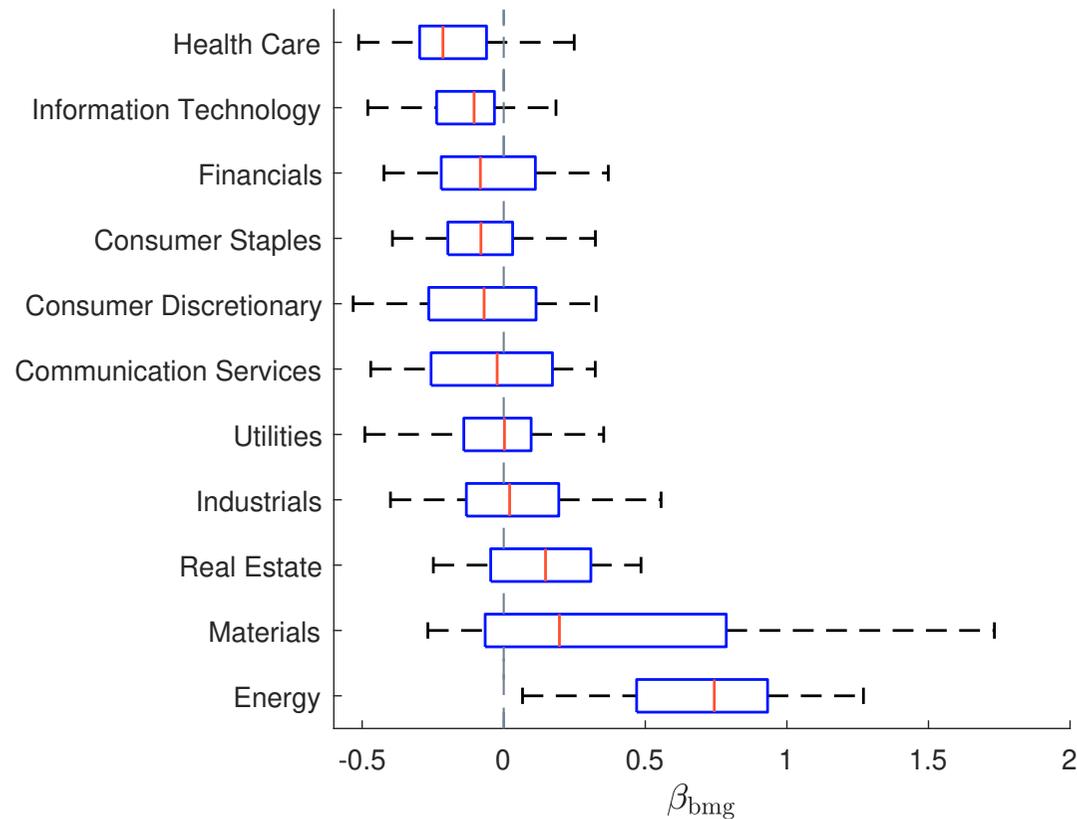


Source: Görgen *et al.* (2019).

Carbon beta

The carbon risk factor approach

Figure 3: Box plots of the carbon sensitivities³



Source: Roncalli *et al.* (2020).

³The box plots provide the median, the quartiles and the 5% and 95% quantiles

Carbon beta

The carbon risk factor approach

Relative carbon risk

- The right measure is $\beta_{\text{bm}g}$
- Sign matters
- **Negative exposure** is preferred

Absolute carbon risk

- The right measure is $|\beta_{\text{bm}g}|$
- Sign doesn't matter
- **Zero exposure** is preferred

Two examples

- 1 We consider three portfolios with a carbon beta of -0.30 , -0.05 and $+0.30$ respectively
- 2 We consider two portfolios with the following characteristics:
 - The value of the carbon beta is $+0.10$ and the stock dispersion of carbon beta is 0.20
 - The value of the carbon beta is -0.30 and the stock dispersion of carbon beta is 1.50

⇒ Impact of portfolio management and theory

Climate beta

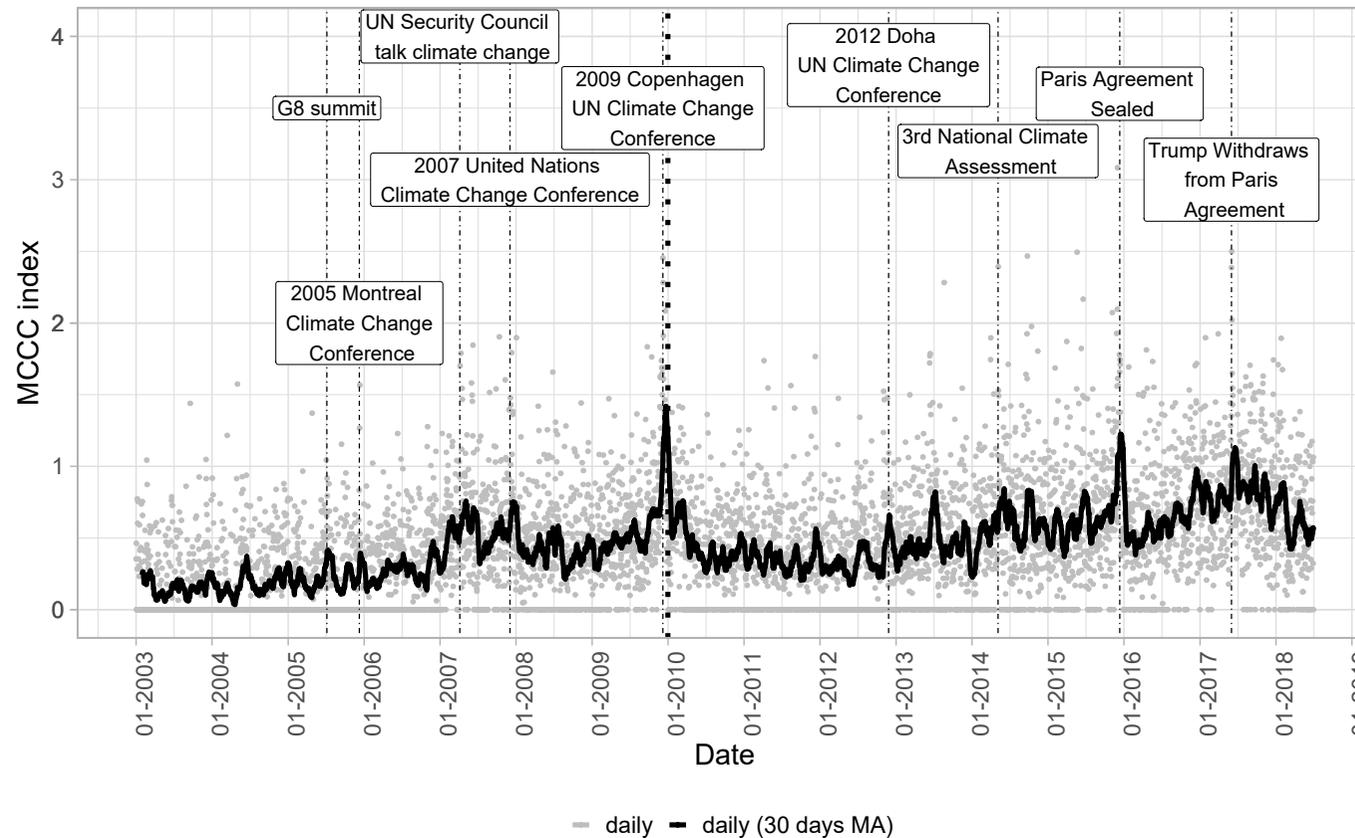
The climate index approach

- Two main references: Engle *et al.* (2020) & Ardia *et al.* (2021)
- We recall that brown assets must exhibit a positive risk premium
- Nevertheless, “[...] *If ESG concerns strengthen unexpectedly and sufficiently, green assets outperform brown ones despite having lower expected returns*” (Pástor *et al.*, 2021)
- Academics proxy concerns about climate change using climate indices based on news

Climate beta

The climate index approach

Figure 4: Media Climate Change Concerns (MCCC) index



Source: Ardia et al. (2021).