The dual face of carbon emissions: transition risk-adjusted probability of default

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Embedding Sustainability in Credit Risk Assessment
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** The views expressed in the paper are those of the authors and do not necessarily reflect those of Banca d'Italia.*

1. Background

Embedding climate-related transition risk (TR) is on top of climate **policy agenda:**

- **ECB** commitment to improve **methodologies** and conduct analyses to monitor the **implications of climate change** and related policies for the economy (ECB, 2021 and ECB, 2022)

Emissions:

- **Control**: Carbon tax vs cap-and-trade system – i.e. the EU Emissions Trading System (EU-ETS) (Stavins, 2003)
- **Measure**: Top-down (Faiella et al., 2022; Aiello & Angelico, 2022) vs bottom-up approach (Grundmann, et al., 2023)

How to **embed climate-related TR** into the credit risk assessment model:

- Carbon tax and long term **NGFS** scenarios (Battiston et al., 2023; Billio & Giacomelli, 2023; Emambakhsh et al., 2023; Di Virgilio et al., 2023)
- Listed firms (i.e. Faiella & Malvolti, 2020: Bolton & Kacperczyk, 2021; Bolton, et al., 2023) using also **EU-ETS** data (i.e. Oestreich & Tsiakas, 2015 and Wen, et al., 2020)

1. Background

The EU-ETS market sets a **limit to GHG emission** produced by participating firms' installations:

- Participating firms can buy or sell allowances as needed
- Firms not provided with free allowances or exceeding free allocations must **buy** allowances at **auctions** or from other firms

Fig. 1: **EUA futures price series** 2018-01-02 / 2023-12-29

Figure 1 - EU Carbon Price measured by daily futures market price of European Emission Allowance (EUA). One EUA equals 1 ton of CO2eq. Contracts traded on the EEX market. Source: Bloomberg.

2. Research question

What is the effect of carbon pricing on non-financial firms' creditworthiness?

Empirical context:

- Measuring emissions is crucial for embedding TR in credit risk assessment
- ECB envisages the inclusion of emissions and carbon price at **firm-level data**, exploiting EU-ETS (Kording & Resch, 2022)

Emissions affect firm creditworthiness:

- Excess emissions over allowances is a cost
- Emission shortage can yield revenues

Identification:

- Stochastic simulations of carbon price trajectories and conditional Value at Risk (CVaR) to identify extreme scenarios
- Project the shocked carbon price onto financial statement to get the firm stressed PD (Grundmann, et al., 2023)

3. Preview of key results

This paper employs a unique dataset on verified emissions from **EU-ETS** to estimate the effect of carbon-price related TR on the one-year probability of default (**PD**) of Italian non-financial firms

By using:

- balance sheet data, we cover **both listed and unlisted firms**
- stochastically simulated price trajectories, we **align TR horizon to the 1-yr** horizon for credit risk

We find that:

1. The EU-ETS market provides direct insights into individual firm emissions, allowing for a more accurate **bottom-up** TR assessment than the standard top-down approach

2. Scenario analysis based on EU-ETS data is **more sensitive** than **NGFS** trajectories to the impact of TR of firms

3. For a few firms we observe a **rating upgrade**

4. Data

Two sources for EU-ETS:

1) **Firm-level** data merged into a new dataset:

European Union Transaction Log (EUTL), a registry of carbon permit transactions

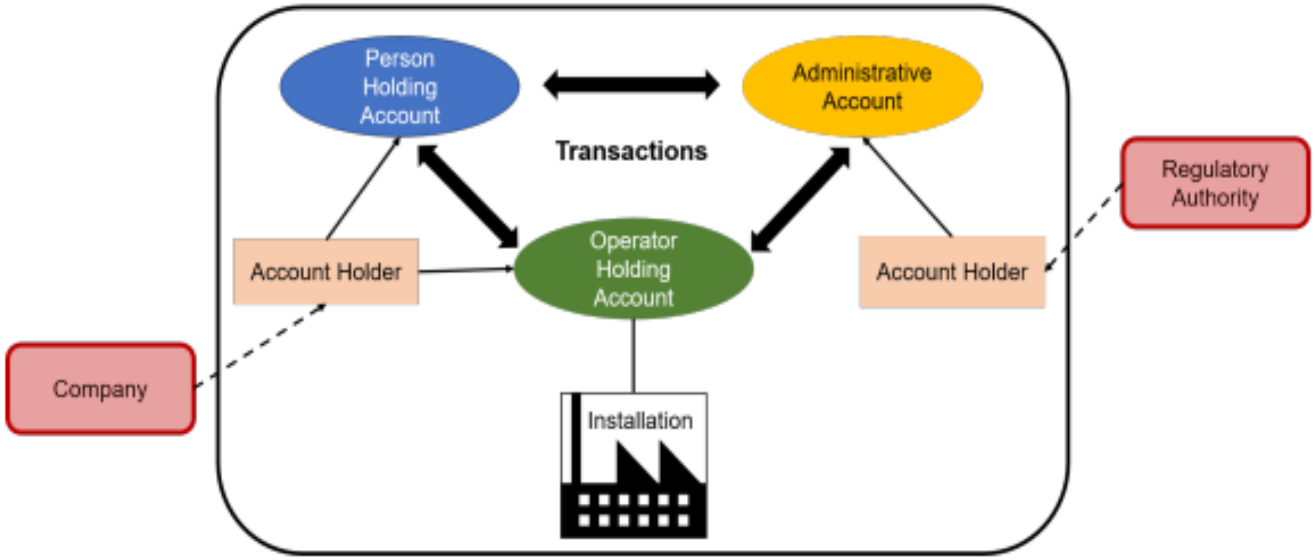


Figure 2 – EUTL registry structure. Source: Letout (2022)

2) **Market data**:

Historical prices and volumes for spot and futures allowance prices sourced from Bloomberg (see Fig. 1)

4. Data

One source for firm information: BI-ICAS database

1. **Financial Statement data** for Italian firms from Cebi and Cerved
2. **Credit behavior data** from the **National Credit Register** (NCR)

The **integration** of BI-ICAS financial and credit data with emissions and transaction records from EU-ETS generates a unique dataset

We employ emissions data for 572 firms, covering 28% of Italian total emissions in 2022

Table 1. BI-ICAS emissions data coverage. Source: ISPRA, EUTL and BI-ICAS dataset.

Emissions	tCO2eq.	%
National emissions (ISPRA)	369.000.000	**100**
EU-ETS emissions	138.272.559	**37**
ICAS emissions	103.738.358	**28**

5. Methodology

First step:

We model price trajectories for futures contracts on EUA certificate via price volatility through an asymmetric parametric model (Taschini & Paolella, 2008): **GJR-GARCH (p, K, q)**

We forecast conditional volatility for $T+h$ (h=252) periods ahead with Monte-Carlo simulations

We get one-year ahead trajectories for EUA certificates futures prices

Second step:

We estimate the extra production cost that firms bear for GHG emissions

- **Baseline scenario**: We take average Monte Carlo simulated prices for the baseline scenario
- **Extreme scenario**: tail analysis (Ordonez, 2022)

Third step: stress-testing financial statements

Firms in deficit:

- We add the purchasing cost of extra allowances to the firm income statement;
- Net effect on the financial statement is **negative**

Firms in surplus:

- The firm sells the extra allowances, generating a non-operating revenue;
- This yields an **improvement** in the financial statement

6. Results (I)

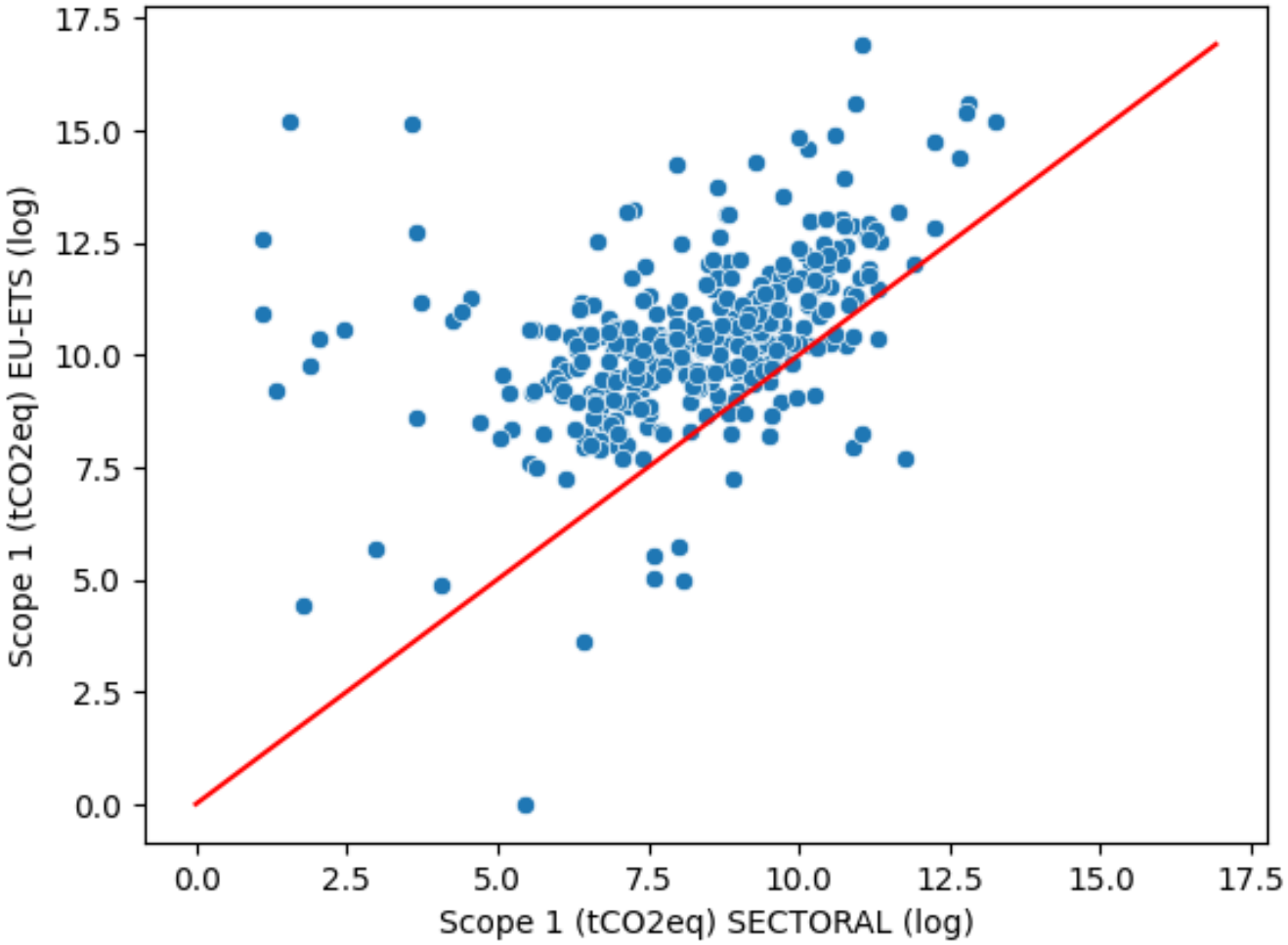


Figure 3 - EU-ETS verified firms' emissions versus sectoral imputation-based emissions. Source: EUTL and Eurostat.

Emissions: top-down vs bottom up

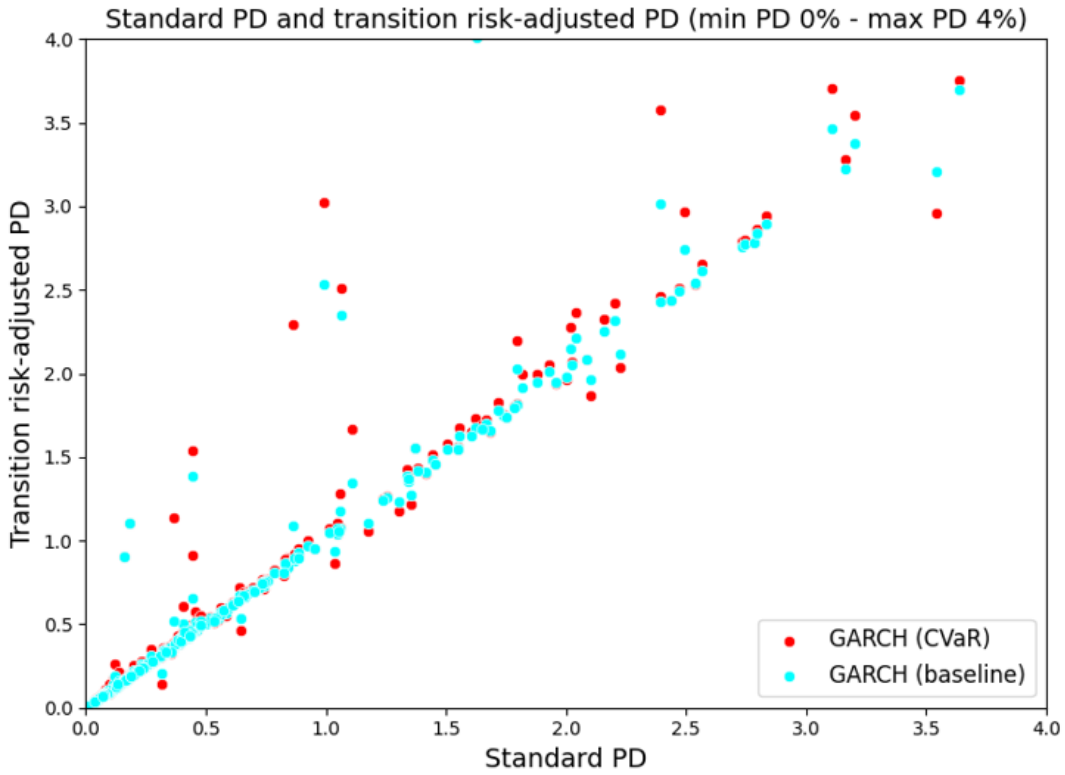
Sectoral attribution **underestimates** emissions, as most data points lie above the 45° line

The EU-ETS market provides a more accurate representation of each firm's emissions

6. Results (II)

Table 5 - 1-year change in credit ratings for GJR-GARCH baseline and CVaR (per cent).

Method	Stable	Upgrade	Downgrade
GJR-GARCH (base)	90	1	9
GJR-GARCH (CVaR)	83	3	14



Baseline scenario

PDs are close to the 45° line: firms historically capable of absorbing carbon costs continue to do so

Extreme scenario

Larger PD changes: only the abrupt shifts in carbon pricing affect firm creditworthiness

Both scenarios

Points below the 45° line: improved PDs due to extra revenues for reduced emissions

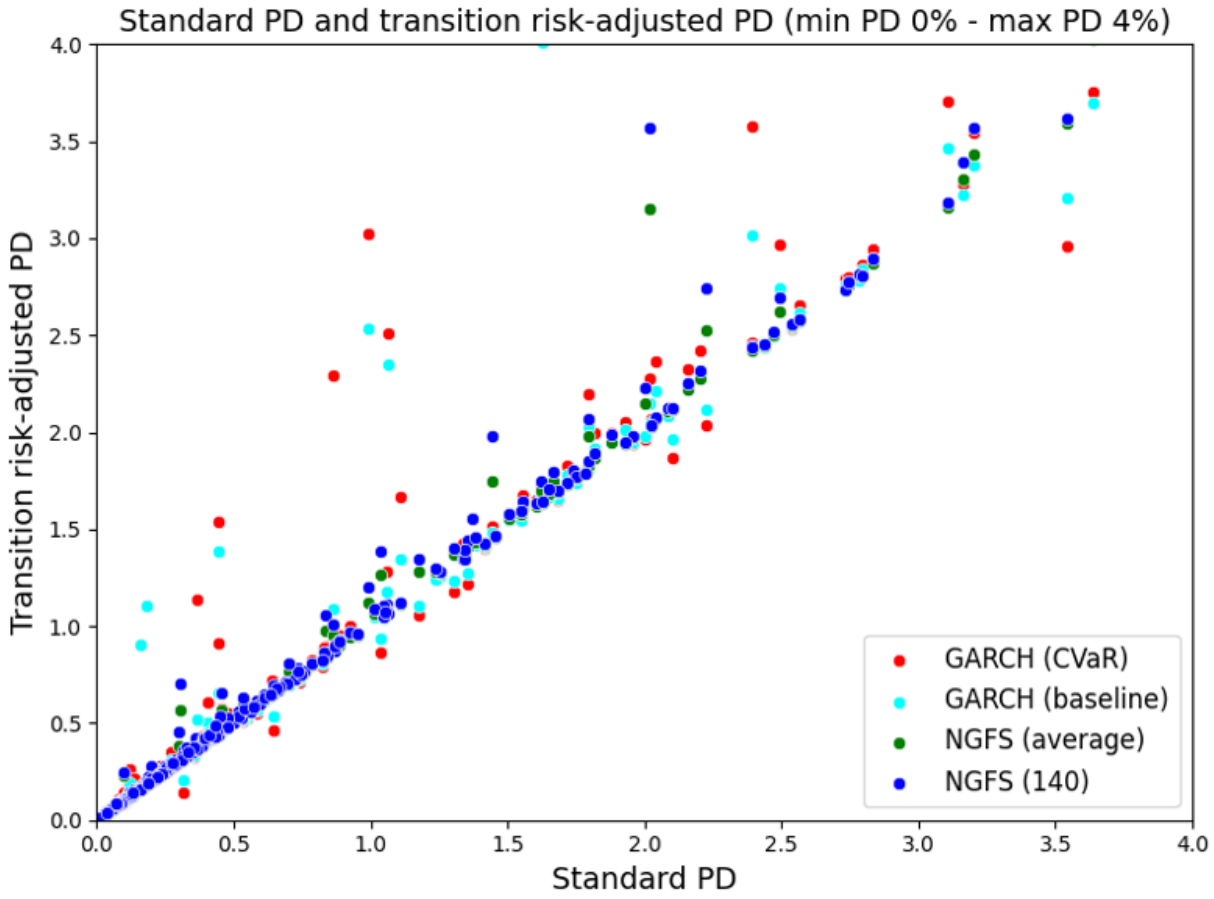
The EU-ETS methodology is responsive to:

- **TR shocks**
- **Cost (downgrade) and revenue changes (upgrade)**

Figure 4 – 1-year probability of default sensitivity to TR. Baseline scenario vs CVaR scenario.

Note: Cyan points represent the baseline scenario PDs, and red points represent the CVaR scenario PDs. The panel reports PDs in percentage.

6. Results (III)



Broader dispersion around the 45° line of baseline EU-ETS scenario data points than the adverse NGFS scenario ones

The new methodology integrates TR more flexibly (by adjusting risk class) compared to the carbon tax approach (NGFS) and sectoral data approach (top-down)

Figure 5 - 1-year probability of default under the baseline ETS scenario, extreme CVaR ETS scenario, average NGFS scenario, and adverse NGFS scenario.
Note: Green points represent the average NGFS scenarios PDs, and the blue points represent the worst NGFS scenario (140€/tCO2eq. tax). Cyan points represent the baseline scenario PDs, and red points represent the CVaR scenario PDs under the EU-ETS methodology. The panel reports PDs in percentage.

7. Conclusions

Key takeaways:

- We **improve** non-financial firms' **credit risk assessment** by incorporating **TR** into the estimate of 1-yr PD
- We focus on implications of **carbon pricing** on firms' **financial statements** with a **bottom-up** methodology based on **EU-ETS** transactions to measure GHG emissions of Italian firms, **listed and unlisted**
- Firms either incur extra costs from excess emissions or benefit by selling surplus allowances
- Such methodology responds to **TR shocks**, as reflected in PD changes
- Emission **allowances** enable environmentally responsible firms to benefit from TR, improving their ratings

EU-ETS data allow for a more accurate TR assessment compared to top-down sectoral emission estimation and NGFS scenarios

7. Conclusions

Policy implications

- Changes in PD level affect the valuation of collateral pledged by *banks* for **monetary policy operations**
- *Firms* with higher emissions face **borrowing** constraints relative to low-emission ones (as in Altavilla, et al., 2023)

Future research

- Exploring scenarios where environmentally virtuous firms **save on certificates** for future use
- Non-virtuous firms **pass additional costs onto final prices**, with overall impact contingent on price elasticity of their products
- Firms' **transition plans** as a risk mitigation tool

Thank you!