Climate change and credit risk

The effect of carbon taxes on Italian banks' business loan default rates

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General overview of the paper

Main research question

- What is the impact of alternative carbon taxes on Italian banks' loan default rates at the sector level in the short-term?
  - ✓ Climate policy shock: carbon tax (EUR 50, EUR 100, EUR 200, EUR 800 per ton of CO2)

Contribution to the literature

- Novel methodology based on firms' energy demand and cost structure to assess the impact on banks' credit risk via the introduction of different carbon taxes
  - ✓ Energy-demand channel
  - ✓ Transition risk
  - ✓ Short-term horizon and partial equilibrium

Strategy

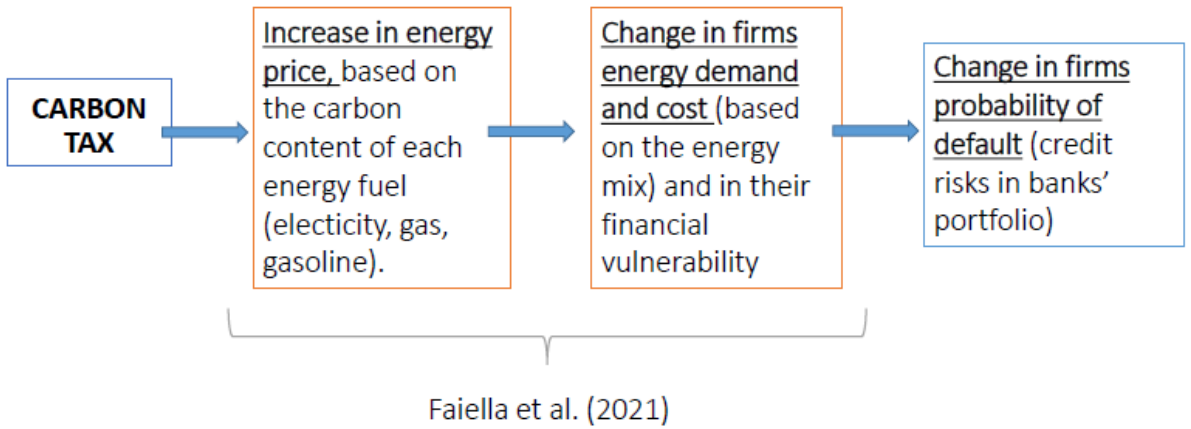
- Simple economic intuition: *ceteris paribus*, the most banks are exposed toward the most vulnerable borrowers the higher banks' credit riskiness would be

Modelling strategy

1. Econometric models for business banks' default rates at sectoral level
   - Data on firms' vulnerability (VUL) obtained from the BdI micro-simulation model (De Socio et al., 2017)
   - Financially vulnerable firm f in a given year t:

$$OP\_INC_{f,t} < 0 \quad \text{or} \quad \frac{NET\_INT\_EXP_{f,t}}{OP\_INC_{f,t}} > 0.5 \tag{1}$$

2. Estimate default rates with carbon taxes by exploiting the sectoral models and data by Faiella et al. (2021) on VUL



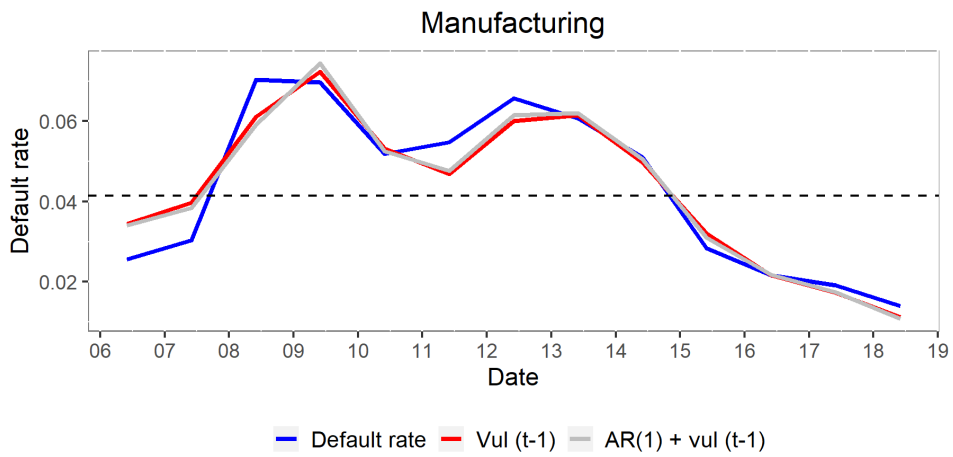
Advantages

- Building on the micro-simulation model by Faiella et al. (2021) provides *advantages* in terms of:
  - Data
    - ✓ No reliance on GHG emissions: data quality issues (expecially Scope 3), *black box*
  - Channel:
    - ✓ Impact of climate policy shocks on firms' energy demand and cost structure: heterogeneity within and across sectors
  - Short horizon (and partial equilibrium):
    - ✓ One-off climate policy shock, reducing modelling risk over longer time horizons and no dynamic balance sheet assumption is needed

Motivating evidence

- Positive and significant correlations (0-3 lags) between the share of vulnerable firms/debt and default rates at the sectoral level
- Share of vulnerable firms/debt anticipates the default rates
- Simple models capture well the trend

Figure: Example on Manufacturing



Motivating evidence

- High explanatory power for all sectors (except for Energy and Mining) although with some differences

Table: Example on Manufacturing default rate model

Model	Adj. R-sq.
AR(1)	0.672
AR(1) + $Vuln\,deb_{t-1}$	0.750
AR(1) + $rgdp\,gr_{t-1}$	0.723
AR(1) + $rgdp\,gr_{t-1}$ + $Vuln\,deb_{t-1}$	0.782
AR(1) + VA_{t-1}	0.701
AR(1) + VA_{t-1} + $Vuln\,deb_{t-1}$	0.756

$\rightarrow$ Results by Faiella et al. (2021) are informative on the impact of alternative carbon taxes on Italian banks' default rates

Data

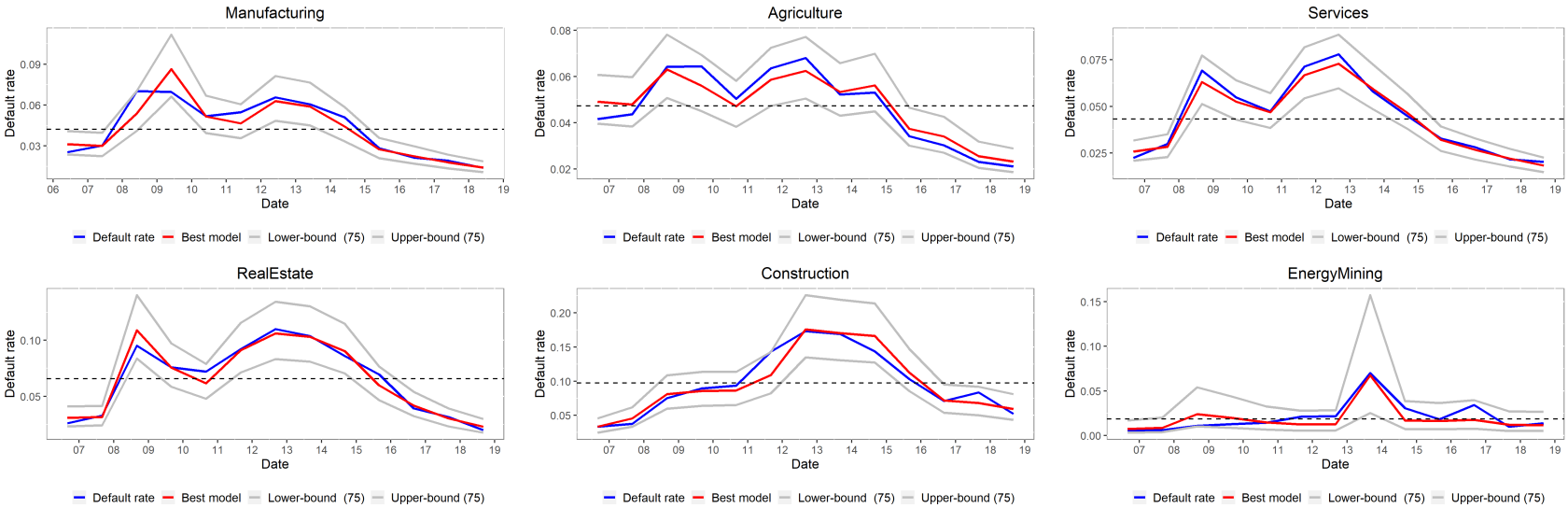
- Quartely data: DR, VUL, MACRO
  - DR: default rates at the sector level from the Italian Credit Register
  - VUL: share of vulnerable firms and debt at the sector level from BdI microsimulation model to monitor financial stability
  - MACRO: macro variables from common scenarios (i.e. GDP, oil price, inflation rate, etc.)
  - VA: sectoral value added growth rate from Eurostat
- Time series: 2006-Q1 to 2019-Q4
  - Caveat: short time series
  - Linear interpolation of VUL to obtain quarterly data from annual one
- Economic sectors: Manufacturing, Agriculture, Construction, Services, Real estate, Energy and mining
  - Focus on *Climate Policy Relevant Sectors*, i.e. the most exposed ones to transition risk (Battiston et al., 2017)

Models' selection: out-of sample

- Target variable: default rate (DR)
  - Log-odd transformation (and Linear models)
- Horizons (h): t+1, t+2, t+3, t+4
  - Direct forecast
- For each sector s and horizon h we estimate more than 210 models
- Rolling windows: T=R+P
  - R (in-sample) and P (out-of-sample)
  - First R: Q4 2014 (35 obs in- and 20 out-of-sample)
- For each h and s, we choose the *best* model in terms of min out-of-sample RMSE

Models' performance

Figure: Models selected for t+1: in-sample performance



- **Good out-of-sample predictive power for all sectors**
- Exception for Energy and Mining
  - Highly volatile DR (small and concentrated sector with big borrowers)
  - Out of the scope of the analysis (small/negligible share of loan exposure of IT banks)

Carbon tax EUR 100: impact on default rates over 1-year

Table: Average annualized quarterly DR in 2019 with tax EUR 100

	Manuf.	Agric.	Const.	Serv.	Real Est.	Tot.
No Tax	0.0144	0.0234	0.0596	0.0187	0.0232	0.028
Mean	0.0191	0.0339	0.0693	0.0306	0.0252	0.036
Low 75	0.0141	0.0258	0.0504	0.0235	0.0194	
High 75	0.0257	0.0445	0.0947	0.0399	0.0326	
Mult. factor	1.3248	1.4459	1.1656	1.6407	1.0864	1.333

- Impact assessment: what if carbon tax EUR 100 were implemented during 2018 $\rightarrow$ impact on 2019 DR
  - ✓ EUR 100 $\sim$ average price of emissions in 2022 registered in the EU-ETS system
- No tax DR: counterfactual values in 2019, estimated using the selected econometric models
  - ✓ Very close to the actual values recorded
- Heterogeneity across sectors: average increase in DR +33 per cent, still below the historical average

Carbon tax EUR 800: impact on default rates over 1-year

Table: Average annualized quartely DR in 2019 with a tax EUR 800

	Manuf.	Agric.	Const.	Serv.	Real Est.	Tot.
No Tax	0.0144	0.0234	0.0596	0.0187	0.0232	0.028
Mean	0.0263	0.0599	0.0687	0.0507	0.0252	0.046
Low 75	0.0183	0.0380	0.0499	0.0347	0.0194	
High 75	0.0376	0.0935	0.0939	0.0735	0.0326	
Mult. factor	1.8269	2.5430	1.1557	2.7118	1.0861	1.865

- Similarly, heterogeneity effect across sectors: higher increase in DR, +90 per cent, but still below historical peaks
  - ✓ EUR 800 corresponds to the value of the social cost of carbon in the event of a disorderly transition (NGFS scenarios, 2021)

Conclusions

- Building on Faiella et al. (2021) we provide a novel methodology to estimate the effect of alternative carbon taxes on the banks' business loans default rates at the sector level
- Our findings suggest a heterogenous impact on the increase in the default rates
  - The higher the carbon taxes the higher the increase in default rates
  - *Stressed* default rates remain below the historical averages (and/or peaks)
  - Partial equilibrium effect in the short run
  - Simple but easily interpretable models and results

Future extensions

- Banca d'Italia Climate Stress Testing
  - Estimate credit losses by applying *stressed* default rates (the output of our model) to individual banks' transition matrixes and credit exposures into BdI top-down stress test model
- Medium-term analysis (i.e. 3 up to 5 year horizon)
  - No (very) long term horizons to ensure results reliability
- Develop modelling framework for Households
  - To complete Italian banks' loan portfolios

Thank you!