A FINANCE APPROACH TO CLIMATE STRESS TESTING

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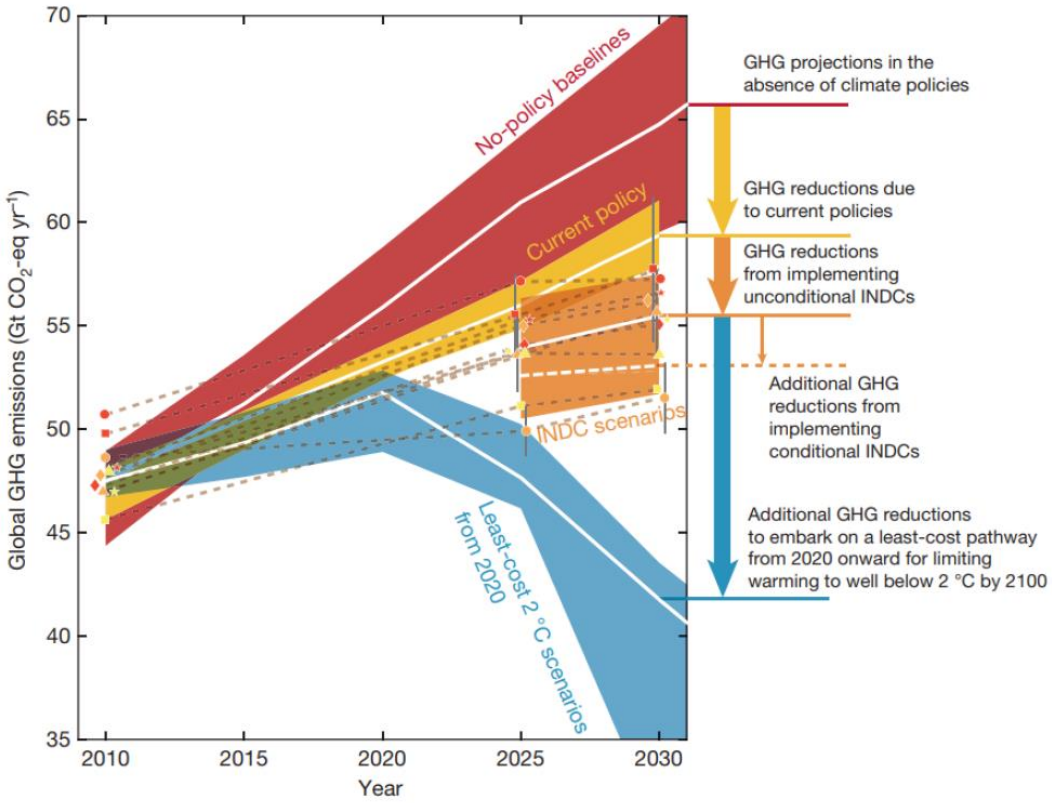
Transition risk

- **The 2015 Paris Agreement aims to limit global warming to well-below 2 degree Celsius**
- **Meeting this goal requires transition to a low-carbon economy**
  - Heavy industry (e.g., steel, cement)
  - Electricity production
  - Transportation
  - Buildings (e.g., heating)
  - Agriculture
- **Potential decarbonization drivers**
  - Climate policies (e.g., pricing, regulation, subsidies)
  - Technological developments
  - Changing consumer preferences
- **For financial institutions, this decarbonization poses transition risk**
  - Banks provide loans and equity to affected sectors
  - Banks provide loans with real-estate as collateral



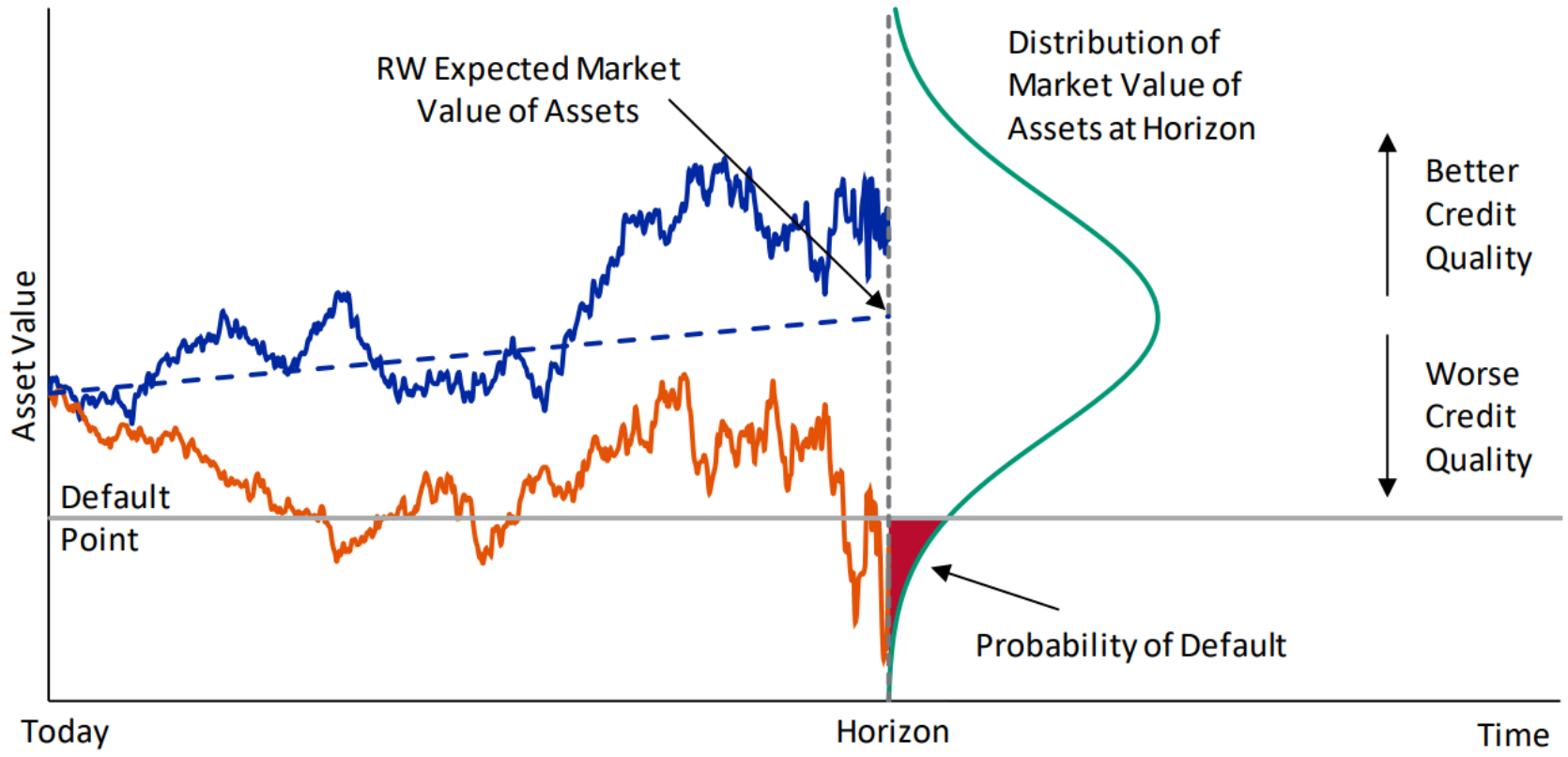
Aim and contribution

- **Develop a banking sector stress test using a tractable sector-level approach instead of a macro-financial model**
- **Allows us to estimate the impact of carbon pricing scenarios on relevant bank assets (i.e., corporate loans, residential mortgages)**
- **Focus on debt is important since, especially in the euro area, most banking assets consists of loans and bonds (only 2% is equity)**

Macro-financial approach

Sector-level (finance, contingent claims) approach

Modeling approach I

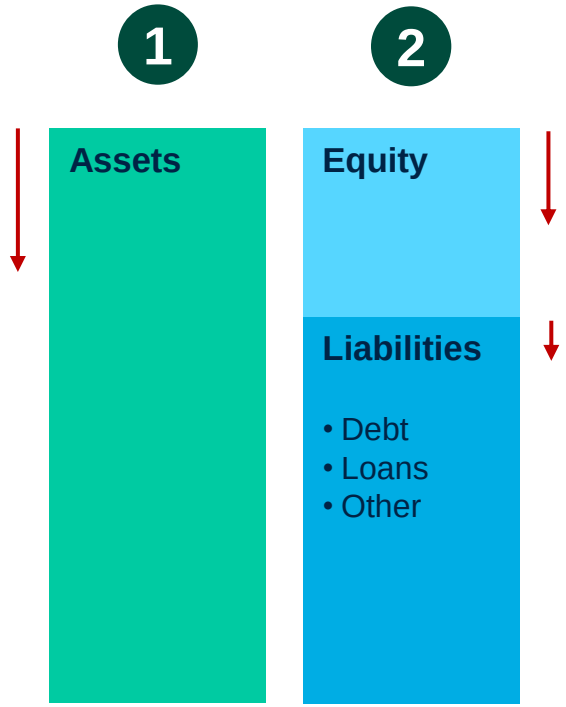


Modeling approach II

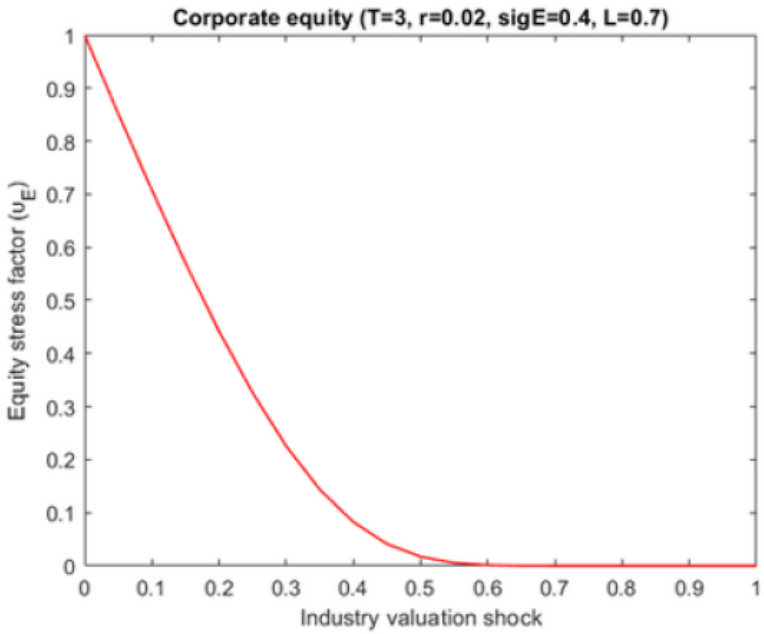
1 $$\xi_k = \frac{NPV_{tax,k}}{Total\ asset\ value_k}$$

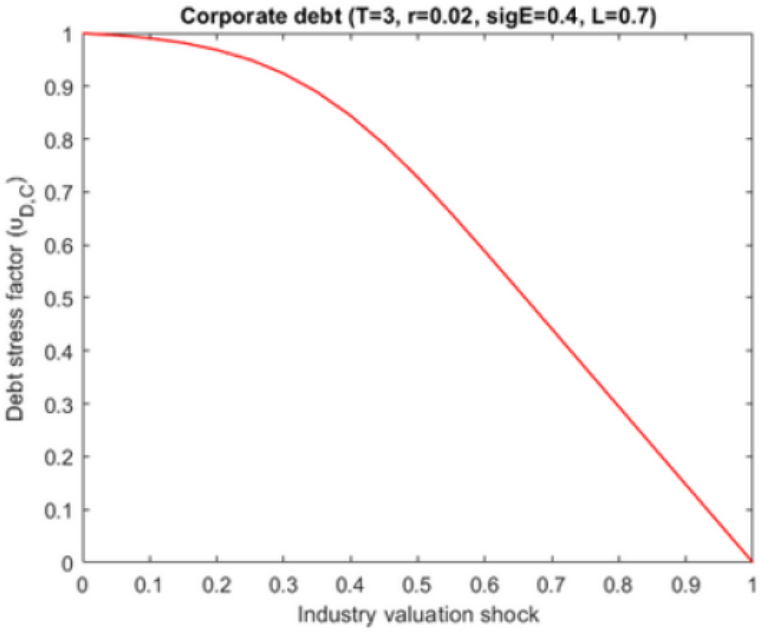
2 $$\vartheta_{E,k}\,, \vartheta_{D,k} = f_{Merton}(\xi_k, \theta_k)$$

3 $$\text{TMVL} = \sum_{k=1}^{n} \vartheta_{E,k} * exposure_{E,k} + \vartheta_{D,k} * exposure_{D,k}$$



Relationship between industry value and market value of equity and debt





Data and calibration

- **Collect data from a range of sources**
  - Trucost (firm level carbon emissions)
  - Orbis (firm level balance sheets)
  - Datastream (firm level equity volatility)
  - Eurostat (real-estate parameters)
  - Dutch central bank (bank exposure data per sector)
- **Aggregate all data to the 2-digit sectoral level**
  - Representative firm approach
  - Firm level approach
- **Estimate asset volatility of non-listed firms based on listed-firms sample to adjust for firm size bias**
- **Calculate outcomes based on standard Merton (1974) model and Merton (1976) jump diffusion model**

Asset value shock estimates (ξ_k)

€100 / tonne carbon tax		Scenario I • Regional • Abrupt	Scenario II • Regional • Phase-in	Scenario III • Global • Abrupt	Scenario IV • Global • Phase-in
A.01	Crop and animal production, hunting and related service activities	0.15	0.12	0.08	0.06
A.02	Forestry and logging	0.66	0.49	0.35	0.24
B.05	Mining of coal and lignite	0.05	0.04	0.03	0.02
B.06	Extraction of crude petroleum and natural gas	0.31	0.22	0.16	0.11
B.07	Mining of metal ores	0.19	0.13	0.10	0.06
B.08	Other mining and quarrying	0.26	0.18	0.14	0.09
B.09	Mining support service activities	0.30	0.21	0.16	0.11
C.16	Manufacture of wood and of products of wood and cork	0.08	0.05	0.04	0.03
C.17	Manufacture of paper and paper products	0.13	0.10	0.07	0.05
C.19	Manufacture of coke and refined petroleum products	0.54	0.40	0.32	0.22
C.20	Manufacture of chemicals and chemical products	0.18	0.14	0.11	0.08
C.23	Manufacture of other non-metallic mineral products	0.54	0.47	0.42	0.35
C.24	Manufacture of basic metals	0.60	0.56	0.54	0.50
D.35	Electricity, gas, steam and air conditioning supply	0.35	0.27	0.21	0.16
E.36	Water collection, treatment and supply	0.51	0.39	0.27	0.19
E.38	Waste collection, treatment and disposal activities	0.81	0.58	0.43	0.29
H.49	Land transport and transport via pipelines	0.11	0.09	0.07	0.05
H.50	Water transport	0.20	0.15	0.11	0.08
H.51	Air transport	0.74	0.52	0.39	0.26

Main results

€100 / tonne carbon tax	Scenario I • Regional • Abrupt	Scenario II • Regional • Phase-in	Scenario III • Global • Abrupt	Scenario IV • Global • Phase-in
Corporate loans and debt	13,428	7,919	5,068	2,884
Corporate equity	0	0	0	0
Residential mortgages	152	117	181	139
Total (three largest banks)	13,580	8,036	5,249	3,023
Total (market estimate)	17,190	10,172	6,647	3,827
% of CET1 capital	**14.3%**	**8.5%**	**5.5%**	**3.2%**
% of total assets	0.7%	0.4%	0.3%	0.2%

Main results

€200 / tonne carbon tax	Scenario I • Regional • Abrupt	Scenario II • Regional • Phase-in	Scenario III • Global • Abrupt	Scenario IV • Global • Phase-in
Corporate loans and debt	29,637	21,816	14,300	7,741
Corporate equity	0	0	0	0
Residential mortgages	335	253	405	303
Total (three largest banks)	29,972	22,069	14,705	8,044
Total (market estimate)	37,939	27,935	18,614	10,182
% of CET1 capital	**31.6%**	**23.3%**	**15.5%**	**8.5%**
% of total assets	1.6%	1.2%	0.8%	0.4%

Limitations

1. **Data availability**

   - Not all the required data to calibrate our model is available on a firm level. We hence have to make some assumptions on relevant parameters as well as on the representativeness of our samples in a given industry (e.g., some information is only available for listed and often larger firms).

2. **Focus on first order effects**

   - Our study focuses on the first order effects of carbon taxation on asset valuation and then on banks. We hence do not account for second order effects, such as effects on other firms along the value chain or in the rest of the economy (e.g., due to the use of tax proceeds for subsidies and increased demand for low-carbon substitutes).

3. **Assumptions in the financial modeling**

   - We rely on several standard assumptions commonly used in financial modelling. We address the this by conducting a range of sensitivity analyses.