Climate Change and the Macroeconomics of Bank Capital Regulation

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Bank capital regulation $\Leftrightarrow$ climate change

- Bank capital regulation $\Rightarrow$ climate change: **mitigation perspective**.
  - By reducing (increasing) capital requirements for clean (fossil) energy loans, bank regulation affects emissions.
  - By taking second round effects of carbon pricing into account, it facilitates stringent climate policy.
  - Qs: How effective is this? Are there side effects? Is it quantitatively relevant?

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- Climate change ⇒ bank capital regulation: **adaptation perspective**.
  - Clean transition: carbon taxes affect clean and fossil sector differently.
  - Qs: Is this quantitatively relevant for bank regulation? How should it respond optimally? Which financial frictions drive the response?

What We Do

- We propose an E-DSGE model with two layers of default.
  - Fossil energy firms cause a climate externality.
  - Bank extend defaultable loans to fossil and clean energy firms.
  - Banks can fail but depositors are protected by deposit insurance.
  - Households value liquidity of deposits.
- Standard parameterization based on Euro area data.

What We Find

- **Mitigation perspective**:
  - Emission reduction of 100% equity requirement for fossil loans corresponds at most to a 5$/ToC tax. Why?
    1. Investment elasticities to capital requirements very small.
    2. Fossil penalizing factor does not provide abatement incentives.

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  - Carbon tax reduces aggregate liquidity provision.

  ⇒ Appropriate bank regulation facilitates (slightly) larger carbon taxes.

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- **Adaptation perspective**: carbon tax shocks.
  - Clean (fossil) firms become profitable and take risk (deleverage).
  - Capital regulation as a macroprudential stabilizer at the sectoral level.
  - ⇒ Increase (decrease) of clean (fossil) capital requirements.

Related Literature

- Macro banking: Clerc et al. (2015), Bahaj and Malherbe (2020), Begenau (2020), Mendicino et al. (2020), Malherbe (2020).

- E-DSGE models with corporate finance/banking frictions: Carattini, Melkadze, and Heutel (2021), Abiry et al. (2021), Ferrari and Nispi Landi (2022), Giovanardi et al. (2022), Annicchiarico, Carli, and Diluiso (2023).

- Bank regulation and climate change: Hong, Wang, and Yang (2021), Döttling and Rola-Janicka (2022), Heider and Inderst (2022), Oehmke and Opp (2022).

Model Overview Results

- Households value liquidity service of bank deposits
  - Deposit insurance: treated as risk-free by household.
- Banks are financed by deposits or equity and invest into loans.
  - Fail if loan portfolio payoff $<$ repayment of deposits.

Model Overview

Results

- Households value liquidity service of bank deposits
  - Deposit insurance: treated as risk-free by household.
- Banks are financed by deposits or equity and invest into loans.
  - Fail if loan portfolio payoff $<$ repayment of deposits.
- Intermediate good firms (clean, fossil, non-energy) financed by loans or equity.
  - Default if investment payoff $<$ repayment of maturing loans.
- Final goods firms combine intermediate goods with labor.
  - Subject to climate externality (emissions by fossil firms).
- Public sector issues bonds, levies carbon tax, and sets capital requirements.

Banks and Deposit Supply

- Household consumes, works, and values liquidity services of bank deposits.
  - Risk-free due to **deposit insurance**.
  - Deposit insurance incurs deadweight losses from managing bank assets.
- Banks supply **deposits** & invest in gvt bonds and **loans** l_{t+1}^{τ} at prices q_t^{τ}.
- Realized return on bond portfolio $\sum_{\tau} \mathcal{R}_t^{\tau} l_t^{\tau}$ with $\tau \in \{b, c, f, n\}$.

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- Subject to an uninsurable return shock μ_t (Clerc et al., 2015).
  - Banks fail if μ_t falls below the threshold: $\overline{\mu}_t = \frac{(1+r_{t-1}^D)d_t}{\sum_{\tau} \mathcal{R}_t^{\tau} l_t^{\tau}}$.
- Banks do not voluntarily finance loans with equity due to (i) **valuation of liquidity services** and (ii) the **deposit insurance put**.

$\Rightarrow$ Bank capital requirements bind in all states.

Loan Pricing

- Banks maximize profits subject to (binding) capital requirement κ^{τ}:

$$(1 + r_t^D) d_{t+1} \leq \sum_{\tau} (1 - \kappa_t^{\tau}) \mathcal{R}_t^{\tau} l_t^{\tau} \ .$$

- Loan pricing condition contains the expected payoff $\mathcal{R}_{t+1}^{\tau}$:

$$q_t^{\tau} = \mathbb{E}_t \left[\left\{ (1 - \kappa^{\tau}) \left(\frac{1}{1 + r_t^D} - \Lambda_{t+1} (1 - F(\overline{\mu}_{t+1})) \right) + \Lambda_{t+1} (1 - G(\overline{\mu}_{t+1})) \right\} \mathcal{R}_{t+1}^{\tau} \right] \ .$$

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- The expression $\frac{1}{1+r_t^D} - \Lambda_{t+1}\big(1-F(\overline{\mu}_{t+1})\big)$ reflects
  - benefit of **financing a loan through deposits** due to their liquidity service.
  - the **deposit insurance put**.

- Note: without banking frictions, discount factor collapses to household sdf Λ_{t+1}.

Fossil Energy Firms

- Issue long-term loans l^f_{t+1} and invest in capital k^f_{t+1}.
- Firms are subject to uninsurable idiosyncratic productivity shocks $z^f_t = m_t k^f_t$.
- **Default** if repayment would exceed production revenues (reduced payoff $\mathcal{R}^f_t$).

Fossil Energy Firms

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- Firms are subject to uninsurable idiosyncratic productivity shocks $z_t^f = m_t k_t^f$.
- **Default** if repayment would exceed production revenues (reduced payoff $\mathcal{R}_t^f$).
- Unabated emissions are taxed, abatement η_t is costly (Heutel, 2012).
- Investment adjustment is costly (Primicieri et al, 2006).

Fossil Energy Firms: FOC

- Optimal abatement effort **increases** in tax rate.

- Revenues from taking up a loan (net of dilution) equal expected repayment.
  - Leverage **increases** in loan supply under standard assumptions.

- Cost of investment equals expected payoff:
  - Investment **increases** in loan supply under standard assumptions.

- Maximization problem similar for clean and non-energy firm (no abatement).

Final Good Firms

- Production function includes pollution damages:

$$y_t = (1 - \mathcal{D}(\mathcal{E}_t))A_t \widetilde{Z}_t^{\alpha} n_t^{1-\alpha} \ .$$

- Intermediate goods are a CES-bundle of energy and non-energy goods (Fried, Novan, and Peterman, 2021):

$$\widetilde{Z}_t = \left(\chi(z_t^e)^{\frac{\phi-1}{\phi}} + (1-\chi)(z_t^n)^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}} \ .$$

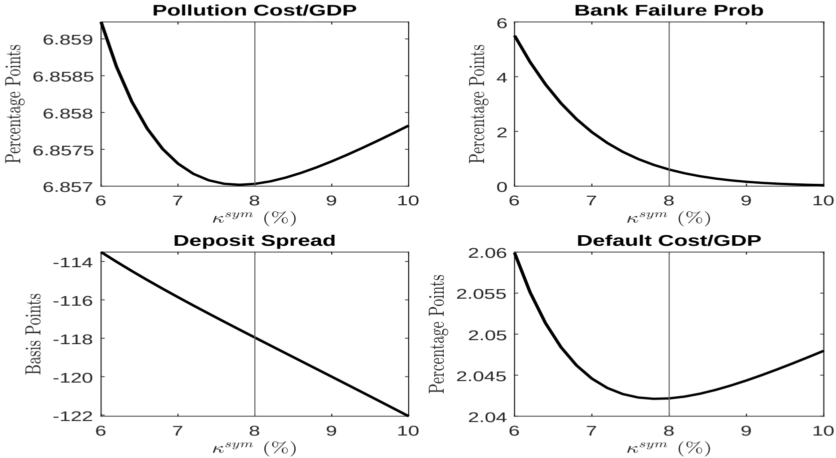
- Energy goods are a CES-bundle of fossil and clean energy:

$$z_t^e \equiv \left(\nu(z_t^c)^{\frac{\epsilon-1}{\epsilon}} + (1-\nu)(z_t^f)^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}} \ .$$

- Emissions accumulate according to $\mathcal{E}_t = \delta_E \mathcal{E}_{t-1} + (1-\eta_t) z_t^f$.

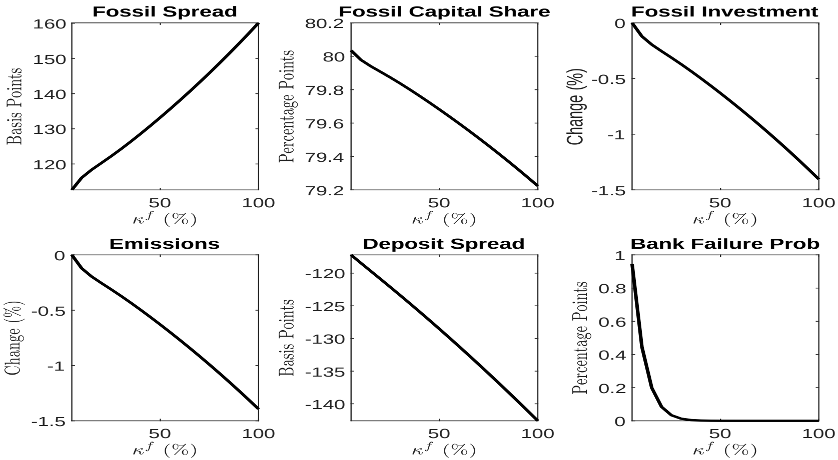
Optimal Symmetric Capital Regulation

- **Limiting excessive risk-taking** incentives by banks **and** firms.
- Ensuring sufficiently **high supply of deposits**.



Capital Regulation as Climate Policy Instrument

- **Penalizing** capital requirement for fossil loans ($\kappa^f > \kappa^{sym}$).
- Emissions decline, but non-negligible effects on banking sector.



Capital Regulation as Climate Policy Instrument

Moment	Baseline	$\kappa^f = 1$
Clean Spread	115bp	106bp
Fossil Spread	115bp	160bp
Clean Leverage	39.4%	39.6%
Fossil Leverage	39.4%	38.3%
Clean Default	2.3%	2.5%
Fossil Default	2.3%	1.7%
Fossil Capital Share	80.00%	79.22%
Δ GHG Stock	-	-1.31%
Damage/GDP	6.86%	5.0%
Bank Failure Prob	0.61%	0%
Deposit Spread	-118bp	-191bp
Δ Welfare	-	-0.37%

Notes: all moments based on calibration to euro area data. Optimal $\kappa^{sym} = 8\%$.

Capital Regulation as Climate Policy Instrument

Moment	Baseline	$\kappa^f = 1$	5.23$ tax
Clean Spread	115bp	106bp	115bp
Fossil Spread	115bp	160bp	115bp
Clean Leverage	39.4%	39.6%	39.4%
Fossil Leverage	39.4%	38.3%	39.4%
Clean Default	2.3%	2.5%	2.3%
Fossil Default	2.3%	1.7%	2.3%
Fossil Capital Share	80.00%	79.22%	79.22%
Δ GHG Stock	-	-1.31%	-7.12%
Damage/GDP	5.1%	5.0%	4.75%
Bank Failure Prob	0.61%	0%	0.61%
Deposit Spread	-117bp	-191bp	-118bp
Δ Welfare	-	-0.37%	+1.04%

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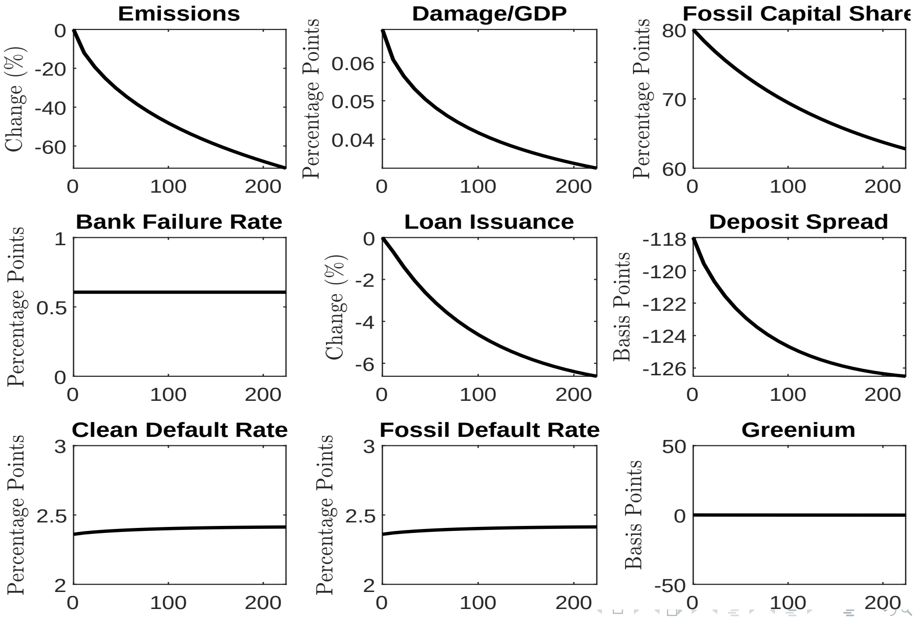
Capital Regulation as Climate Policy Instrument

Moment	Baseline	$\kappa^f = 1$	5.23$ tax	0.44$ tax
Clean Spread	115bp	106bp	115bp	115bp
Fossil Spread	115bp	160bp	115bp	115bp
Clean Leverage	39.4%	39.6%	39.4%	39.4%
Fossil Leverage	39.4%	38.3%	39.4%	39.4%
Clean Default	2.3%	2.5%	2.3%	2.3%
Fossil Default	2.3%	1.7%	2.3%	2.3%
Fossil Capital Share	80.00%	79.22%	79.22%	79.93%
Δ GHG Stock	-	-1.31%	-7.12%	-1.32%
Damage/GDP	5.1%	5.0%	4.75%	5.0%
Bank Failure Prob	0.61%	0%	0.61%	0.61%
Deposit Spread	-117bp	-142bp	-118bp	-117bp
Δ Welfare	-	-0.37%	+1.04%	+0.21%

Notes: all moments based on calibration to euro area data. Optimal $\kappa^{sym} = 8\%$.

Macro Effects of Carbon Taxes: Medium Run



Bank Regulation and Carbon Taxes: Medium Run

- **Anticipated carbon taxes**
  - reduce loan demand if intermediate goods are imperfect substitutes.
  - have no effect on bank failure rates (binding regulation).
  - do not heterogeneously affect firm default rates and debt-equity trade-off.
  - have a negative effect on liquidity provision (via bank balance sheet).
  - this increases firm risk-taking (bank refinancing cheaper).

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- Implications for **bank regulation**:
  - no scope for differentiated capital requirements.
  - symmetric relaxation of capital requirements to increase liquidity provision.
- Regulation can facilitate higher carbon taxes in the medium-run.

Bank Regulation as Facilitator

κ^{sym}	8%	8%	7.9%
Tax ($/ToC)	0	163.57	163.71
Clean Spread	115bp	112bp	112bp
Fossil Spread	115bp	112bp	112bp
Clean Leverage	39.4%	39.4%	39.4%
Fossil Leverage	39.4%	39.4%	39.4%
Clean Default	2.3%	2.4%	2.4%
Fossil Default	2.3%	2.4%	2.4%
Fossil Capital Share	80.00%	65.47%	65.48%
Bank Failure Prob	0.61%	0.61%	0.68%
Deposit Spread	-117bp	-126bp	-125bp
Δ GHG Stock	-	-61.81%	-61.84%
Damage/GDP	6.28%	2.66%	2.66%
Δ Welfare	-	+4.98%	+4.98%

Bank capital regulation ⇒ climate change

- Differentiated capital requirements are an **ineffective** climate policy instrument.
  - low elasticity of bank lending to capital requirements (macro perspective).
  - low elasticity of real investment to lending conditions.
  - Fossil-penalizing factor does not provide abatement incentives.
- Facilitator role to address adverse effects of carbon taxes on liquidity provision.
  - **Small symmetric** relaxation of capital requirements.

Macro Effect of Carbon Tax Shocks

- Abstract from policy interaction and assume stochastic tax:

  $$\tau_t = (1 - \rho_\tau)\tau^{SS} + \rho_\tau \tau_{t-1} + \sigma_\tau \epsilon_t \ .$$

- We fix $\tau^{SS} = 163.57\$/\text{ToC}$ and consider a surprise $5\$/\text{ToC}$ increase.

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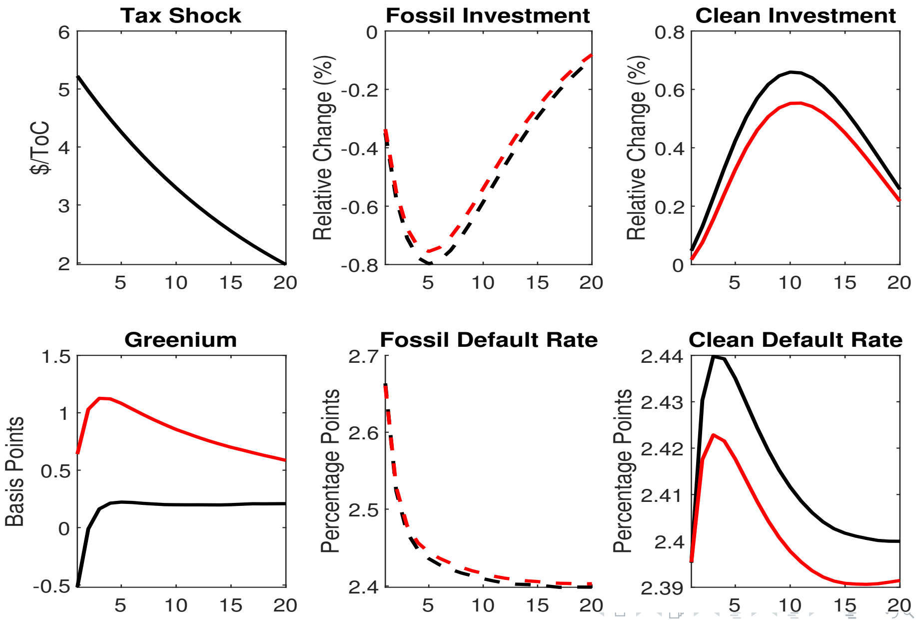
- Dynamic response of bank regulation. Simple type-specific rule:

  $$\kappa_t^\tau = \kappa^{sym}(1 + \varphi_\kappa^{sym}\widehat{\tau}_t) \ ,$$

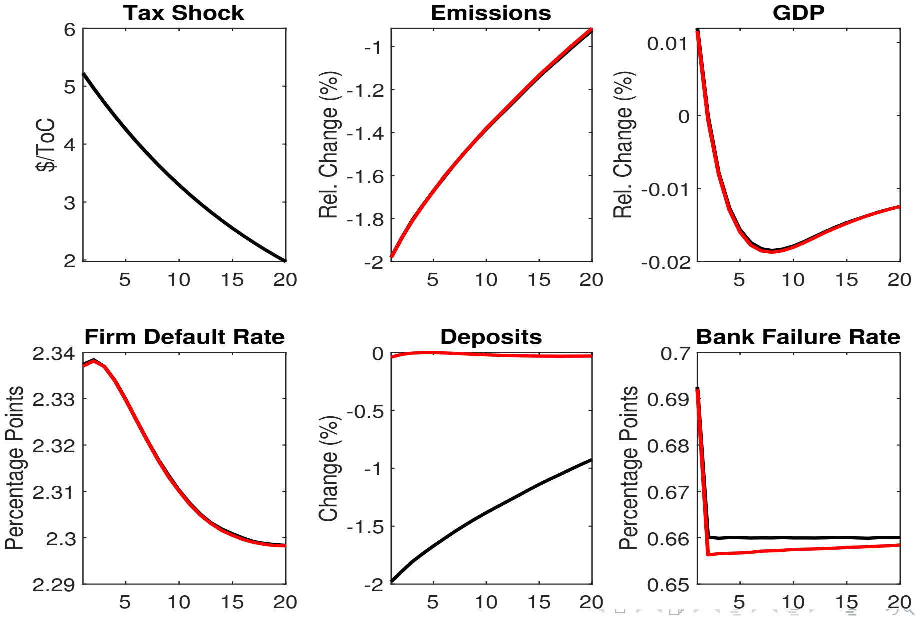
  $\varphi_\kappa^\tau > 0 \Rightarrow$ counteracts (forward-looking) credit expansion.

  $\varphi_\kappa^\tau < 0 \Rightarrow$ requires banks to hold more equity for adversely affected loans.

Sectoral Effects of Carbon Tax Shocks



Macro Effects of Carbon Taxes: Short Run



Bank Regulation and Carbon Taxes: Short-Run

- Tax shock induces **recession** and bank losses.
- Aggregate firm default rate rises ⇒ tighten cap requirements.
- Deposits scarcer ⇒ relax cap requirements.
- Quantitatively, latter effect dominates: $\varphi_\kappa^c = 0.04$ and $\varphi_\kappa^f = -0.02$.
- Response to 1 \$/ToC shock: $\kappa_t^c = 9.9\%$ and $\kappa_t^f = 6.9\%$. Why?
  - Firm risk-taking decision is forward looking.
  - Taxes already provide deleveraging incentives to fossil firms.

Conclusion

- Bank regulation not a suitable **climate policy instrument**.
  - Very *limited* efficacy, non-negligible side effects.
- Bank regulation as **facilitator** of stringent carbon taxes:
  - *Symmetric relaxation* to counteract negative effect on liquidity provision.
  - The effect on optimal climate policy is small.
- Bank regulation under climate policy as **source of risk**:
  - Slight decrease *aggregate* capital requirements.
  - Cyclical increase (decrease) of capital requirements for clean (fossil) loans.