CLIMATE TRANSITION RISK AND THE ROLE OF BANK CAPITAL REQUIREMENTS

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MOTIVATION

- Climate related risks are a growing concern among policymakers
  - → Goals set to reach net-zero require distortionary policies ⇒ transition risks
  - → Financial stability concerns: asset revaluation, credit risk, bank failure, systemic risk

- What can macroprudential policy do?
  - → How complementary are Capital Requirements (CR) with Carbon Taxes (CT)?

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CONTRIBUTION: WHAT DO WE DO?

- **Build** a DSGE with financial intermediaries (Gertler and Karadi, 2011), bank failure (Clerc et al., 2015), and fossil and low-carbon energy sectors (Diluiso et al., 2021)

- **Model** climate transition risk: carbon taxes and heightened financial risk

- **Assess** the role of capital requirements in the presence of climate transition risk

  1. Optimal CR in the medium-run steady-state with carbon taxes

  2. Capital requirements as climate policy tool

  2. Full non-linear deterministic carbon transition

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CONTRIBUTION: WHAT DO WE FIND?

- With climate transition risk $\Longrightarrow$ asymmetrical increase in sectoral CR is optimal
- Optimal sectoral CR depend on energy inputs substitution capacity
- Short-run costs but medium-run gains from increasing sectoral CR along the transition
- Macroprudential policy can complement carbon taxes in achieving emission reduction targets while staying within its mandate
- Capital requirements alone cannot substitute for climate policy action

RELATED LITERATURE

- DSGE with financial frictions and climate risk: Benmir and Roman (2020), Diluiso et al. (2021), Carattini et al. (2023)
  - → Extend to include bank failure
- DSGE with bank failure: Clerc et al. (2015), Mendicino et al. (2018), Aguilar et al. (2019), Mendicino et al. (2020)
  - → Incorporate aggregate risk from differentiated energy inputs (fossil and low-carbon)
- Structural change and green sustainable growth: Acemoglu et al. (2012), Mattauch et al. (2015), Papageorgiou et al. (2017), Jo and Miftakhova (2022)
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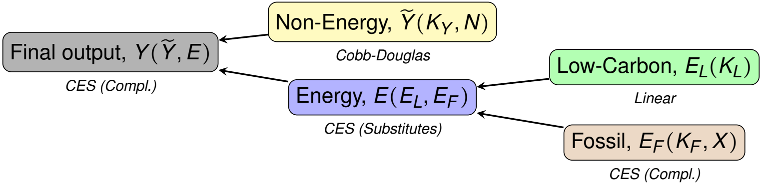

Final output, $Y(\widetilde{Y}, E)$

CES (Compl.)

Non-Energy, $\widetilde{Y}(K_Y, N)$

Cobb-Douglas

Energy, $E(E_L, E_F)$

CES (Substitutes)

Low-Carbon, $E_L(K_L)$

Linear

Fossil, $E_F(K_F, X)$

CES (Compl.)

- 3 types of capital (K_Y, K_L, K_F) + fossil natural resources (X) + labor (N)
- Elastic supply of fossil natural resources $P_{X,t}(X_t, P_{E_F,t}, E_{F,t}, \tau_{X,t})$
- Fossil natural resources = Emissions
- Banks directly invest in K_Y, K_L, K_F (Gertler and Karadi, 2011)

▸ diagram

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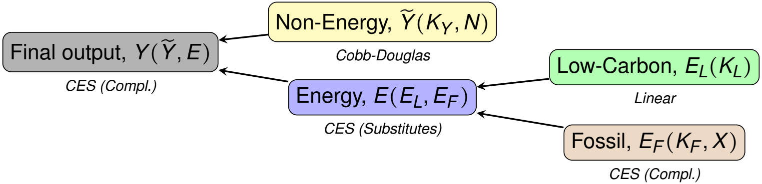

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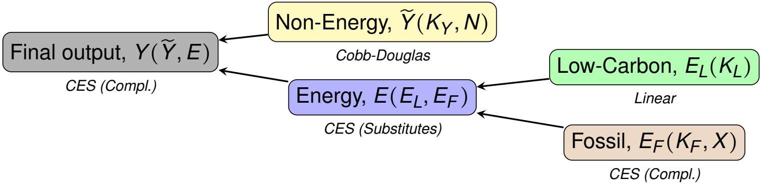

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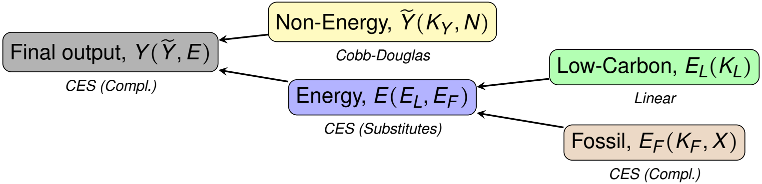

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THE MODEL: WORKERS AND BANKERS

- Households maximize $\mathbb{E}_t \sum_{i=0}^{\infty} \beta^{t+i} U(C_t, L_t)$ subject to the budget constraint
- Hold bank deposits D_t and can invest in physical capital, $S^H_{j,t}$ by paying a management fee $\zeta_{j,t}$
- Bankers (Gertler and Karadi, 2011) invest their wealth $NW_{j,t}$ in bank equity in exchange of a return $\rho_{j,t+1}$

$$NW_t = \theta \sum_j \rho_{j,t} NW_{j,t-1} + \iota_t$$

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- One period ex-ante identical ventures owned by bankers
- Enjoy limited liability $\Longrightarrow$ Bank specialization $j \in \{Y, L, F\}$
- Subject to risk on the net return from their investments $S^B_{j,t}$
  - → aggregate risk $R_{j,t+1} Q_{j,t}$
  - → idiosyncratic risk $\omega_{j,t+1} \sim LogNormal(-\frac{\tilde{\sigma}^2_{j,t}}{2}, \tilde{\sigma}_{j,t})$

$$NPV_{j,t} = \mathbb{E}_t\Big[\Lambda^B_{t+1} \max\Big[\omega_{j,t+1} \underbrace{R_{j,t+1} Q_{j,t} S^B_{j,t}}_{\text{return on assets}} - \underbrace{R^D_t D_{j,t}}_{\text{liability repayments}}, 0\Big] - \underbrace{v_t NW_{j,t}}_{\text{cost of capital}}\Big]$$

- Balance sheet constraint, $Q_{j,t} S^B_{j,t} = NW_{j,t} + D_{j,t}$
- Regulatory capital constraint, $NW_{j,t} \geq \phi_{j,t} Q_{j,t} S^B_{j,t}$

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THE MODEL: ENERGY-PRICE RISK CHANNEL

- Bank performance is affected by energy prices (Nasim et al., 2023)
- Energy-price risk channel

$$\widetilde{\sigma}_{j,t} = \sigma_j [P_{E_j,t}]^{\beta_j}$$

  → The cross-sectional volatility of banks' idiosyncratic return risk $\widetilde{\sigma}_{j,t}$ depends upon a time-invariant component σ_j and the level of sectoral energy prices $P_{E_j,t}$ weighted by β_j

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THE MODEL: AUTHORITIES

- Macroprudential authority sets capital requirements: $\phi_{Y,t}$, $\phi_{F,t}$ and $\phi_{L,t}$
  - → Sectoral CR $\{\phi_{Y,t}, \phi_{F,t}, \phi_{L,t}\}$
  - → General CR $\phi_t = \phi_{Y,t} = \phi_{F,t} = \phi_{L,t}$
- Fiscal authority balances budget
  - → Losses from the Deposit Insurance Scheme (DIS)
  - → Revenue from carbon tax is fully rebated to the households

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MAIN FEATURES

- **Energy-price risk channel**
  - → Tight link between energy prices and bank stability
- **Limited liability + deposit insurance**
  - → Banks want to lever up to the regulatory limit
- **Bank failure is costly**
  - → Deadweight costs (resolution + NBFI fees)
  - → Banks' deposit funding costs increases with average risk of bank failure
- **Macroprudential trade-off**
  - → reducing costs of bank failure vs disrupting the supply of bank credit

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BENCHMARK CALIBRATION

- Production: Euro Area

Description	Parameter	Value	Source/Target
Energy production			
Weight of fossil energy	α_F	0.8	Coenen et al. (2023)
Weight of fossil natural resources	α_X	0.3	Coenen et al. (2023)
ES between energy inputs	φ_E	3	Papageorgiou et al. (2017)
ES between capital and resources	φ_F	0.3	Coenen et al. (2023)

- Financial sector: Euro Area
  - → Bank failure rate of 0.67% (ann.) in all sectors (Mendicino et al., 2020)
  - → Optimal General CR, $\phi = 9.4\%$

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CONTERFACTUAL EXERCISES

1. Carbon Tax steady state
2. Optimal Capital Requirements with Carbon Taxes
3. How effective is macroprudential policy as sole climate policy tool?
4. Capital Requirements over the Carbon Transition

CARBON TAX STEADY STATE

- Carbon Tax ($\tau_{X,t}$) $\longrightarrow$ 35% emission reduction (European Commission, 2023)

- Large credit reallocation from fossil to low-carbon sector
- Increase in bank fragility
- GDP falls by 2%

	B	CT
Carbon Emissions, %Δ.	-	-35.3
Price of Fossil Energy, %Δ.	-	25.7
Price of Low-Carbon Energy, %Δ.	-	0.87
Price of Energy Bundle, %Δ.	-	19.2
Fossil Energy, ratio (%).	80.0	68.3
GDP, %Δ.	-	-2.12
Welfare, cons. equivalent %Δ.	-	-2.22
Fossil Bank Credit, %Δ.	-	-21.2
Low-Carbon Bank Credit, %Δ.	-	62.4
NBFI, ratio (%).	20.3	23.9
Bank Failure, annual rate (%).	0.67	2.90

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OPTIMAL CAPITAL REQUIREMENTS WITH CARBON TAX

- What is the optimal level of capital requirements with carbon taxes?

- Welfare gains from asymmetrical increase in sectoral CR

- Optimal CR indirectly support a stronger green credit transition

	B	CT	CT + GCR	CT + SCR
Non-Energy CR, ϕ_Y. Δbp.	-	-	145	142
Fossil CR, ϕ_F. Δbp.	-	-	145	183
Low-Carbon CR, ϕ_L. Δbp.	-	-	145	29
Carbon Emissions, %Δ.	-	-35.3	-35.7	-36.0
Price of Fossil Energy, %Δ.	-	25.7	25.8	26.0
Price of Low-Carbon Energy, %Δ.	-	0.87	0.80	0.23
Price of Energy Bundle, %Δ.	-	19.2	19.3	19.3
Fossil Energy, ratio (%).	80.0	68.3	68.2	67.8
GDP, %Δ.	-	-2.12	-2.19	-2.16
Welfare, cons. equivalent %Δ.	-	-2.22	-2.03	-1.98
Fossil Bank Credit, %Δ.	-	-21.2	-22.4	-23.5
Low-Carbon Bank Credit, %Δ.	-	62.4	62.9	72.0
NBFI, ratio (%).	20.3	23.9	24.5	24.2
Bank Failure, annual rate (%).	0.67	2.90	0.88	0.86

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OPTIMAL CAPITAL REQUIREMENTS: ENERGY SUBSTITUTION

- How does optimal macroprudential policy depend on the economy's capacity to substitute energy inputs?

- With higher capacity to substitute energy inputs:
  - → Smaller optimal increase in fossil and non-energy CR
  - → Larger optimal increase in low-carbon CR

	Low	Medium	High
Elasticity of substitution fossil-clean	$\varphi_E = 1.5$	$\varphi_E = 3$	$\varphi_E = 5$
Non-Energy CR, ϕ_Y. Δbp.	190	142	103
Fossil CR, ϕ_F. Δbp.	254	172	119
Low-Carbon CR, ϕ_L. Δbp.	0	29	58
Carbon Emissions, %Δ.	-35.9	-36.0	-35.9
Price of Fossil Energy, %Δ.	34.3	26.0	19.2
Price of Low-Carbon Energy, %Δ.	0.11	0.23	0.35
Price of Energy Bundle, %Δ.	26.2	19.3	13.9
Fossil Energy, ratio (%).	72.8	67.8	63.7
GDP, %Δ.	-3.11	-2.16	-1.40
Fossil Bank Credit, %Δ.	-19.5	-23.5	-26.7
Low-Carbon Bank Credit, %Δ.	31.0	72.0	104.5
NBFI, ratio (%).	25.7	24.2	23.1
Bank Failure, annual rate.	0.94	0.86	0.81

OPTIMAL CAPITAL REQUIREMENTS: ENERGY SUBSTITUTION

- How does optimal macroprudential policy depend on the economy's capacity to substitute energy inputs?

Elasticity of substitution fossil-clean	Low $\varphi_E = 1.5$	Medium $\varphi_E = 3$	High $\varphi_E = 5$
Non-Energy CR, ϕ_Y. Δbp.	190	142	103
Fossil CR, ϕ_F. Δbp.	254	172	119
Low-Carbon CR, ϕ_L. Δbp.	0	29	58
Carbon Emissions, %Δ.	-35.9	-36.0	-35.9
Price of Fossil Energy, %Δ.	34.3	26.0	19.2
Price of Low-Carbon Energy, %Δ.	0.11	0.23	0.35
Price of Energy Bundle, %Δ.	26.2	19.3	13.9
Fossil Energy, ratio (%).	72.8	67.8	63.7
GDP, %Δ.	-3.11	-2.16	-1.40
Fossil Bank Credit, %Δ.	-19.5	-23.5	-26.7
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- With higher capacity to substitute energy inputs:
  - → Smaller optimal increase in fossil and non-energy CR
  - → Larger optimal increase in low-carbon CR

CAPITAL REQUIREMENTS AS CLIMATE POLICY TOOL

- How effective is macroprudential policy as sole climate policy tool?

Elasticity of substitution fossil-clean	$\varphi_E = 1.5$	$\varphi_E = 3$	$\varphi_E = 5$
Fossil CR, ϕ_F.	50	50	50
Carbon Emissions, %Δ.	-7.4	-12.3	-19.8
Price Fossil Energy, %Δ.	17.4	17.4	17.4
Price Low-Carbon Energy, %Δ.	0.45	0.44	0.42
Price Energy, %Δ.	20.4	13.3	12.8
Fossil Energy, ratio (%).	76.2	71.9	65.4
GDP, %Δ.	-1.87	-1.71	-1.45
Fossil Bank Credit, %Δ.	-65.6	-70.7	-78.6
Low-Carbon Bank Credit, %Δ.	12.0	43.9	92.5
NBFI, ratio (%).	32.0	31.8	31.5
Bank Failure, annual rate.	1.07	1.04	0.99

- 50% Fossil CR
  - → 78% reduction in fossil bank lending ...
  - → ... only 20% emission reduction

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CLIMATE TRANSITION

1. Full non-linear deterministic **transition path** from Benchmark to Carbon Tax

   → Carbon tax unexpectedly introduced 2 years from now

2. **Compare** transition path to Carbon Tax **vs** Carbon Tax + Optimal SCR

   → Sectoral CR are phased-in in the first 4 quarters to their optimal level

◂ back

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◂ back

CLIMATE TRANSITION: SUMMARY OF RESULTS

Year	Bank (F) Credit [a]	NBFI (F) Credit [a]	*PD* [b]	*GDP* [a]	Welfare [a]
1	-7.98	0.6	-1.00	-0.04	-0.05
3	-6.62	0.8	-1.40	-0.05	-0.01
10	-5.68	1.4	-1.78	-0.1	0.2
15	-5.92	1.8	-2.00	-0.2	0.4

Differences between Carbon Tax vs Carbon Tax + Optimal SCR

- Optimal sectoral CR entails short-run costs but medium-run gains

back

CONCLUDING REMARKS

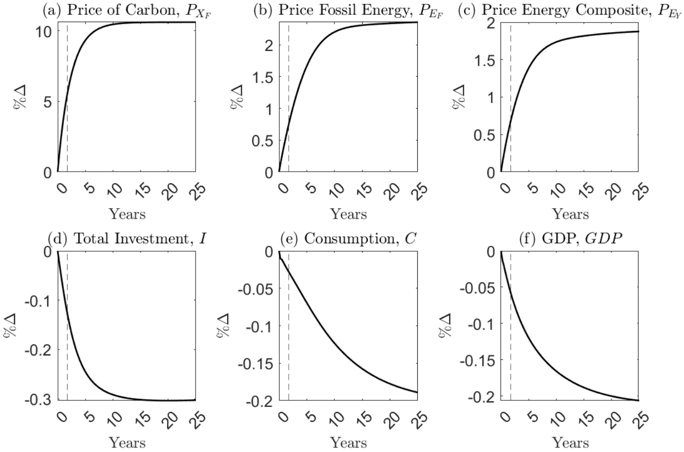
- We asses the role of macroprudential policy in DSGE model with financial frictions, bank default and energy sectors
- With climate transition risk $\Longrightarrow$ asymmetrical increase in sectoral CR is optimal
- Optimal sectoral CR depend on energy inputs substitution capacity
- Short-run costs but medium-run gains from increasing sectoral CR along the transition
- Macroprudential policy can complement carbon taxes in achieving emission reduction targets while staying within its mandate
- Capital requirements alone cannot substitute for climate policy action

BENCHMARK CALIBRATION

Description	Parameter	Value	Source/Target
Households			
Discount factor	β	0.995	2% risk-free rate
Disutility of labor	η	1	Normalization
Frisch elasticity of labor	ν	1	Carattini et al. (2023)
Risk aversion	σ	2	Carattini et al. (2023)
Government expenditure	G	0.10	$C/Y = 0.56$ (Fagan et al., 2005)
Final output			
Weight of energy sector	α_E	0.1	Eurostat (2013-2020)
ES between energy and non-energy	φ_Y	0.5	Diluiso et al. (2021)
Weight of capital	α_Y	0.36	Carattini et al. (2023)
Non-Energy Factors Efficiency	A_Y	0.33	$Y = 1$
Energy production			
Weight of fossil energy	α_F	0.8	Coenen et al. (2023)
Weight of fossil natural resources	α_X	0.3	Coenen et al. (2023)
ES between energy inputs	φ_E	3	Papageorgiou et al. (2017)
ES between capital and resources	φ_F	0.3	Coenen et al. (2023)
Energy Capital Efficiency	A_F, A_L	$\{0.02, 0.03\}$	$P_{E_F} = P_{E_L} = 1$
Capital producers			
Capital adjustment cost	ρ_Y, ρ_F, ρ_L	$\{4.57, 4.57, 4.57\}$	Mendicino et al. (2020)
Depreciation rate	$\delta_Y, \delta_L, \delta_F$	$\{0.03, 0.025, 0.02\}$	Fagan et al. (2005); Diluiso et al. (2021)
Financial sector			
Share of insured deposits	κ	0.54	Demirgüç-Kunt et al. (2015)
Survival rate of banks	θ	0.84	Bank price-to-book ratio of 1.1
Transfers from HH to bankers	χ	0.87	Bank return on equity of 7.9%
STD iid bank risk	$\sigma_Y, \sigma_F, \sigma_L$	$\{0.033, 0.033, 0.033\}$	0.67% bank failure rate

QUANTITATIVE VALIDATION

- 10% increase in P_{X_F} → 0.3% fall in GDP (Peersman and Van Robays, 2009, 2012)



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THE MODEL: DIAGRAM