Should There Be a Green Supporting Factor? Carbon Policies and Climate Financial Regulation

Frédéric Cherbonnier
TSE

Ulrich Hege
TSE

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Motivation

- "Green Supporting Factor" = differentiation of (Basel Accord) capital requirements in favor of energy transition
  - recent policy proposals as part of the EU Green Deal
  - similar to SME Supporting Factor of EU Capital Requirements Regulation (Art. 501 CRR)
  - Can be complemented by a "brown-penalizing factor"
- Central banks show interest (NGFS), but unsure about role
- Many sound arguments against climate finance regulation
  - limited prudential mandate (financial stability)
  - lack of political legitimacy due to CB independence
  - green investments may not carry lower stability risk
  - discrepancy of horizons ("tragedy of horizons")
- Should financial regulators adjust regulation to energy transition:
  - are they within their (traditional) mandate?
  - when and how should they get involved?

Motivation (2)

- Debate on climate financial regulation mostly avoids core regulatory instruments (e.g., Basel framework)
  - regulators avoid to touch Basel, and prefer looking at other venues of action, for example:
  - climate stress tests (ECB, 2021)
  - requirements for carbon transparency, reporting, impact on investor portfolios
- We look for theoretical foundations, and hence intentionally consider core regulatory instrument
  - pragmatic adjustments do not require tedious multilateral negotiations (see EU SME Supporting Factor)

Scope of Our Analysis

- We specifically address interaction of carbon policies & financial regulation
  - Consider separately optimal climate regulation when carbon price is efficient or inefficient
- We consider only regulation within financial stability mandate
  - regulator is not substituting for (democratic) policy process, only reacting to it
- Differentiate between mitigation and adaptation (resilience) since rationale for financial regulation might be different
  - whereas mitigation addresses global externality, adaptation investments are *heterogeneous* and *local*
- We focus on physical risks and abstract from transition risks
  - natural conflict between regulating physical and transition risks
  - high-powered brown penalizing-factor exacerbates the latter
  - central banks like to focus on transition risks (Disorderly scenarios of NGFS)

Literature

- Carbon policies and uncertainty about climate risks
  - Nordhaus (1994), Gillingham et al. (2015), Gollier and Kessler (2018), Gollier (2022), IPCC (2021)
- Financial stability risks and climate change
  - Bolton et al. (2020), Battiston et al. (2017), Battiston et al. (2019); Monasterolo and Raberto (2018); NGFS (2021)
- Optimal financial regulation
  - Duffie (2016), Adrian and Brunnermeier (2016), Dewatripont and Tirole (2019), Farhi and Tirole (2021)
- Interaction of carbon policies and financial regulation
  - Hagen et al. (2022), Kalkuk et al. (2020), focusing on transition risks

Outline

- Model
- Financial regulation and policy puts
- Theoretical insights
- Calibration and Policy Implications
- Conclusion

Model Overview

- Dynamic model to represent uncertainty about optimal carbon policy path and climate risk
- We focus on uncertainty about climate risk: most relevant for physical financial stability risks
  - we abstract from macro & technology risks affecting carbon trajectory
  - climate risk uncertainty implies readjustment of optimal carbon trajectory (carbon prices)
  - Optimal path of energy transition investments depends on discount rate and "climate beta"

Model

- CCAPM model with representative agent, utility $U\left(C_t\right) = \frac{1}{\gamma} C_t^{\gamma}$
- Output $\tilde{Y}_t$, exogenous
- Emissions $Q_t Y_t - I_t$, where abatement I_t determined by abatement spending: $A_t\left(I_t\right) = a_1 I_t + \frac{a_2}{2}\left(I_t\right)^2$
- Cumulative emissions $E_t = E_{t-1}(1-\delta) + \left(Q_t Y_t - I_t\right)$, leading to climate-related damage $D(E_t)$
- Damage function $D(E_t) = Y_t d(E_t)$, depending on climate sensitivity $\tilde{\omega}_1$
- Besides abatement A_t, decision on adaption expenditure R_t that reduces damages
- Consumption: $C_t = Y_t - D_t - A_t - R_t$

Adaptation Investment

- R_t = expense for climate adaptation, annualized social cost
- R_t is often local and heterogeneous. Examples:
  - new climate infrastructure (dams, shelter)
  - climate-proving of existing infrastructure and real estate
  - changes in land use, crops, and vegetation
- R_t reduces $D(E_t)$ by $fR_t^{\frac{1}{2}}$, where f = efficiency parameter
- rep. agent solves "static" optimization problem for:

$$\max_{R_t} \left\{ Y_t \left(1 - d(E_t) \left(1 - fR_t^{\frac{1}{2}} \right) - R_t \right) \right\}$$

- Optimization leads to gross damage reduction of $Y_t \frac{(df)^2}{2}$, and net damage reduction (minus R_t) of $Y_t \frac{(df)^2}{4}$
- Often, only fraction $\alpha < 1$ of benefits of R_t is internalized, incl. failure of local coordination $\leftarrow$ underinvestment

Welfare and Optimal Carbon Path

- With uncertain parameters Y_t, ω_t, a_t, dynamic optimization problem (Bellman equation):

$$V_t\left(Y_t, I_t, E_t, \omega_t, a_t\right) = \max_{\{A_t, R_t\}} \left(U\left(C_t\right) + \beta E V_{t+1}\left(Y_{t+1}, I_{t+1}, \ldots\right)\right)$$

subject to:

$$\begin{aligned} C_t &= Y_t\left(1 - d\left(E_t\right)\left(1 - fR_t^{\frac{1}{2}}\right) - R_t\right) - A_t\left(I_t\right) \\ A_t\left(I_t\right) &= a_1 I_t + \frac{a_2}{2}\left(I_t\right)^2 \\ E_t &= E_{t-1}(1-\delta) + \left(Q_t Y_t - I_t\right) \end{aligned}$$

Welfare and Optimal Carbon Path (2)

- Euler condition of this problem leads to equation:

$$\left(A_t' - d'\left(E_t\right)\right) = E\left[\beta(1-\delta)\frac{U'\left(C_{t+1}\right)}{U'\left(C_t\right)}\left(A_{t+1}' - d'\left(E_{t+1}\right)\right)\right]$$

  where:
  - $A_t' - d'\left(E_t\right)$: marginal abatement reduces net income by A_t' and net damages by $-d'\left(E_t\right)$
  - $\beta(1-\delta)\frac{U'(C_{t+1})}{U'(C_t)}$ = stochastic discount factor (SDF), depends on state of the world and "climate beta"
  - in bad scenarios, SDF is high $\rightarrow$ climate investment is accelerated

- Solution recursively defines optimal carbon trajectory, incl. carbon price p_t^* that follows a stochastic process and increases at rate defined by SDF

Financial Regulation: Capital Requirements

- Green Supporting Factor for climate-related investments
- Regulator makes an adjustment in risk weight RW
  - illustration: bank ROE of 15%, Tier 1 ratio = 8% of equity, debt funding costs of 1%
  - with risk weight $RW = 1$, bank funding cost $r_B = 0.08 \times 15\% + 0.92 \times 1\% = 2.12\%$
  - when $RW^G = 0.5$ (as for EU SME Supporting Factor): $r_B^G \downarrow$ to $r_B^G = 0.04 \times 15\% + 0.96 \times 1\% = 1.56\%$
  - Say adaptation project has 75% leverage (infrastructure)
  - When $RW \downarrow$ from 1 to 0.5, project cost $r_{CC} \downarrow$ by about 10% (depends on cost of equity)
  - Similar for effect on A_t

Capital Requirements: Effect on Funding Costs

- Socially efficient financing cost determined by climate discount rate, r_{CLIM} (Gollier, 2022: $r_{CLIM} = 3.5\%$)
- Effective cost of capital r_{CC} depends on project WACC: wedge in annual funding cost of $c_R \cdot R_t > R_t$
  - Elasticity of c_R increases in project lifetime
- Net effect on financing cost now accounts for $c_R \cdot R_t$:

$$Y_t \left(1 - d \left(1 - fR_t^{\frac{1}{2}}\right) - c_R R_t\right) - Y_t (1 - d) = Y_t \frac{(df)^2}{4c_R}$$

- Financial frictions magnify effect:, when $RW \downarrow$ from 1 to 0.5: financing capacity doubled for equity-constrained banks
  - Important e.g. for public development banks

Climate Emergencies: Public Policy Puts

- Ex-post efficient reaction of authorities in adverse climate scenarios: mitigate climate shock for private agents
  - "Public policy put option" = all public policies, fiscal and monetary, in climate-related emergencies
  - Puts lead to damage reduction for rep. agent, limiting damage to $Y_t d(E_t)\, b$, where $b < 1$
- Ex ante, financial regulator optimally attempts to offset such perverse incentives with differentiated capital requirements
- Regulator could fully compensate $b < 1$ with a proportional decrease in capital cost c_R, so that $\frac{b}{c_R}$ constant
- Regulator only concerned about financial stability: will only partially compensate

Baseline Case: Efficient Carbon Prices and Adaptation

- Assumption 1: carbon price path adjusts efficiently over time
- Assumption 2: full local internalization of benefits of resilience investments ($\alpha = 1$), no bailout benefits
- Assumption 3: No policy puts, $b = 1$.

- **Proposition 1:** With Assumptions 1 - 3, there is no role for climate financial regulation

- Intuition:
  - carbon price path implements optimal abatement A_t
  - absent policy put benefits and when $\alpha = 1$, agent chooses optimal resilience expenditure R_t

Effect of Policy Puts (Optimal Carbon Path)

- Relax Assumption 3: policy put with $b < 1$ in adverse climate scenarios
- Keep Assumptions 1 and 2: efficient carbon price, $\alpha = 1$
- **Proposition 2:** role for climate financial regulation
  - Financial regulator introduces differentiated capital requirements for R_t, but not for A_t
  - R_t lower and carbon price higher than in baseline
- Intuition: policy put weakens incentive to invest in adaptation
- Carbon policies only target emissions, not resilience
- Optimal carbon prices adjust to policy put and financial regulator's ex ante stance: higher than in baseline as regulator's action limited to financial stability concerns

Optimal Carbon Path, Inefficient Adaptation Investments

- Relax Assumption 2 of full local internalization: $\alpha < 1$
- Maintain Assumptions 1 and 3: efficient carbon price, $b = 1$
- **Proposition 3:** role for climate financial regulation
  - Financial regulator introduces differentiated capital requirements for R_t, but not for A_t
  - R_t lower and carbon price higher than in baseline
- Intuition: $\alpha < 1$ has similar effect as policy put (Prop. 2), reduces resilience spending: same response of regulator
- Financial regulation is not the only (or optimal) policy instrument. But as long as other corrective tools insufficient, regulator will react and (partially) address climate externality

Inefficient Carbon Path

- Relax Assumption 1: carbon prices do not follow efficient trajectory (conflict scenario)
- (initially maintain Assumptions 2 and 3, then relax together)
  - this is probably the most likely case
- **Proposition 4**: Regulator will differentiate to encourage investments in abatement A_t *and* resilience R_t
  - if $\alpha = 1$ and $b = 1$: regulator only differentiates capital requirements for abatement investments A_t
  - if also R_t inefficient $(\alpha < 1$ and/or $b < 1)$: regulator also differentiates rules in favor of resilience investments R_t
- When carbon policies fail, other actors and mechanisms partially assume their role
- Financial regulator stay within financial stability mandate: climate mitigation impact smaller than socially optimal

Calibration: Approach

- Choose parameters where each shock on Y_t, ω_1, a_t is binomially distributed, for 6 periods (10 years) from 2022 to 2082, following IPCC, Nordhaus, Gollier (2022), and Dietz, Gollier, and Kessler (2018)
- Focus on uncertainty about climate risk, (ω_1)
  - Take mean and uncertainty approx. from IPCC AR6 (for BAU): mean 2.9 deg C, variance 1.3 deg C.
  - Translate into binomial tree of six 10-year periods
  - represent skewness by assuming that bad shock less likely, $p_U = 0.3$.
- Other parameters follow Gollier (2022) and Dietz, Gollier, and Kessler (2018)

Calibration: Carbon Policy Scenarios

- Consider two main scenarios:
  - Efficient carbon policy: "Orderly Transition". Roughly equivalent to Paris Accord objective: limit warming to 1.5 deg C, carbon-neutral after 2052 and global carbon budget of 650 Gt CO2e until then
  - Inefficient carbon policy: "Hothouse World": roughly equivalent to static BAU scenario: continued emission of 40 Gt CO2e per year
- When is climate damage a financial stability risk?
- Possible threshold: economic loss $>$ 10% of local GDP
- Optimal adjustment of *RW* depends on
  - financial stability-related portion of climate damage
  - social cost of financial regulation

Calibrating Aggregate Damages (Mitigation): Carbon Policy Scenarios

- Efficient: "Orderly Transition":
  - substantial variation in damage function after 2050 ($>$ 15% of GDP in worst case in 2070)
  - these events very unlikely as of today (Prob. $<$ 0.3%), so tiny impact on differentiated capital requirements today
  - but substantial differentiation will be delayed, occurs in future bad scenarios
- Inefficient: "Hothouse World" (BAU):
  - strong variation of damages, and high damages with substantial probability (20% damage in 2052 with prob. 3%).
  - regulator cannot ignore adverse scenarios, will substantially differentiate capital requirements much sooner

Adaptation Investments

- Assumptions needed for expected value of policy put benefit: $b > 20\%$ probably realistic (Covid-19)
- Assumptions needed to model local carbon damages
  - local variation in climate-related shocks and heterogeneity in adaptation efforts
  - example calibrations can use insights from ECB (2021) stress tests, but need additional parameters

Policy Implications

- Policy puts and inefficient resilience investment justify differentiated rules even when carbon path efficient
- Capital rules should be differentiated *unless* carbon policies *and* resilience are efficient
- Argument in favor of dual-track approach: Green Supporting Factors react to efficient or inefficient carbon policies
- Currently, "Hothouse World" the relevant scenario: regulator will start differentiating much sooner
- Overall impact can be neutralized with Brown-Penalizing Factor
- Integrating transition risks might lead to more cautious approach

Financial Regulation of Adaptation: Thoughts

- Theory favors local variation in differentiation geared towards adaptation
  - Calibrating adjustments will be case-dependent
- But some general insights are possible:
  - depends on effectiveness of local collective action ($\alpha \approx 1$) and role of private sector financing
  - defining Brown-Penalizing Factors for investments with deficient adaptation will be challenging
  - cannot avoid addressing optimal trade and migration impact (comparative advantage)

Conclusion

- Theory foundations for Green Supporting Factor: central banks and regulators should account for climate risk of assets
- Model with carbon policies, efficient and inefficient, and two types of climate investments: mitigation and adaptation
- Magnitude (and timing) of differentiation depends on carbon policies
- Simple binomial framework that can be completed with parameters, to derive calibrated approximations for risk weight adjustments