The New Keynesian Climate Model

Jean-Guillaume Sahuc[1, 2] Frank Smets[3, 4] Gauthier Vermandel[5, 6, 1]

[1]Banque de France
[2]Université Paris-Nanterre
[3]European Central Bank
[4]Ghent University
[5]CMAP, Ecole polytechnique, Institut Polytechnique de Paris.
[6]LEDa, Paris-Dauphine and PSL Universities.

– Bank of Spain, Madrid, Nov 2024 –

Introduction

- Climate change will change the macroeconomic landscape in the next decades and the central bank will have to face 2 phenomena [Schnabel 2022]:
  - On the one hand, a warming planet causes damages that will make resources scarcer & prices higher → **climateflation**.
  - On the other hand, the fight against climate change through increasing carbon taxes will increase production costs → **greenflation**.
- How should the central bank conduct monetary policy in this new landscape?
- Answering this question requires a new class of IAM with New Keynesian ingredients to capture inflation dynamics.

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This paper

- The canonical New Keynesian model (e.g. Woodford, 2003) has not been design for climate analysis.
- This paper develops The New Keynesian Climate (NKC) model by:
  - extending the canonical model with a carbon accumulation constraint and a mitigation policy from the Integrated Assessment Model (IAM) literature;
  - estimating this model for the world economy with techniques that take into account nonlinearities resulting from climate change;
  - providing projections up to horizon 2100 under mitigation versus *laissez-faire* policy by changing an exogenous carbon tax rate.
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Methodological breakthrough

- Standard view: stable propagation mechanism with fluctuations naturally decaying over time back to a steady state [Smets and Wouters 2007].
- Climate problem: cumulative emissions permanently changes the propagation patterns → no steady state.
- We solve our nonlinear model taking into account both long and short term effects using the Fair and Taylor (1983)'s extended path solution method.
- We estimate the model using Bayesian nonlinear techniques based on the inversion filter from Fair and Taylor (1983).
- Methodology embedded into Dynare to allow an update of the macro toolkit of central bankers.

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Literature

Our paper is connected to three literatures:

- IAMs analyze the long-term effect of carbon accumulation [Nordhaus 1992; Dietz and Venmans 2019; Barrage and Nordhaus 2023; Folini et al. 2024], but ignore fluctuations and/or price rigidity.
- E-DSGE with nominal rigidities [Annicchiarico and Di Dio 2015; Ferrari and Nispi Landi 2022; Benmir and Roman 2022; Coenen et al. 2023; Del Negro et al. 2023; Airaudo et al. 2023; Nakov and Thomas 2023; Olovsson and Vestin 2023], but no explicit demographic and climate trends.
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Outline

Plan

NKC MAIN INGREDIENTS

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Climate main ingredients: Carbon stock

- Irreversible carbon in GtC (TCRE framework):

$$\tilde{m}_t = \tilde{m}_{t-1} + \xi_m e_t, \tag{1}$$

$\xi_m \geq 0$ physical parameter translating $GtCO_2$ into GtC.

- CO_2 emissions are given by:

$$e_t = \sigma_t (1 - \mu_t) y_t \varepsilon_{e,t} \tag{2}$$

$\sigma_t = \sigma_{t-1}(1 - g_{\sigma,t})$ decoupling rate of carbon emissions
$\varepsilon_{e,t}$ AR(1) emission shock
μ_t abatement share

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- Determination of the marginal cost

$$\max_{\{y_{j,t},\mu_{j,t}\}} mc_{j,t}y_{j,t} - \underbrace{w_t n^d_{j,t}}_{\text{labor cost}} - \underbrace{\theta_{1,t}\mu^{\theta_2}_{j,t}y_{j,t}}_{\text{Abatement cost}} - \underbrace{\tau_{e,t}e_{j,t}}_{\text{carbon tax}} \tag{3}$$

$\theta_{1,t} = (p_b/\theta_2)(1-\delta_{pb})^{t-t_0}\sigma_t$ exogenous efficiency of abating carbon [Barrage and Nordhaus 2023]
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Climate main ingredients: Damage function

- Monopolistic firm j's production function:

$$y_{j,t} = z_t \Phi\left(\tilde{m}_t\right) n_{j,t}^{\alpha} \tag{4}$$

- Following Golosov et al. (2014), exponential economic damages:

$$\Phi(\tilde{m}_t) = \exp(-\gamma \tilde{m}_t) \tag{5}$$

$\gamma \geq 0$ the damage parameter

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Carbon accumulation and its damages:

$$\textbf{IS:} \quad \left(\frac{\tilde{y}_t x_t - \omega d}{1-\omega}\right)^{-\sigma_c} = \beta \mathbb{E}_t \frac{\varepsilon_{b,t+1}}{\varepsilon_{b,t}} \frac{r_t}{\pi_{t+1}} \left((1-\omega) \left(\frac{x_{t+1}\tilde{y}_{t+1} - \omega d}{1-\omega}\right)^{-\sigma_c} + \omega d^{-\sigma_c} \right)$$

$$x_t = 1 - (1-\vartheta) 0.5 \kappa \left(\pi_t - \pi_t^*\right)^2 - \vartheta (1 - \varepsilon_{p,t} mc_t)$$

$$\textbf{PC:} \quad \left(\pi_t - \pi_t^*\right) \pi_t = (1-\vartheta) \beta \mathbb{E}_t \, g_{z,t} \tilde{y}_{t+1} / \tilde{y}_t \left(\pi_{t+1} - \pi_{t+1}^*\right) \pi_{t+1} + \zeta \kappa^{-1} \varepsilon_{p,t} mc_t + \kappa^{-1} (1 - \zeta)$$

$$mc_t = \psi \left(x_t \tilde{y}_t - \omega d\right)^{\sigma_c} \tilde{y}_t^{(1+\sigma_n)/\alpha - 1} \, \Phi\left(\tilde{m}_t\right)^{-(1+\sigma_n)/\alpha}$$

$$\textbf{MP:} \quad r_t = r_{t-1}^{\rho} \left[r_r \left(\pi_t^*/\pi\right) \left(\pi_t/\pi_t^*\right)^{\phi_\pi} \left(\tilde{y}_t / \tilde{y}_t^n\right)^{\phi_y} \right]^{1-\rho} \varepsilon_{r,t}$$

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$$mc_t = \psi \left(x_t \tilde{y}_t - \omega d\right)^{\sigma_c} \tilde{y}_t^{(1+\sigma_n)/\alpha - 1} \, \Phi\left(\tilde{m}_t\right)^{-(1+\sigma_n)/\alpha}$$

MP:
$$r_t = r_{t-1}^{\rho} \left[r_r \left(\pi_t^*/\pi\right) \left(\pi_t/\pi_t^*\right)^{\phi_\pi} \left(\tilde{y}_t / \tilde{y}_t^n\right)^{\phi_y} \right]^{1-\rho} \varepsilon_{r,t}$$

CC:
$$\tilde{m}_t = \tilde{m}_{t-1} + \xi_m \, \sigma_t \, z_t \, l_t \, \tilde{y}_t \, \varepsilon_{e,t}$$

Anthropogenic carbon stock

The New Keynesian Climate Model

Carbon accumulation and its damages:

IS:
$$\left(\frac{\tilde{y}_t x_t - \omega d}{1-\omega}\right)^{-\sigma_c} = \beta \mathbb{E}_t \frac{\varepsilon_{b,t+1}}{\varepsilon_{b,t}} \frac{r_t}{\pi_{t+1}} \left((1-\omega) \left(\frac{x_{t+1}\tilde{y}_{t+1} - \omega d}{1-\omega}\right)^{-\sigma_c} + \omega d^{-\sigma_c} \right)$$

$$x_t = 1 - (1-\vartheta) 0.5 \kappa \left(\pi_t - \pi_t^*\right)^2 - \vartheta (1 - \varepsilon_{p,t} mc_t)$$

PC:
$$\left(\pi_t - \pi_t^*\right)\pi_t = (1-\vartheta)\beta \mathbb{E}_t \, g_{z,t} \tilde{y}_{t+1}/\tilde{y}_t \left(\pi_{t+1} - \pi_{t+1}^*\right)\pi_{t+1} + \zeta \kappa^{-1} \varepsilon_{p,t} mc_t + \kappa^{-1}(1-\zeta)$$

$$mc_t = \psi \left(x_t \tilde{y}_t - \omega d\right)^{\sigma_c} \tilde{y}_t^{(1+\sigma_n)/\alpha - 1} \, \Phi\left(\tilde{m}_t\right)^{-(1+\sigma_n)/\alpha}$$

Deterministic Decoupling trend

MP:
$$r_t = \ldots [\ldots /\pi_t^*)^{\phi_\pi} \left(\tilde{y}_t/\tilde{y}_t^n\right)^{\phi_y}\Big]^{1-\rho} \varepsilon_{r,t}$$

CC:
$$\tilde{m}_t = \tilde{m}_{t-1} + \xi_m \, \sigma_t \, z_t \, l_t \, \tilde{y}_t \, \varepsilon_{e,t}$$

Anthropogenic carbon stock

The New Keynesian Climate Model

Carbon accumulation and its damages:

IS:
$$\left(\frac{\tilde{y}_t x_t - \omega d}{1-\omega}\right)^{-\sigma_c} = \beta \mathbb{E}_t \frac{\varepsilon_{b,t+1}}{\varepsilon_{b,t}} \frac{r_t}{\pi_{t+1}} \left((1-\omega)\left(\frac{x_{t+1}\tilde{y}_{t+1} - \omega d}{1-\omega}\right)^{-\sigma_c} + \omega d^{-\sigma_c}\right)$$

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$$mc_t = \psi\left(x_t\tilde{y}_t - \omega d\right)^{\sigma_c} \tilde{y}_t^{(1+\sigma_n)/\alpha - 1}\, \Phi\left(\tilde{m}_t\right)^{-(1+\sigma_n)/\alpha}$$

Deterministic Decoupling trend

MP:
$$r_t = \ldots /\pi_t^*)^{\phi_\pi} \left(\tilde{y}_t/\tilde{y}_t^n\right)^{\phi_y}\Big]^{1-\rho} \varepsilon_{r,t}$$

CC:
$$\tilde{m}_t = \tilde{m}_{t-1} + \xi_m\, \sigma_t\, z_t\, l_t\, \tilde{y}_t\, \varepsilon_{e,t}$$

Anthropogenic carbon stock

Deterministic TFP trend

Carbon accumulation and its damages:

IS:
$$\left(\frac{\tilde{y}_t x_t - \omega d}{1-\omega}\right)^{-\sigma_c} = \beta \mathbb{E}_t \frac{\varepsilon_{b,t+1}}{\varepsilon_{b,t}} \frac{r_t}{\pi_{t+1}} \left((1-\omega) \left(\frac{x_{t+1}\tilde{y}_{t+1} - \omega d}{1-\omega}\right)^{-\sigma_c} + \omega d^{-\sigma_c} \right)$$
$$x_t = 1 - (1-\vartheta) 0.5 \kappa \left(\pi_t - \pi_t^*\right)^2 - \vartheta (1 - \varepsilon_{p,t} mc_t)$$

PC:
$$\left(\pi_t - \pi_t^*\right) \pi_t = (1-\vartheta) \beta \mathbb{E}_t \; g_{z,t} \tilde{y}_{t+1} / \tilde{y}_t \left(\pi_{t+1} - \pi_{t+1}^*\right) \pi_{t+1} + \zeta \kappa^{-1} \varepsilon_{p,t} mc_t + \kappa^{-1} (1-\zeta)$$
$$mc_t = \psi \left(x_t \tilde{y}_t - \omega d\right)^{\sigma_c} \tilde{y}_t^{(1+\sigma_n)/\alpha - 1} \; \Phi\left(\tilde{m}_t\right)^{-(1+\sigma_n)/\alpha}$$

MP: r_t = ...

CC:
$$\tilde{m}_t = \tilde{m}_{t-1} + \xi_m \, \sigma_t \, z_t \, l_t \, \tilde{y}_t \, \varepsilon_{e,t}$$

Deterministic Decoupling trend (σ_t)

Deterministic population trend (l_t)

Deterministic TFP trend (z_t)

Anthropogenic carbon stock ($\tilde{m}_t$)

Carbon accumulation and its damages:

IS:
$$\left(\frac{\tilde{y}_t x_t - \omega d}{1-\omega}\right)^{-\sigma_c} = \beta \mathbb{E}_t \, \frac{\varepsilon_{b,t+1}}{\varepsilon_{b,t}} \frac{r_t}{\pi_{t+1}} \left((1-\omega)\left(\frac{x_{t+1}\tilde{y}_{t+1} - \omega d}{1-\omega}\right)^{-\sigma_c} + \omega d^{-\sigma_c}\right)$$

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PC:
$$\left(\pi_t - \pi_t^*\right)\pi_t = (1-\vartheta)\beta \mathbb{E}_t \; g_{z,t} \tilde{y}_{t+1}/\tilde{y}_t \left(\pi_{t+1} - \pi_{t+1}^*\right)\pi_{t+1} + \zeta \kappa^{-1} \varepsilon_{p,t} mc_t + \kappa^{-1}(1-\zeta)$$

$$mc_t = \psi \left(x_t \tilde{y}_t - \omega d\right)^{\sigma_c} \tilde{y}_t^{(1+\sigma_n)/\alpha - 1} \; \Phi\left(\tilde{m}_t\right)^{-(1+\sigma_n)/\alpha}$$

MP: $r_t = \ldots$

CC:
$$\tilde{m}_t = \tilde{m}_{t-1} + \xi_m \, \sigma_t \, z_t \, l_t \, \tilde{y}_t \, \varepsilon_{e,t}$$

Deterministic Decoupling trend (σ_t)

Deterministic population trend (l_t)

Emission AR(1) shock ($\varepsilon_{e,t}$)

Anthropogenic carbon stock ($\tilde{m}_t$)

Deterministic TFP trend (z_t)

The New Keynesian Climate Model

Carbon accumulation and its damages:

$$\textbf{IS:} \quad \left(\frac{\tilde{y}_t x_t - \omega d}{1-\omega}\right)^{-\sigma_c} = \beta \mathbb{E}_t \, \frac{\varepsilon_{b,t+1}}{\varepsilon_{b,t}} \frac{r_t}{\pi_{t+1}} \left((1-\omega) \left(\frac{x_{t+1}\tilde{y}_{t+1} - \omega d}{1-\omega}\right)^{-\sigma_c} + \omega d^{-\sigma_c} \right)$$

$$x_t = 1 - (1-\vartheta) 0.5 \kappa \left(\pi_t - \pi_t^*\right)^2 - \vartheta (1 - \varepsilon_{p,t} mc_t)$$

$$\textbf{PC:} \quad \left(\pi_t - \pi_t^*\right) \pi_t = (1-\vartheta) \beta \mathbb{E}_t \, g_{z,t} \tilde{y}_{t+1} / \tilde{y}_t \left(\pi_{t+1} - \pi_{t+1}^*\right) \pi_{t+1} + \zeta \kappa^{-1} \varepsilon_{p,t} mc_t + \kappa^{-1} (1-\zeta)$$

$$mc_t = \psi \left(x_t \tilde{y}_t - \omega d\right)^{\sigma_c} \tilde{y}_t^{(1+\sigma_n)/\alpha - 1} \, \Phi \left(\tilde{m}_t\right)^{-(1+\sigma_n)/\alpha}$$

← **Climate damages**

$$\textbf{MP:} \quad r_t = r_{t-1}^{\rho} \left[r_r \left(\pi_t^* / \pi\right) \left(\pi_t / \pi_t^*\right)^{\phi_\pi} \left(\tilde{y}_t / \tilde{y}_t^n\right)^{\phi_y} \right]^{1-\rho} \varepsilon_{r,t}$$

$$\textbf{CC:} \quad \tilde{m}_t = \tilde{m}_{t-1} + \xi_m \, \sigma_t \, z_t \, l_t \, \tilde{y}_t \, \varepsilon_{e,t}$$

The New Keynesian Climate Model

Mitigation policies as function of exogenous carbon tax $\tilde{\tau}_t$:

Mitigation expenditures

$$\textbf{IS:} \quad \left(\frac{\tilde{y}_t x_t - \omega d}{1-\omega}\right)^{-\sigma_c} = \beta \mathbb{E}_t \frac{\varepsilon_{b,t+1}}{\varepsilon_{b,t}} \frac{r_t}{\pi_{t+1}} \left((1-\omega) \left(\frac{x_{t+1}\tilde{y}_{t+1} - \omega d}{1-\omega}\right)^{-\sigma_c} + \omega d^{-\sigma_c} \right)$$

$$x_t = 1 - (1-\vartheta)0.5\kappa \left(\pi_t - \pi_t^*\right)^2 - \vartheta(1 - \varepsilon_{p,t} mc_t) - \theta_{1,t}\tilde{\tau}_t^{\theta_2/(\theta_2-1)}$$

$$\textbf{PC:} \quad \left(\pi_t - \pi_t^*\right)\pi_t = (1-\vartheta)\beta\mathbb{E}_t\, g_{z,t}\tilde{y}_{t+1}/\tilde{y}_t \left(\pi_{t+1} - \pi_{t+1}^*\right)\pi_{t+1} + \zeta\kappa^{-1}\varepsilon_{p,t} mc_t + \kappa^{-1}(1-\zeta)$$

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$$\textbf{MP:} \quad r_t = r_{t-1}^{\rho} \left[r_r \left(\pi_t^*/\pi\right) \left(\pi_t/\pi_t^*\right)^{\phi_\pi} \left(\tilde{y}_t/\tilde{y}_t^n\right)^{\phi_y} \right]^{1-\rho} \varepsilon_{r,t}$$

$$\textbf{CC:} \quad \tilde{m}_t = \tilde{m}_{t-1} + \xi_m\, \sigma_t\, z_t\, l_t\, \tilde{y}_t\, \varepsilon_{e,t} \left(1 - \tilde{\tau}_t^{1/(\theta_2-1)}\right)$$

The New Keynesian Climate Model

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$$x_t = 1 - (1-\vartheta) 0.5 \kappa \left(\pi_t - \pi_t^*\right)^2 - \vartheta (1 - \varepsilon_{p,t} mc_t) - \theta_{1,t} \tilde{\tau}_t^{\theta_2/(\theta_2 - 1)}$$

Carbon tax costs

PC:
$$\left(\pi_t - \pi_t^*\right) \pi_t = (1-\vartheta) \beta \mathbb{E}_t \, g_{z,t} \tilde{y}_{t+1}/\tilde{y}_t \left(\pi_{t+1} - \pi_{t+1}^*\right) \pi_{t+1} + \zeta \kappa^{-1} \varepsilon_{p,t} mc_t + \kappa^{-1} (1-\zeta)$$

$$mc_t = \psi \left(x_t \tilde{y}_t - \omega d\right)^{\sigma_c} \tilde{y}_t^{(1+\sigma_n)/\alpha - 1} \, \Phi \left(\tilde{m}_t\right)^{-(1+\sigma_n)/\alpha} + \theta_{1,t} \tilde{\tau}_t \left(\theta_2 + (1-\theta_2) \tilde{\tau}_t^{1/(\theta_2 - 1)}\right)$$

MP:
$$r_t = r_{t-1}^{\rho} \left[r_r \left(\pi_t^*/\pi\right) \left(\pi_t/\pi_t^*\right)^{\phi_\pi} \left(\tilde{y}_t/\tilde{y}_t^n\right)^{\phi_y} \right]^{1-\rho} \varepsilon_{r,t}$$

CC:
$$\tilde{m}_t = \tilde{m}_{t-1} + \xi_m \, \sigma_t \, z_t \, l_t \, \tilde{y}_t \, \varepsilon_{e,t} \left(1 - \tilde{\tau}_t^{1/(\theta_2 - 1)}\right)$$

The New Keynesian Climate Model

Mitigation policies as function of exogenous carbon tax $\tilde{\tau}_t$:

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$$\textbf{IS:} \quad \left(\frac{\tilde{y}_t x_t - \omega d}{1-\omega}\right)^{-\sigma_c} = \beta \mathbb{E}_t \, \frac{\varepsilon_{b,t+1}}{\varepsilon_{b,t}} \frac{r_t}{\pi_{t+1}} \left((1-\omega) \left(\frac{x_{t+1}\tilde{y}_{t+1} - \omega d}{1-\omega}\right)^{-\sigma_c} + \omega d^{-\sigma_c} \right)$$

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Carbon tax costs

$$\textbf{PC:} \quad \left(\pi_t - \pi_t^*\right) \pi_t = (1-\vartheta) \beta \mathbb{E}_t \, g_{z,t} \tilde{y}_{t+1}/\tilde{y}_t \left(\pi_{t+1} - \pi_{t+1}^*\right) \pi_{t+1} + \zeta \kappa^{-1} \varepsilon_{p,t} mc_t + \kappa^{-1} (1 - \zeta)$$

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$$\textbf{MP:} \quad r_t = r_{t-1}^{\rho} \left[r_r \left(\pi_t^*/\pi\right) \left(\pi_t/\pi_t^*\right)^{\phi_\pi} \left(\tilde{y}_t/\tilde{y}_t^n\right)^{\phi_y} \right]^{1-}$$

Abatement share

$$\textbf{CC:} \quad \tilde{m}_t = \tilde{m}_{t-1} + \xi_m \, \sigma_t \, z_t \, l_t \, \tilde{y}_t \, \varepsilon_{e,t} \left(1 - \tilde{\tau}_t^{1/(\theta_2-1)}\right)$$

Plan

Estimation

- Estimation on world data from 1985Q1 to 2023Q3 (sources: World Bank, OECD and OurWorldInData).

- There are four observable variables:

$$\begin{bmatrix} \text{Real output growth rate} \\ \text{Inflation rate} \\ \text{Short-term interest rate} \\ \text{CO}_2 \text{ emissions growth rate} \end{bmatrix} = 100 \times \begin{bmatrix} \Delta \log(y_t) \\ \pi_t - 1 \\ r_t - 1 \\ \Delta \log(e_t) \end{bmatrix}$$

Estimation

- Our statistical model is an extension of Fair and Taylor (1983) to deal with trends:

$$\tilde{y}_t = g_\Theta\left(y_0, y, 0\right) \tag{6}$$

$$y_t = \mathbb{E}_{t,t+S}\left\{g_\Theta\left(y_{t-1}, \tilde{y}_{t+S+1}, \varepsilon_t\right)\right\} \tag{7}$$

$$\mathcal{Y}_t = h_\Theta\left(y_t\right) \tag{8}$$

$$\varepsilon_t \sim \mathcal{N}\left(0, \Sigma_\varepsilon\right) \tag{9}$$

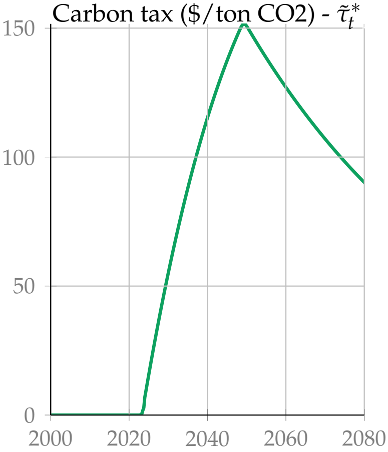
- Compute the deterministic path $\tilde{y}_t$, add stochastic innovations through extended path $\mathbb{E}_{t,t+S}\{\cdot\}$ with expectation horizon S.
- Maximize sample likelihood $\mathcal{L}(\theta, \mathcal{Y}_{1:T^*})$ & run Metropolis-Hastings to compute uncertainty bands.

Estimation

- Large uncertainty about future carbon tax: implications for estimation in particular at the end of the sample.
- Let $\tilde{\tau}_t^*$ denote the Paris-Agreement tax, with linear decrease in carbon emissions up to 2050;
- We let the data inform about the market-based expectations on future carbon mitigation policies:

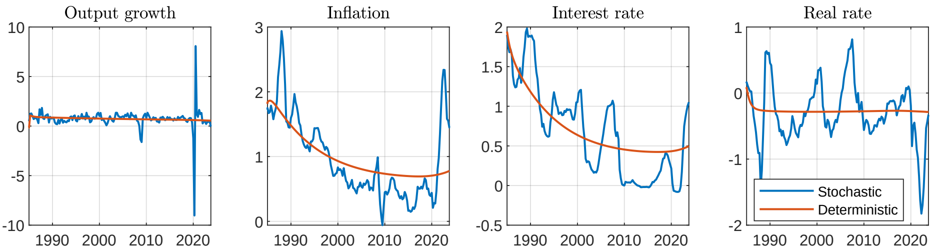
$$\mathbb{E}_t\{\tilde{\tau}_t\} = \varphi \tilde{\tau}_t^*$$

where $\varphi \in [0, 1]$ is the fraction of believers (or expected intensity) of Paris-Agreement policy.



Stochastic and deterministic paths

Figure 1: Implied deterministic and stochastic paths



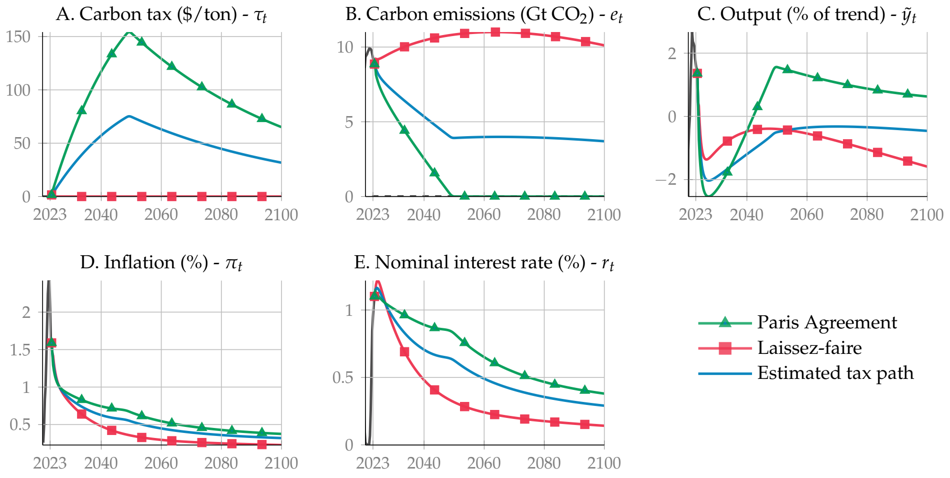
Plan

The Anatomy of Green/Climateflation

- What is the future macroeconomic landscape by the end of the century?
- We consider three alternative scenarios based on the realization of the carbon tax $\varphi\tilde{\tau}_t^*$:
  - Paris-Agreement with $\varphi = 1$.
  - Estimated carbon path with $\varphi = 0.53$.
  - Laissez-faire with $\varphi = 0$.

Three Transitions

Figure 2: Model-implied projections based on alternative control rates of emissions



Dissecting the PC curve

- Stabilization objective of a central bank: important to understand how climate affects inflation.
- One can split the marginal cost into three term:

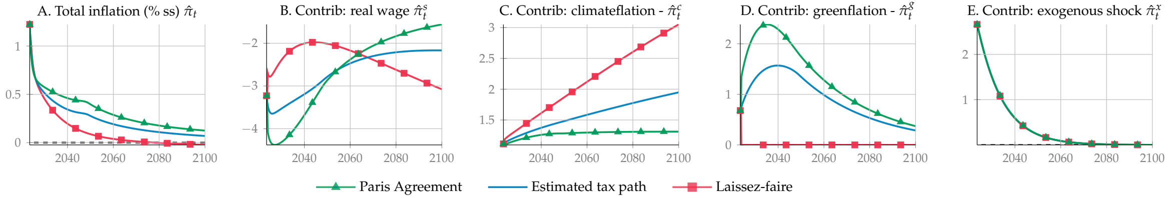
$$mc_t = \underbrace{\tilde{w}_t}_{\text{real wage}} / \underbrace{\Phi\left(m_t\right)}_{\text{climateflation}} + \underbrace{\theta_{1,t}\mu_t^{\theta_2} + \tau_{e,t}\sigma_t\left(1-\mu_t\right)\varepsilon_{e,t}}_{\text{greenflation}}, \tag{10}$$

which allows to break down inflation into 4 different forces:

$$\hat{\pi}_t \simeq \underbrace{\hat{\pi}_t^s}_{\text{wage term}} + \underbrace{\hat{\pi}_t^c}_{\text{climateflation}} + \underbrace{\hat{\pi}_t^g}_{\text{greenflation}} + \underbrace{\hat{\pi}_t^x}_{\text{exogenous shocks}} \tag{11}$$

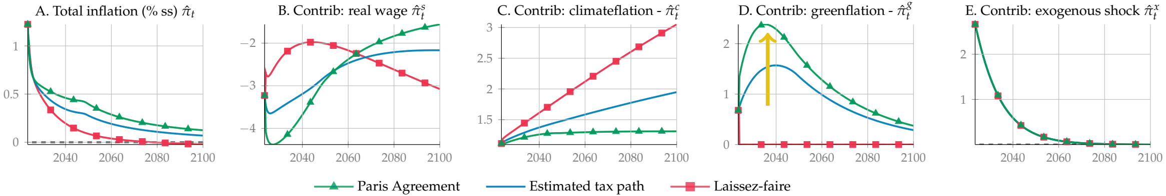
with $\hat{\pi}_t = \pi_t - \pi_t^\star$

Dissecting the PC curve



- Under Paris Agreement:
  - The immediate increase in carbon tax fuels inflation.
  - General equilibrium effect: increasing abatement expenditures reduces both consumption and in turn the wealth effect on the labor supply.
  - Net zero stabilizes damages, and hence climateflation.

Dissecting the PC curve



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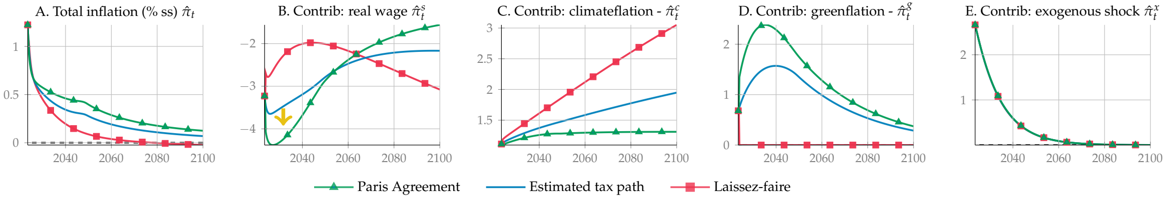

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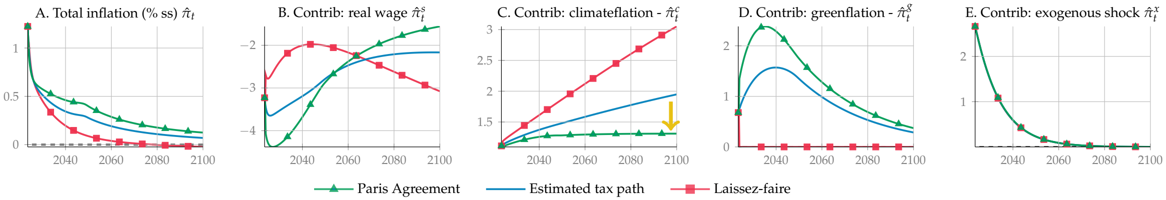

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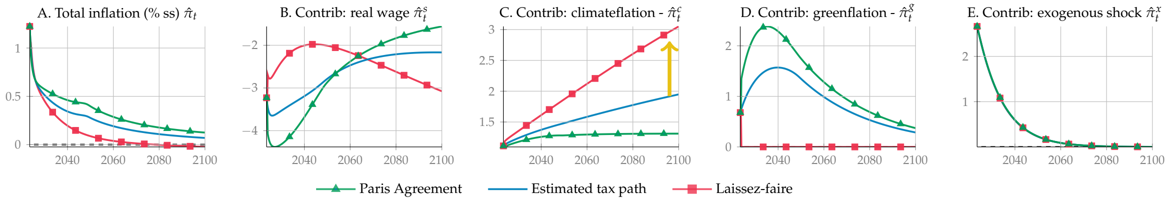

- Under Laissez-faire:
  - The rising damage makes resources scarcer: ever growing inflation as long as planet warms.
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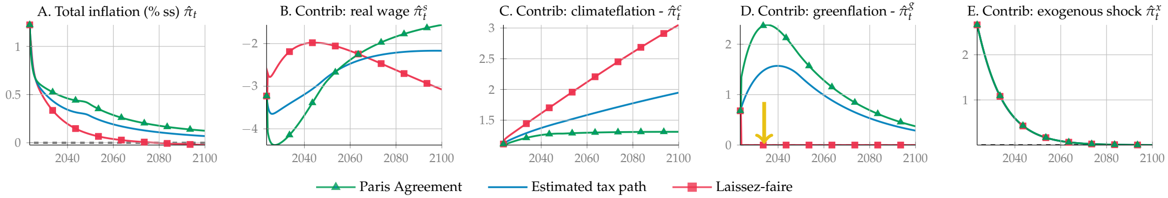

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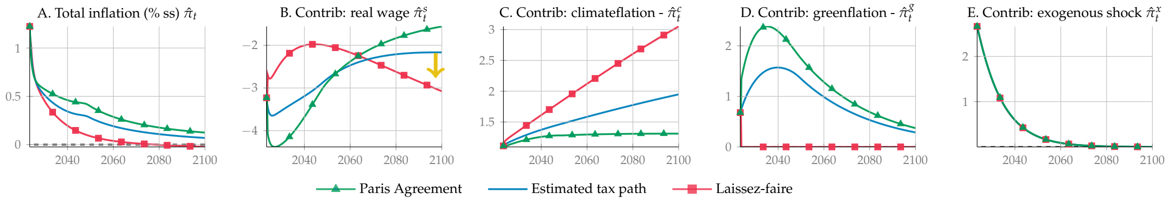

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What drives greenflation?

Inflationary Transition: Robust Across Various Specifications:

- Does capital in production increase inflation?
  - **Yes!** By dampening the cooling effects from real wage cuts.
- Do social transferts matter for greenflation?
  - **Yes!** Progressive redistribution softens the consumption decline, mitigating the recession.
- Do sticky wages increase inflation?
  - **Yes!** By reducing the decreases in real wages.
- Does implementing the optimal transition increase inflation?
  - **Yes (in the short term)!** SCC increases faster initially, boosting greenflation.

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  - **Yes!** By reducing the decreases in real wages.
- Does implementing the optimal transition increase inflation?
  - **Yes** (in the short term)! SCC increases faster initially, boosting greenflation.

What drives greenflation?

Inflationary Transition: Robust Across Various Specifications:

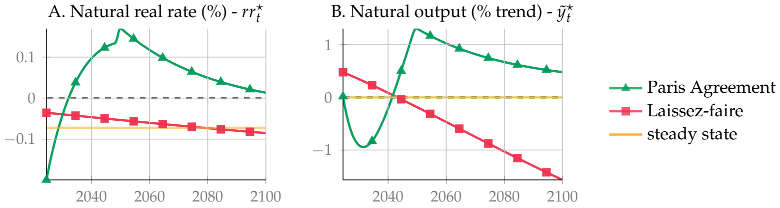
- Does capital in production increase inflation?
  - **Yes!** By dampening the cooling effects from real wage cuts.
- Do social transferts matter for greenflation?
  - **Yes!** Progressive redistribution softens the consumption decline, mitigating the recession.
- Do sticky wages increase inflation?
  - **Yes!** By reducing the decreases in real wages.
- Does implementing the optimal transition increase inflation?
  - **Yes** (in the short term)! SCC increases faster initially, boosting greenflation.

Plan

The design of policy rules

- The New Keynesian model assumes **the natural interest rate (r^*) is stable** over time;
- This leads to monetary policy (e.g., the Taylor Rule) being designed around deviations from a steady-state targets;
- **Climate factors disrupt the natural economy** proportionally to the carbon stock/tax;
- As a result, the traditional design of monetary policy rules based on a stable (r^*) may become flawed.

The design of policy rules



- Substantial changes in the natural rate: decline under laissez faire, increase under transition;
- A standard Taylor rule could be **persistently misaligned** with the neutral rate;
- If the **natural rate is persistently lower** (higher) than the steady-state target, monetary policy could be **persistently too tight** (too loose).

The design of policy rules

Monetary policy rule reads as:

$$\varsigma_{r,t} = \varsigma_{r,t-1}^{\rho} \left[\frac{\pi_t^*}{\pi} \left(\frac{\pi_t}{\pi_t^*} \right)^{\phi_\pi} \varsigma_{y,t}^{\phi_y} \right]^{1-\rho} \varepsilon_{r,t},$$

- **Current taylor rule**:

$$\varsigma_{r,t} = r_t / r, \; \varsigma_{y,t} = y_t / y_t^*.$$

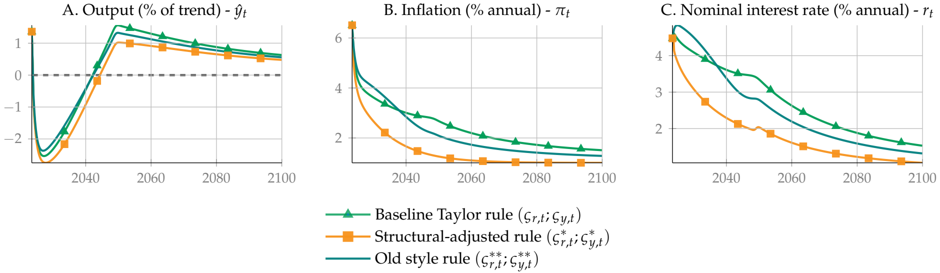
- **Structural-adjusted rule:**

$$\varsigma_{r,t}^* = r_t / r_t^*, \; \varsigma_{y,t}^* = y_t / y_t^*$$

- **Old style rule:**

$$\varsigma_{r,t}^{**} = r_t / r, \; \varsigma_{y,t}^{**} = y_t / y$$

The design of policy rules



- Baseline and old style rules are quite similar during the transition.
- Structural rule more aggressive, cutting down inflation by 1.5 percent.
- Baseline rule is too loose, inefficiently driving up inflation from misalignment with natural rate.

Plan

Conclusion

- This framework allows us to identify *climateflation* and *greenflation*
- With conservative assumptions, *climateflation* and *greenflation* are sizable and depends on how real wages adjust
- Structural change of r^* matters: could inefficiently increase inflation by 1.5 percent during transition

Thank you for your attention

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