Optimal Climate Policy with Incomplete Markets

Thomas Douenne* Sebastian Dyrda†

Albert Jan Hummel* Marcelo Pedroni*

*University of Amsterdam

†University of Toronto

Oslo, October 2025

Motivations

- Climate change might be considered "the biggest market failure the world has seen" (Stern, 2008).
  - ➢ Hence, it is an efficiency issue.
  - ➢ If no other market failure, and if equity and efficiency are orthogonal: optimal policy is Pigouvian tax, i.e. $\tau^{\text{carbon}} = SSC$.

Motivations

- Climate change might be considered "the biggest market failure the world has seen" (Stern, 2008).
  - ➢ Hence, it is an efficiency issue.
  - ➢ If no other market failure, and if equity and efficiency are orthogonal: optimal policy is Pigouvian tax, i.e. $\tau^{\text{carbon}} = SSC$.
- Yet, the real world is far from this abstraction:
  - ➢ in practice, aggregates and distributions interact;
  - ➢ redistributive policies affect incentives to work and invest;
  - ➢ some households are borrowing constrained $\rightarrow$ Ricardian equivalence fails.

Motivations

- Climate change might be considered "the biggest market failure the world has seen" (Stern, 2008).
  - ➢ Hence, it is an efficiency issue.
  - ➢ If no other market failure, and if equity and efficiency are orthogonal: optimal policy is Pigouvian tax, i.e. $\tau^{\text{carbon}} = SSC$.
- Yet, the real world is far from this abstraction:
  - ➢ in practice, aggregates and distributions interact;
  - ➢ redistributive policies affect incentives to work and invest;
  - ➢ some households are borrowing constrained $\rightarrow$ Ricardian equivalence fails.

$\rightarrow$ **How should we tax carbon in this world?**

What we do

- Develop a fiscal climate–economy model in the spirit of Barrage (2020), with inequality and uninsurable risk as in the standard incomplete-markets model.

What we do

- Develop a fiscal climate–economy model in the spirit of Barrage (2020), with inequality and uninsurable risk as in the standard incomplete-markets model.

- Theoretically:
  - characterize optimal carbon tax in this incomplete-market economy;
  - compare it with first-best Pigouvian benchmark.

- Quantitatively:
  - calibrate model to match U.S. macro data, inequality, and income risk;
  - solve a Ramsey problem to study *i)* the optimal climate policy, and *ii)* its effects on the economy.

▸ Contributions

Road map

1. Model

2. Theory

3. Quantitative analysis

4. Discussion

Model

Model: Households

- Continuum of households of size N_t, with preferences over consumption, labor, and temperature: $\mathbb{E}_0\left[\sum_t \beta^t u(c_t, h_t, Z_t)\right]$.

- Individuals characterized by assets $a \in A$ and stochastic productivity $e \in E$ that follows a Markov process with matrix Γ.

- Given a sequence of prices and taxes the household solves

$$v_t(a, e) = \max_{c_t, h_t, a_{t+1}} u\big(c_t(a, e), h_t(a, e), Z_t\big) + \beta \sum_{e_{t+1} \in E} v_{t+1}\big(a_{t+1}(a, e), e_{t+1}\big)\Gamma_{e, e_t+1},$$

subject to

$$c_t(a, e) + a_{t+1}(a, e) = (1 - \tau_t^h) w_t e h_t(a, e) + (1 + (1 - \tau_t^k) r_t) a_t + T_t,$$
$$a_{t+1}(a, e) \geq \underline{a}.$$

Model: Firms

- Final good sector

$$Y_{1,t} = (1 - D(Z_t))A_{1,t}F(K_{1,t}, H_{1,t}, E_t).$$

- Energy sector

$$E_t = A_{2,t}G\left(K_{2,t}, H_{2,t}\right)$$

Model: Firms

- Final good sector

$$Y_{1,t} = (1 - D(Z_t))A_{1,t}F(K_{1,t}, H_{1,t}, E_t).$$

- Energy sector

$$E_t = A_{2,t}G\left(K_{2,t}, H_{2,t}\right)$$

- Energy production generates emissions $E_t^M = (1-\mu_t)E_t$, with μ_t fraction of pollution abated at total costs $\Theta_t(\mu_t, E_t)$.

- With τ^e denoting carbon taxes, profits are

$$\mathcal{P}_t = p_t^e E_t - w_t H_{2,t} - (r_t + \delta)K_{2,t} - \tau_t^e E_t^M - \Theta_t\left(\mu_t, E_t\right)$$

Model: Government and Climate

- The government's budget constraint is

$$G_t + T_t + r_t B_t = \tau_t^h w_t H_t + \tau_t^k r_t (K_t + B_t) + \tau_t^e E_t^M + (B_{t+1} - B_t).$$

Model: Government and Climate

- The government's budget constraint is

$$G_t + T_t + r_t B_t = \tau_t^h w_t H_t + \tau_t^k r_t (K_t + B_t) + \tau_t^e E_t^M + (B_{t+1} - B_t).$$

- Temperature Z_t determined by history of endogenous emissions, $\{E_t^M\}$, and exogenous drivers, $\{\eta_t\}$:

$$Z_t = J(S_0, E_0^M, \ldots, E_t^M, \eta_0, \ldots, \eta_t).$$

Competitive equilibrium and Ramsey problem

- The **competitive equilibrium** is defined as usual (i.e., households and firms maximize given prices and policies, laws of motion are consistent, markets clear). ▸ Formal definition

- **Ramsey problem**: Given equilibrium constraints, chooses time path of policies $\pi \equiv \{\tau_t^h, \tau_t^k, \tau_t^e, T_t\}_{t=0}^{\infty}$ to maximize the (utilitarian) social welfare function,

$$\mathcal{W}(\pi) = \int_S \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t u\big(c_t(a_0, e_0|\pi), h_t(a_0, e_0|\pi), Z_t(\pi)\big) \right] d\lambda_0.$$

Theory

Optimal carbon tax formula (1/2)

Definition. *The* **Pigouvian tax** *is defined as*

$$\tau_t^{e,Pigou} = \frac{1}{\mathcal{W}_{c,t}} \sum_{j=0}^{\infty} \beta^j \left(\mathcal{W}_{c,t+j} D'_{t+j} A_{1,t+j} F_{t+j} - N_{t+j} \mathcal{W}_{Z,t+j} \right) J_{E_t^M, t+j}, \tag{1}$$

where $\mathcal{W}_{c,t} = \sum_i \alpha_i \sum_{e_i^t} \pi_{it} u_{c,it}$ *and* $\mathcal{W}_{Z,t} = -v'(Z_t)$.

Optimal carbon tax formula (1/2)

Definition. *The* **Pigouvian tax** *is defined as*

$$\tau_t^{e,Pigou} = \frac{1}{\mathcal{W}_{c,t}} \sum_{j=0}^{\infty} \beta^j \left(\mathcal{W}_{c,t+j} D'_{t+j} A_{1,t+j} F_{t+j} - N_{t+j} \mathcal{W}_{Z,t+j} \right) J_{E_t^M, t+j}, \tag{1}$$

where $\mathcal{W}_{c,t} = \sum_i \alpha_i \sum_{e_i^t} \pi_{it} u_{c,it}$ *and* $\mathcal{W}_{Z,t} = -v'(Z_t)$.

Proposition. *The* **second-best carbon** *tax satisfies a modified Pigouvian rule:*

$$\tau_t^{e,SB} = \frac{1}{\nu_t} \sum_{j=0}^{\infty} \beta^j \left(\nu_{t+j} D'_{t+j} A_{1,t+j} F_{t+j} - N_{t+j} \mathcal{W}_{Z,t+j} \right) J_{E_t^M, t+j},$$

with ν_t *the multiplier on the resource constraint for the final consumption good, which at the optimum satisfies:*

$$\nu_t = \mathcal{W}_{c,t} + \sum_i \alpha_i \sum_{e_i^t} \pi_{it} (SD_{it} + LD_{it}),$$

where $SD_{i,t}$ *and* LD_{it} *capture distortions through the household's intertemporal (Euler, saving decisions) and intratemporal (labor supply) conditions.*

Optimal carbon tax formula (2/2)

- The terms *SD* and *LD* depend on Lagrange multipliers, not on quantities observed in equilibrium. Some special cases:
  - *If the borrowing constraint for household i binds following both history e_i^{t-1} and history e_i^t, interactions with saving decisions are absent:* $SD_{it} = 0$.
  - *If households have GHH preferences, then* $LD_{it} = 0$ *for all i and all e_i^t.*

Optimal carbon tax formula (2/2)

- The terms *SD* and *LD* depend on Lagrange multipliers, not on quantities observed in equilibrium. Some special cases:
  - ➢ *If the borrowing constraint for household i binds following both history e_i^{t-1} and history e_i^t, interactions with saving decisions are absent:* $SD_{it} = 0$.
  - ➢ *If households have GHH preferences, then* $LD_{it} = 0$ *for all i and all e_i^t.*

- Other insight: *The second-best carbon tax can be expressed as a modified Pigouvian rule adjusted for the marginal cost of public funds (MCF).*

See formula

Optimal carbon tax formula (2/2)

- The terms *SD* and *LD* depend on Lagrange multipliers, not on quantities observed in equilibrium. Some special cases:
  - *If the borrowing constraint for household i binds following both history e_i^{t-1} and history e_i^t, interactions with saving decisions are absent: $SD_{it} = 0$.*
  - *If households have GHH preferences, then $LD_{it} = 0$ for all i and all e_i^t.*

- Other insight: *The second-best carbon tax can be expressed as a modified Pigouvian rule adjusted for the marginal cost of public funds (MCF).*

  See formula

- These results highlight mechanisms but leave the sign and size of these deviations an open question.
  - To say more about $\tau^{e,SB}$ we use computational methods.

Quantitative analysis

Calibration strategy

- Conceptual exercise: optimal policy of the U.S. with RoW behaving symetrically.
- Households: we follow Dyrda and Pedroni (2023) and target three sets of statistics:
  i) macroeconomic variables; See details
  ii) inequality statistics; See details
  iii) measures of idiosyncratic risk. See details
- Firms: as in Douenne et al (2023), updated based on Friedlingstein et al. (2022) and Barrage and Nordhaus (2023).
- Government: extend procedure of Trabandt and Uhlig (2011) up to 2019.
- Climate: model from Dietz and Venmans (2019) calibrated based on IPCC (2021), remaining parameters from Friedlingstein et al. (2022) and Barrage and Nordhaus (2023).

Computational method: Overview

- We want to find the time paths $\{\tau_t^k, \tau_t^h, \tau_t^e, T_t\}_{t=0}^{\infty}$ that maximize welfare.
- If optimal paths are smooth over time, we can approximate them with polynomials as in Dyrda and Pedroni (2023). ▸ Details
- Polynomial parameters → path of fiscal instruments → transition to new balanced-growth path → welfare.
- Optimize welfare by choosing polynomial parameters.
- Bypasses the need to rewrite the Ramsey problem recursively.

Policy experiments

We study a government that chooses time-varying carbon taxes under three fiscal regimes:

1. Fixed debt-to-GDP, fixed other taxes.
   - Level of transfers adjusts to balance the budget.
2. Flexible debt-to-GDP, fixed other taxes.
   - Transfers follow a flexible path: optimal to front-load transfers.
3. Flexible debt-to-GDP, optimal constant labor and capital taxes.
   - Optimal to increase both taxes $\tau_H = 27.7\% \rightarrow 41.5\%$, and $\tau_K = 33.6\% \rightarrow 44.7\%$.

Results: Optimal carbon tax

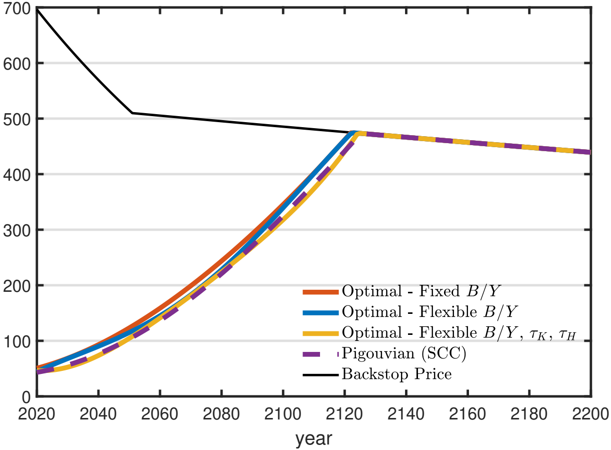


Figure: Optimal Carbon Taxes and Backstop Price (in $/tCO$_2$).

Optimal carbon tax: Takeaways

Two main takeaways from this figure:

1. Across all scenarios, the optimal carbon tax is very close to the SCC.
   - Welfare loss from doing simply Pigou: 0.008% to 0.001%.
   - Holds in an economy with significant inequality, risk, fiscal distortions, and in which Ricardian equivalence fails.
   - Holds even with strong “third-best” restrictions.

Optimal carbon tax: Takeaways

Two main takeaways from this figure:

1. Across all scenarios, the optimal carbon tax is very close to the SCC.
   - ➢ Welfare loss from doing simply Pigou: 0.008% to 0.001%.
   - ➢ Holds in an economy with significant inequality, risk, fiscal distortions, and in which Ricardian equivalence fails.
   - ➢ Holds even with strong "third-best" restrictions.

2. The paths of carbon taxes remain strikingly similar across scenarios.
   - ➢ Holds despite the economy looking vastly different across these scenarios.

Why is the optimal tax so close to the SCC?

Intuitively, deviations from Pigou optimal only if the carbon tax can effectively address (or exacerbate) other issues.

- Consider a government maximizing welfare $f(x, y)$ by choosing how much efforts to put in abatement, x, and in combating inequality, y.
- Consider now the constraint that inequality is fixed at $y = \bar{y}$. To what extent does this constraint affect the optimal level of abatement?

Why is the optimal tax so close to the SCC?

Intuitively, deviations from Pigou optimal only if the carbon tax can effectively address (or exacerbate) other issues.

- Consider a government maximizing welfare $f(x, y)$ by choosing how much efforts to put in abatement, x, and in combating inequality, y.
- Consider now the constraint that inequality is fixed at $y = \overline{y}$. To what extent does this constraint affect the optimal level of abatement?
- From first-order Taylor expansion around (x^*, y^*),

$$x^{**} - x^* \approx \frac{f_{xy}(x^*, y^*)}{f_{xx}(x^*, y^*)} (y^* - \overline{y}).$$

- If y could be freely optimized, then the optimal carbon tax would not be affected by inequality (envelope argument).
- If y can't be optimized, then optimal deviations depend on the distance $(y^* - \overline{y})$ and the cross-derivative f_{xy} relative to f_{xx}.

Distribution of Gains

Figure: Welfare Gain Relative to SSP5 (in %)

- Gains fairly evenly distributed, although richest households benefit most. ▸ See SSP5 scenario

Welfare Gain and Decomposition Relative to SSP5

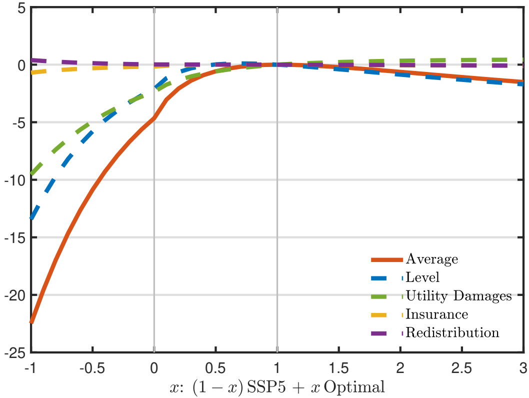


Figure: Welfare Gains and Decomposition

- Carbon taxes are efficient at fixing an efficiency problem, but they are bad at targeting inequality and risk. ▸ Decomposition

Welfare Gain and Decomposition Relative to SSP5

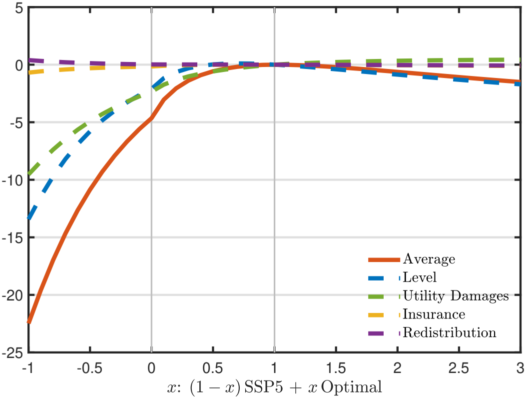


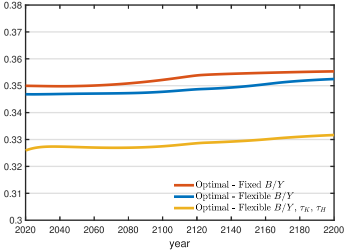
Figure: Welfare Gains and Decomposition

- Carbon taxes are efficient at fixing an efficiency problem, but they are bad at targeting inequality and risk. ▸ Decomposition
- Other insight: even with substantial inequality and risk, doing too much climate policy is (much!) better than doing too little.

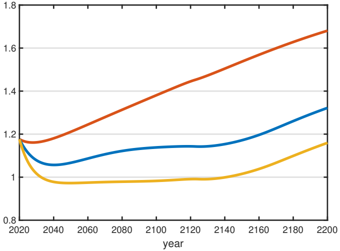
Why is the tax path almost invariant across scenarios?

- When the government can choose the timing of lump sum transfers, it chooses to front-load them massively. See figures
- When it can also choose the level of income taxes, it increases them significantly.
- This results in an economy with less inequality, less risk, but also lower output:
  - income effect from transfers, reducing labor supply;
  - higher public debt, crowding out private capital;
  - etc.
- So, if everything else moves, why is there no effect on the time path of carbon taxes?

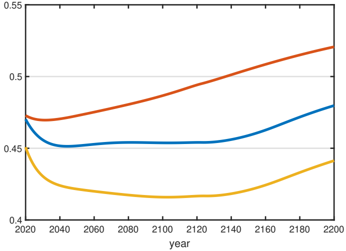
Results: Aggregates



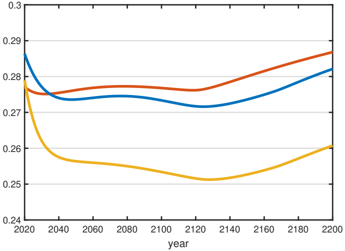
(a) Labor



(b) Capital



(c) Production



(d) Consumption

Decomposing the SCC

- Since the optimal carbon tax closely tracks the SCC, we can use our analytical expression and decompose it as follows:

$$\tau_t^{e,Pigou} = \frac{1}{\lambda_t^A} \sum_{j=0}^{\infty} \beta^j \left(\lambda_{t+j}^A \lambda_{t+j}^B - \lambda_{t+j}^C \right) J_{E_t^M, t+j},$$

with

$$\lambda_t^A = \mathcal{W}_{c,t}, \qquad \lambda_t^B = D_t' A_{1,t} F_t, \qquad \lambda_t^C = \mathcal{W}_{Z,t}.$$

- With front-loaded transfers and higher income taxes:
  - ➢ λ_t^C barely moves, similar temperature trajectories. See paths
  - ➢ λ_t^A depends on the path of consumption. Initially lower, then higher.
  - ➢ λ_t^B depends on the path of production, the other way around.

- A smaller economy in the future means less damages ($\lambda_t^B \downarrow$), but they are valued more ($\lambda_t^A \uparrow$). These effects do not perfectly cancel each other, but negative co-movement explains limited differences across scenarios. See figures

Discussion

Discussion

- What I haven't presented: extension to non-homothetic preferences for a clean and a dirty good.
  - ➢ Calibrated to replicate distribution of budget shares.
  - ➢ Meant to make a tighter link between inequality and carbon taxation.
  - ➢ Still, we obtain the same results.

- What we don't do:
  - ➢ heterogeneous preferences;
  - ➢ heterogeneous exposure to climate damages;
  - ➢ differences in ability to adapt;
  - ➢ interactions with aggregate climate risk.

Discussion

- What I haven't presented: extension to non-homothetic preferences for a clean and a dirty good.
  - ➢ Calibrated to replicate distribution of budget shares.
  - ➢ Meant to make a tighter link between inequality and carbon taxation.
  - ➢ Still, we obtain the same results.

- What we don't do:
  - ➢ heterogeneous preferences;
  - ➢ heterogeneous exposure to climate damages;
  - ➢ differences in ability to adapt;
  - ➢ interactions with aggregate climate risk.

Thank you!

Appendix

Contribution (1/2)

We contribute to three strands of literature:

- Optimal climate policy with distortionary taxation (e.g., Bovenberg and de Mooij, 1994; Jacobs and de Mooij, 2015; Barrage, 2020; Douenne et al, 2023).
  - ➢ **Novelty**: introduce incomplete markets.
- Distributional effects of climate policy (e.g., Benmir and Roman, 2022; Känzig, 2023; Fried et al, 2018 and 2023; Labrousse and Perdereau, 2024).
  - ➢ **Novelty**: study optimal policy, analyze the transition, and account for welfare benefits of mitigation.
- Optimal fiscal policy with incomplete markets (e.g., Conesa et al, 2009; Dyrda and Pedroni, 2023).
  - ➢ **Novelty**: introduce climate change and study climate policy.

Back

Contribution (2/2)

Other papers on optimal carbon taxes in an Aiyagari model:

- Bourany (2024): heterogeneity between countries (so, no other fiscal instrument).
- Kubler (2024): constrained-optimal policy à la Davila et al (2012), i.e. abstracts from concerns for redistribution. Theory-focused, characterizes deviations from SCC.
- Belfiori, Carroll, Hur (2024): also constrained-optimal policy, theory and quantitative.
- Malafry and Brinca (2022): first attempt at solving this problem (full welfare maximization), more stylized setting (2 periods, no other instrument, etc.).
- Wöhrmüller (2024): richer model and careful calibration, but also fixes other instruments and focuses on steady-state policy.

→ **Our paper**: solve for dynamic optimal fiscal policy to maximize social welfare, with a rich calibration and more flexibility over the instruments.

◂ Back

Competitive equilibrium: a definition

Given K_0, B_0, an initial distribution λ_0, and a policy $\pi \equiv \{\tau_t^h, \tau_t^k, \tau_t^i, \tau_t^e, T_t\}_{t=0}^{\infty}$, a **competitive equilibrium** is a sequence of value functions $\{v_t\}_{t=0}^{\infty}$, an allocation $X \equiv \{c_t, h_t, a_{t+1}, Z_t, E_t, \mu_t, K_{1,t}, K_{2,t}, K_{t+1}, H_{1,t}, H_{2,t}, H_t, B_{t+1}\}_{t=0}^{\infty}$, a price system $P \equiv \{R_t, w_t, r_t, p_t^e\}_{t=0}^{\infty}$, and a sequence of distributions $\{\lambda_t\}_{t=0}^{\infty}$, such that for all t:

1. the allocations solve the consumers' and the firms' problems given prices and policies;
2. the sequence of probability measures $\{\lambda_t\}_{t=1}^{\infty}$ satisfies

$$\lambda_{t+1}(\mathcal{S}) = \int_S Q_t((a, e), \mathcal{S}) d\lambda_t, \quad \forall \mathcal{S} \text{ in the Borel } \sigma\text{−algebra of } \mathcal{S}, \tag{2}$$

   where Q_t is the transition probability measure;
3. the government budget constraint is satisfied in every period, and debt is bounded;
4. temperature change satisfies the law of motion stated above in every period, and;
5. markets clear, i.e., the following equations are satisfied:

$$H_t = H_{1,t} + H_{2,t}, \tag{3}$$
$$K_t = K_{1,t} + K_{2,t}, \tag{4}$$
$$C_t + G_t + K_{t+1} + \Theta_t(\mu_t, E_t) = \big(1 - D(Z_t)\big) A_{1,t} F(K_{1,t}, H_{1,t}, E_t) + (1-\delta) K_t, \tag{5}$$
$$E_t = A_{2,t} G(K_{2,t}, H_{2,t}), \tag{6}$$
$$H_t = \int_S e h_t(a, e) d\lambda_t, \tag{7}$$
$$K_t + B_t = \int_S a d\lambda_t. \tag{8}$$

The economy is on a **balanced growth path** if all the aggregate variables grow at a constant rate and the economy satisfies competitive equilibrium conditions. ◂ Back

MCF-adjusted Pigouvian tax

- Define the marginal cost of public funds (MCF) as the ratio of the public to the private marginal utility of consumption, i.e.,

$$\mathrm{MCF}_t \equiv \frac{\nu_t}{\mathcal{W}_{c,t}}.$$

- Then, one can rewrite $\tau_t^{e,SB}$ as

$$\tau_t^{e,SB} = \sum_{j=0}^{\infty} \beta^j \left(\frac{\mathrm{MCF}_{t+j}}{\mathrm{MCF}_t} \frac{\mathcal{W}_{c,t+j}}{\mathcal{W}_{c,t}} D'_{t+j} A_{1,t+j} F_{t+j} - \frac{1}{\mathrm{MCF}_t} \frac{\mathcal{W}_{Z,t+j}}{\mathcal{W}_{c,t}} \right) J_{E_t^M,t+j},$$

- Thus, all deviations from Pigou come from MCF, i.e., the welfare cost of raising additional public funds, expressed in terms of the average marginal utility of consumption.

Back

Calibration: macroeconomic variables

Macroeconomic aggregates		
	Target	**Model**
Intertemporal elasticity of substitution	0.66	0.66
Capital to output	2.57	2.54
Average Frisch elasticity (Ψ)	1.0	1.0
Average hours worked	0.24	0.25
Transfer to output (%)	14.7	14.7
Debt to output (%)	104.5	104.5
Fraction of hhs with negative net worth (%)	10.8	11.5
Correlation between earnings and wealth	0.51	0.43

◂ Back

Calibration: inequality

Cross-sectional distributions

	Bottom (%)	Quintiles					Top (%)	Gini
	0–5	1st	2nd	3rd	4th	5th	95–100	
Wealth								
Data	−0.5	−0.5	0.8	3.4	8.9	87.4	65.0	0.85
Model	−0.2	0.1	1.7	3.6	6.7	88.1	70.0	0.85
Earnings								
Data	−0.1	−0.1	3.5	10.8	20.6	65.2	35.3	0.65
Model	0.0	0.1	3.6	12.0	17.7	66.6	37.5	0.65
Hours								
Data	0.0	2.7	13.8	19.2	27.9	36.4	11.1	0.34
Model	0.0	0.4	11.4	26.1	28.3	33.9	8.9	0.35

Back

Calibration: risk

Statistical properties of labor income		
	Target	**Model**
Variance of 1-year growth rate	2.33	2.32
Kelly skewness of 1-year growth rate	−0.12	−0.13
Moors kurtosis of 1-year growth rate	2.65	2.65

◂ Back

Computational Method: Details

- Solving this problem involves searching on the space of sequences $\{\tau_t^k, \tau_t^h, \tau_t^e, T_t\}_{t=0}^{\infty}$.

- To reduce the dimensionality of the problem, we follow Dyrda and Pedroni (2023) and parameterize the time paths of fiscal instruments:

$$x_t = \left(\sum_{i=0}^{m_{x0}} \alpha_i^x P_i(t)\right) \mathsf{exp}\left(-\lambda^x t\right) + \left(1 - \mathsf{exp}\left(-\lambda^x t\right)\right) \left(\sum_{j=0}^{m_{xF}} \beta_j^x P_j(t)\right), \quad (9)$$

  where

  - x_t can be any of the fiscal instruments $\{\tau_t^h, \tau_t^k, \tau_t^e, T_t\}$;
  - $\{P_i(t)\}_{i=0}^{m_{x0}}$ and $\left\{P_j(t)\right\}_{j=0}^{m_{xF}}$ are families of Chebyshev polynomials;
  - $\{\alpha_i^x\}_{i=0}^{m_{x0}}$ and $\left\{\beta_j^x\right\}_{j=0}^{m_{xF}}$ are weights on the consecutive elements of the family;
  - λ^x controls the convergence rate of the fiscal instruments.

Back

Welfare decomposition

- The utilitarian welfare function can increase for four reasons:

  1. Reduction in distortions, if the utility of the average agent, $\sum_{t=0}^{\infty} \beta^t u(C_t, N_t)$, increases: **the level effect (Δ_L)**
  2. Lower utility damages from climate, $\sum_{t=0}^{\infty} \beta^t v(Z_t)$: **the utility-damages effect (Δ_{UD})**
  3. Transfers from ex-post rich to ex-post poor, if the risk of each individual path $\{c_t, n_t\}_{t=1}^{\infty}$ is reduced: **the insurance effect (Δ_I)**
  4. Transfers from ex-ante rich to ex-ante poor, if the inequality between certainty equivalents for $\{c_t, n_t\}_{t=1}^{\infty}$ is reduced: **the redistribution effect (Δ_R)**

Proposition. Let Δ be the utilitarian (average) welfare gain. The following decomposition holds:

$$(1 + \Delta) = (1 + \Delta_L)(1 + \Delta_{UD})(1 + \Delta_I)(1 + \Delta_R)$$

Back

Paths of temperature across scenarios.

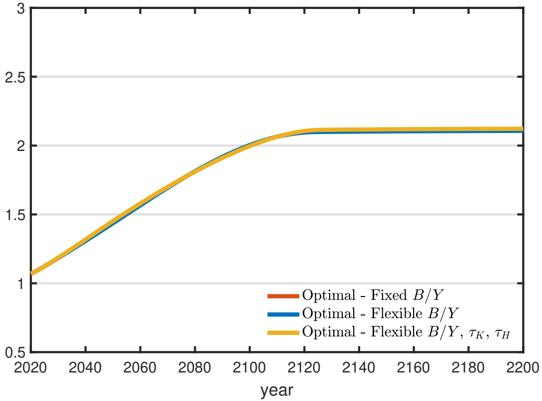
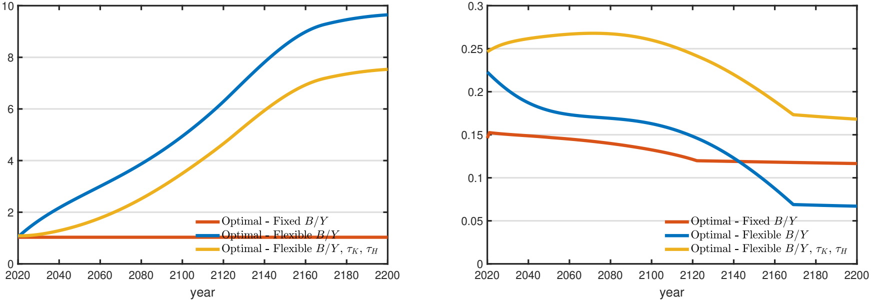


Figure: Temperature (in °C)

Back

Paths of debt and transfers

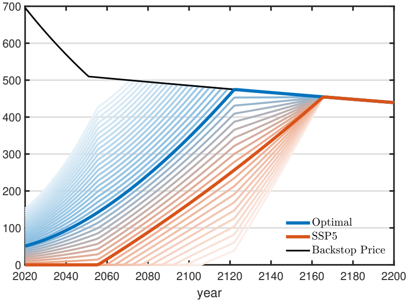


(a) Debt-to-GDP ratio (B/Y) (b) Transfers-to-GDP ratio (T/Y)

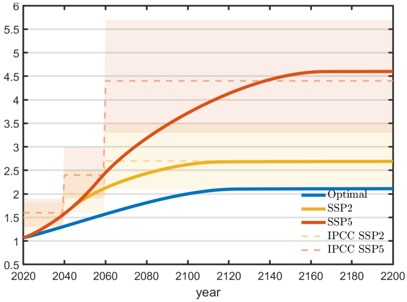
Figure: Ratios of Debt and Transfers to GDP

◂ Back

SSP2 and SSP5



(a) Path of carbon taxes



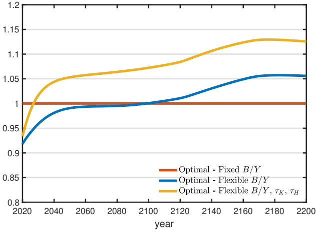
(b) Path of temperature

Figure: Optimal Policy vs. SSP5.

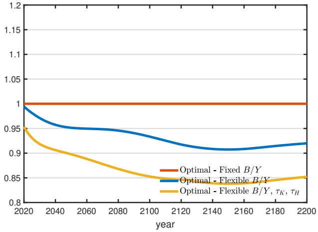
Back

SCC by components across scenarios

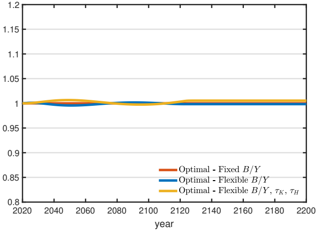
Back



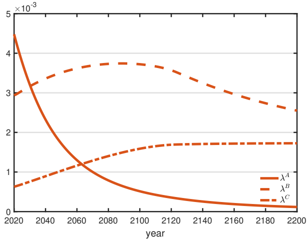
(a) Marginal Utility of Consumption (λ_t^A)



(b) Marginal Production Damages (λ_t^B)

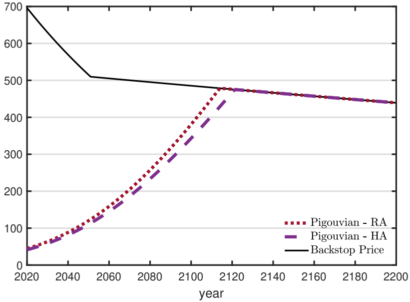


(c) Marginal Utility from Climate Amenities (λ_t^C)

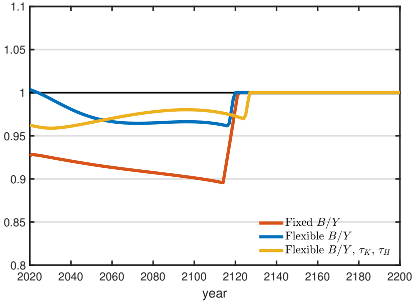


(d) Scale of Components

Inequality-adjusted SSC



(a) Levels in the baseline (in $/t$CO_2$)



(b) Ratios across scenarios

Figure: Social Cost of Carbon for Representative vs. Heterogeneous Agents.