Environmental subsidies to mitigate transition risk

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March 2022

Motivations

- Commitment of **zero emission by 2060** to maintain temperatures below 2°C;
- Benchmark models suggest **gradual rise in carbon tax** sufficient to reach this target;
- However carbon tax is **permanent negative shock** to firms cost structure: harmful for the economy (**transition risk**);

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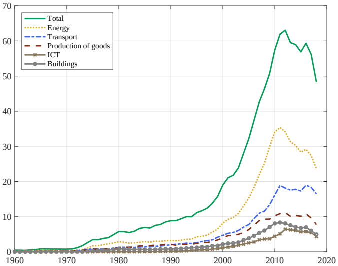
- Net zero carbon transition requires **large entry of new varieties/product** with low carbon footprint (green product);
- Nonetheless, creation of green products (measured by patents) has **stalled** over the last decade;
- Need to **boost green products creation** to reach net zero emissions.



Number of new patents (in thousands, world data) for climate change mitigation

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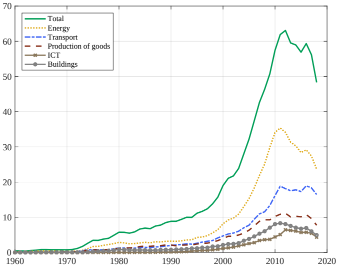

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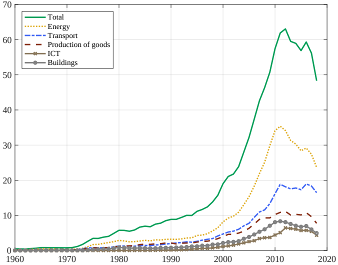

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- Competition and green product creation are **important matter** for successful environmental policies, as in Nesta et al. (2014) and Nicolli and Vona (2016);

- So far, these **dimensions are absent** in benchmark models of climate change, such as DICE;

- Could **policy actions play a role** in boosting the creation of new green products?

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This paper:

- **Objective:**

  Investigating how public subsidies can play a role in mitigating transition risk.

- **How?**

  - We develop and estimate an Environmental DSGE model for the world economy;

  - The model features endogenous green product variety;

  - We provide projections up to horizon 2100, conditional on CO2 reduction efforts as in last IPCC report;

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Take aways

- **Product creation important matter** for transition risk;
- Welfare improving to **subsidize the creation** of new green products;
- We estimate that **this policy saves up to $2.5 trillion** in GDP each year.

Plan

Model overview

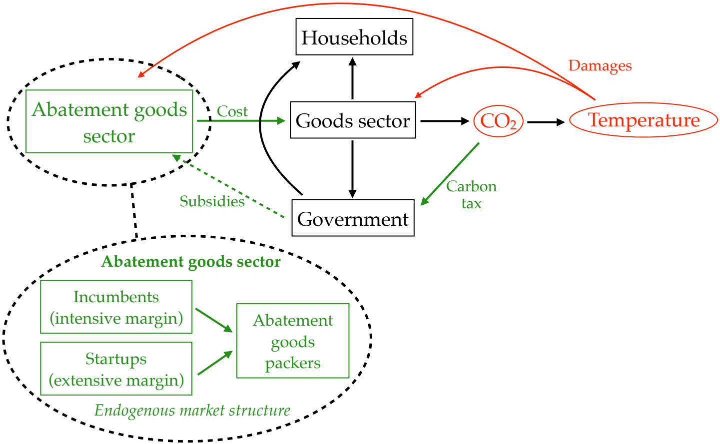

Figure 1: A presentation of the model

From DICE to E-DSGE

We depart from DICE on 3 aspects:

1. Rational expectations and explicit micro-foundations: immune à la Lucas critique;
2. Presence of cyclical shocks (TFP, spending, temperature, etc.) to capture the business cycle component;
3. Product creation mechanism in abatement sector *à la* Bilbiie et al. (2012).

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Firms and CO2 emissions

- Real profits in production sector:

$$\Pi_t = Y_t - w_t H_t - \underbrace{p_t^A \Lambda\ (\mu_t) Y_t}_{\text{abatement cost}} - \underbrace{\tau_t\ E_t}_{\text{carbon tax}}$$

- With flow of emissions:

$$E_t = \sigma_t \left(1 - \mu_t\right) Y_t$$

Two important variables:

- Abatement effort μ_t (e.g. carbon sequestration, solar/wind plants, electrification, etc);
- p_t^A relative price of abatement goods (in DICE, $p_t^A = 1$);

Abatement goods sector: firm dynamics

- The number of green products N_t:

$$N_t = (1 - \delta_A)\left(N_{t-1} + N^E_{t-1}\right), \tag{1}$$

with:
- δ_A obsolescence rate,
- N^E_{t-1} number of new products/startups.

- One firm = one product;

- Need to determine the production of *existing firms* and the number of *startups*.

Abatement goods sector: existing firms

- Their production function:

$$N_t Y_t^A = \Gamma_t H_t^A$$

with H_t^A hours worked demand, Γ_t exogenous TFP.

- In equilibrium, demand from production sector equals supply from existing firms in abatement sector:

$$\underbrace{\Lambda\ (\mu_t) Y_t}_{\text{Demand from polluting firms}} \quad = \quad \underbrace{N_t Y_t^A}_{\text{Supply from existing firms}}$$

Abatement goods sector: startups

- First-order condition determining creation of new green products:

$$\underbrace{X_t\left(1 - s_t^E\right)}_{\text{marginal cost}} = \underbrace{v_t}_{\text{marginal gain}}$$

with:
- X_t a sunk cost,
- v_t the firm value (discounted future profits),
- s_t^E a subsidy to startups.

Abatement goods sector: competition effect

- Incumbent production price:

$$\tilde{p}_t^A = \underbrace{\frac{\zeta_A}{\zeta_A - 1}}_{\text{markup}} \times \underbrace{\frac{w_t}{\Gamma_t}}_{\text{wage}} \times \underbrace{\left(1 - s_t^A\right)}_{\text{subsidy to intensive}} . \tag{2}$$

- Aggregate price under monopolistic competition:

$$p_t^A = \underbrace{\tilde{p}_t^A}_{\text{individual prices}} \times \underbrace{N_t^{1/(1-\zeta_A)}}_{\text{competition effect}} . \tag{3}$$

Plan

Estimation

- We estimate 15 parameters using **Bayesian techniques**;
- Inference based on World annual data 1961-2019;
- Fully-nonlinear method that **takes into account trends** (no balanced growth) and nonlinear climate change effects (but assumes certainty equivalence).

$$\begin{bmatrix} \text{Real output growth rate} \\ \text{Real consumption growth rate} \\ \text{CO}_2 \text{ Emissions growth rate} \\ \text{Temperature anomaly change} \\ \text{Patents growth rate} \end{bmatrix} = \begin{bmatrix} \Delta \log \left(Y_t \right) \\ \Delta \log \left(C_t \right) \\ \Delta \log \left(E_t \right) \\ \Delta T_t \\ \log \left(N_t^E / N_{t-1}^E \right) \end{bmatrix}$$

Estimation

- Our model features:
  - 5 **cyclical shocks** (from business cycle theory);
  - 4 **deterministic trends** (from DICE);
- Our quantitative method endogenously **disentangle business cycle vs permanent** components in data;
- Our methodology also quantifies **both parametric and business cycle uncertainties**;
- To our knowledge, **first inference** of macro-climate model with full-information method.

Plan

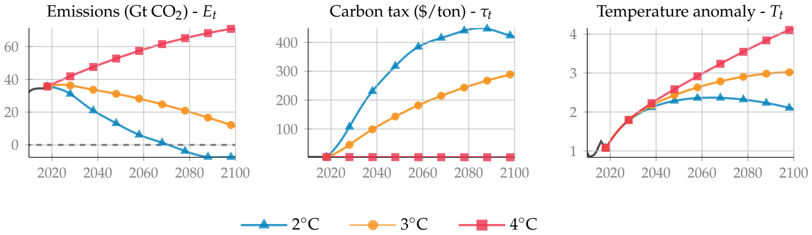
A (uncertain) future path of emissions

- Large uncertainty about future path of CO_2 emissions;

- We consider 3 alternative scenarios for CO_2 emission cuts, consistent with IPCC:

1. **Carbon neutrality in 2060-2070** (stringent policy, Paris agreement);
2. **Carbon neutrality after 2100** (soft policy);
3. **Business as usual** (no CO_2 reduction).

Transition scenarios



- Each path for emission cuts (μ_t) is matched by adjusting carbon tax (τ_t);
- More emissions translate into more temperature anomalies.

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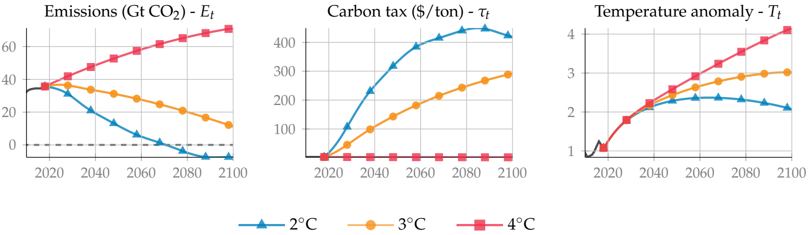

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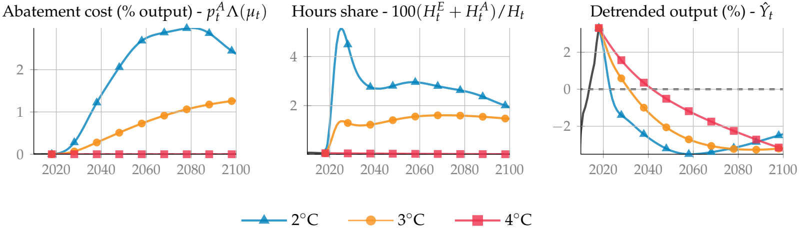
Transition scenarios: macroeconomic projections



- More emission cuts (μ_t) imply a rise in abatement cost ($p_t^A \Lambda(\mu_t)$);
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- Implication: GDP persistently below its trend.

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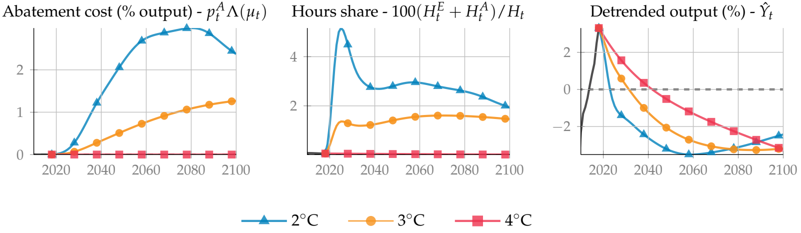

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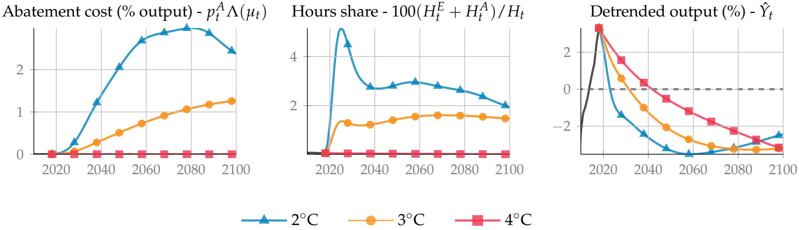

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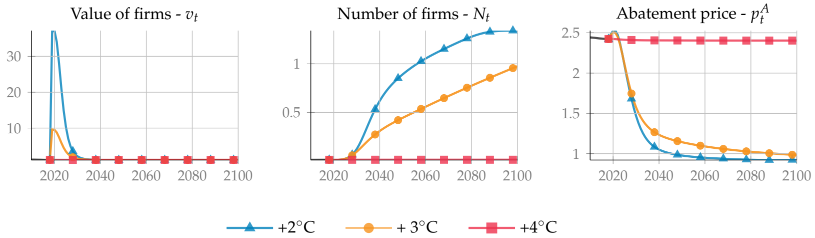
Dissecting the firm entry mechanism



- The prospect of future profits in abatement goods boosts the value of firms;
- Startup creation occurs as long as future profits are high;
- Strong competition effect making abatement goods cheaper by 2050;

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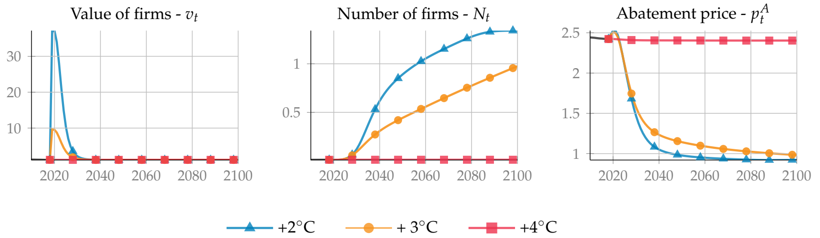

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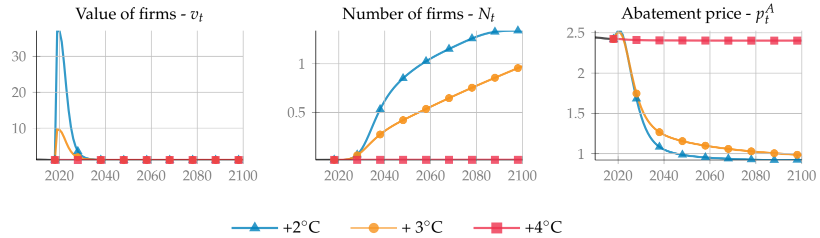

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Environmental subsidies

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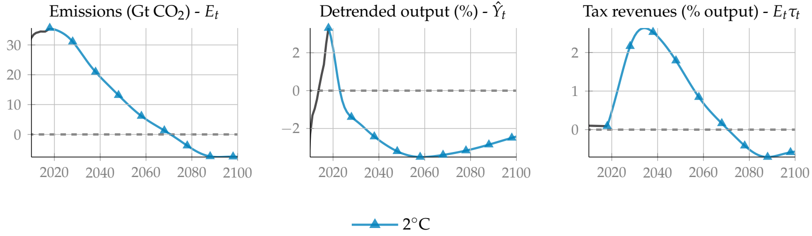

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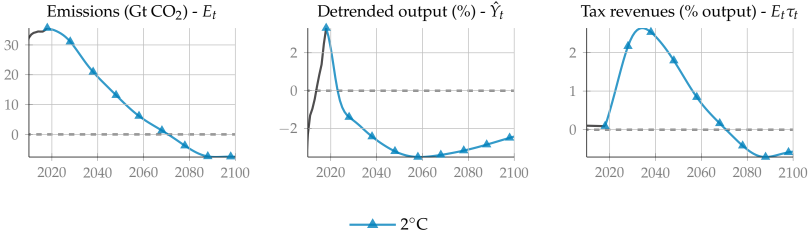

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Environmental subsidies

- Let s_t^A & s_t^E denote resp. subsidy rates to existing firms and startups;

- How should be split the carbon tax revenues across firms?

- Let ς and 1-ς the share of the carbon tax revenues going to startups and existing firms:

$$s_t^E H_t^E w_t = \varsigma \tau_t E_t$$
$$s_t^A H_t^A w_t = (1 - \varsigma) \tau_t E_t$$

An optimal sharing rule across firms

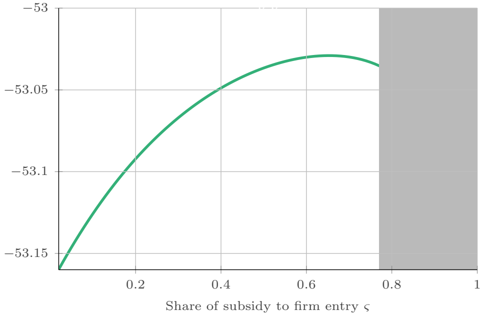
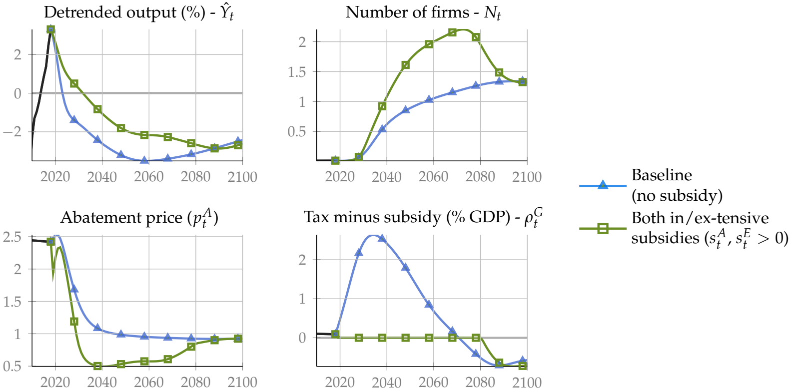


Figure 2: Welfare index for various sharing rules between startups/existing firms

- **Optimal sharing rule across firms**: 70% of carbon tax revenues given to startups and 30% to existing firms;

Understanding the mechanism



- Subsidy to startups boosts the number of firms and competition;
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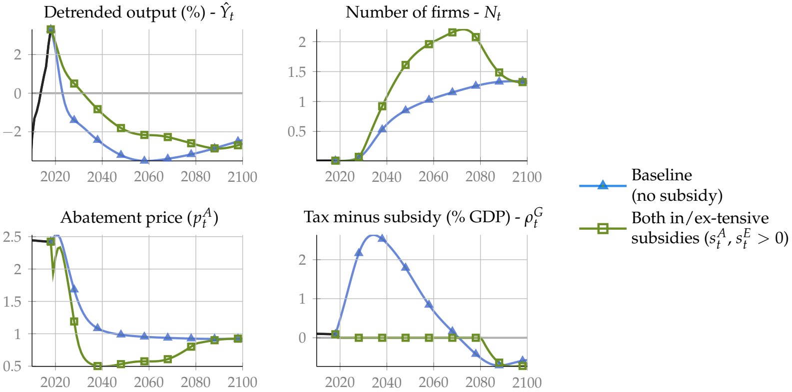

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Concluding remarks

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Bilbiie, F. O., Ghironi, F., and Melitz, M. J. (2012). Endogenous entry, product variety, and business cycles. *Journal of Political Economy*, 120(2):304–345.

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