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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▶ 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;
- We propose various strategies to subsidize firms operating in the abatement sector;
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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.
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:
  \[
  \Pi_t = Y_t - w_t H_t - p^A_t \Lambda (\mu_t) Y_t - \tau_t E_t
  \]
  - abatement cost
  - carbon tax

- With flow of emissions:
  \[
  E_t = \sigma_t (1 - \mu_t) Y_t
  \]

Two important variables:

- Abatement effort \( \mu_t \) (e.g. carbon sequestration, solar/wind plants, electrification, etc);

- \( p^A_t \) relative price of abatement goods (in DICE, \( p^A_t = 1 \));
The number of green products $N_t$:

$$N_t = (1 - \delta_A) \left( N_{t-1} + N_{t-1}^E \right), \quad (1)$$

with:
- $\delta_A$ obsolescence rate,
- $N_{t-1}^E$ 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, \( \Gamma_t \) exogenous TFP.

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

\[
\underbrace{\Lambda (\mu_t) Y_t}_{\text{Demand from polluting firms}} = \underbrace{N_t Y_t^A}_{\text{Supply from existing firms}}
\]
First-order condition determining creation of new green products:

\[ X_t \left(1 - s_t^E \right) = v_t \]

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

\[ \tilde{p}_t^A = \frac{\zeta_A}{\zeta_A - 1} \times \frac{w_t}{\Gamma_t} \times (1 - s_t^A) . \]  

Aggregate price under monopolistic competition:

\[ p_t^A = \tilde{p}_t^A \times N_t^{1/(1 - \zeta_A)} . \]
Plan

1. Introduction
2. Model
3. Estimation
4. Model-implied projections
5. Competition-friendly policies
6. Conclusion
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).

\[
\begin{bmatrix}
\text{Real output growth rate} \\
\text{Real consumption growth rate} \\
\text{CO}_2 \text{ Emissions growth rate} \\
\text{Temperature anomaly change} \\
\text{Patents growth rate}
\end{bmatrix}
= \begin{bmatrix}
\Delta \log (Y_t) \\
\Delta \log (C_t) \\
\Delta \log (E_t) \\
\Delta T_t \\
\log \left( \frac{N_t^E}{N_{t-1}^E} \right)
\end{bmatrix}
\]
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.
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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 ($\mu_t$) is matched by adjusting carbon tax ($\tau_t$);

More emissions translate into more temperature anomalies.
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Transition scenarios: macroeconomic projections

More emission cuts ($\mu_t$) imply a rise in abatement cost ($p_t^A \Lambda (\mu_t)$);

More hours spent in the abatement goods sector;

Implication: GDP persistently below its trend.
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Implication: GDP persistently below its trend.
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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Dissecting the firm entry mechanism

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- Quick but costly cuts in CO2 emissions;
- Carbon tax revenues can be used to subsidize the abatement sector.
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Environmental subsidies

Let $s^A_t$ & $s^E_t$ denote resp. subsidy rates to existing firms and startups;

How should be split the carbon tax revenues across firms?

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

\[
\begin{align*}
  & s^E_t H^E_t w_t = \varsigma \tau_t E_t \\
  & s^A_t H^A_t w_t = (1 - \varsigma) \tau_t E_t
\end{align*}
\]
Optimal sharing rule across firms: 70% of carbon tax revenues given to startups and 30% to existing firms;
Subsidy to startups boosts the number of firms and competition;

The subsidy policy allows to save about $2.5 trillion GDP per year.
Understanding the mechanism

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CONCLUDING REMARKS

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