The Macroeconomic Effects of a Carbon Tax to Meet the U.S. Paris Agreement Target: The Role of Firm Creation and Technology Adoption

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Joint Work with Alan Finkelstein Shapiro

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CEEPR
MIT Center for Energy and Environmental Policy Research

A Renewed Commitment to Climate Change

THE WHITE HOUSE

Administration

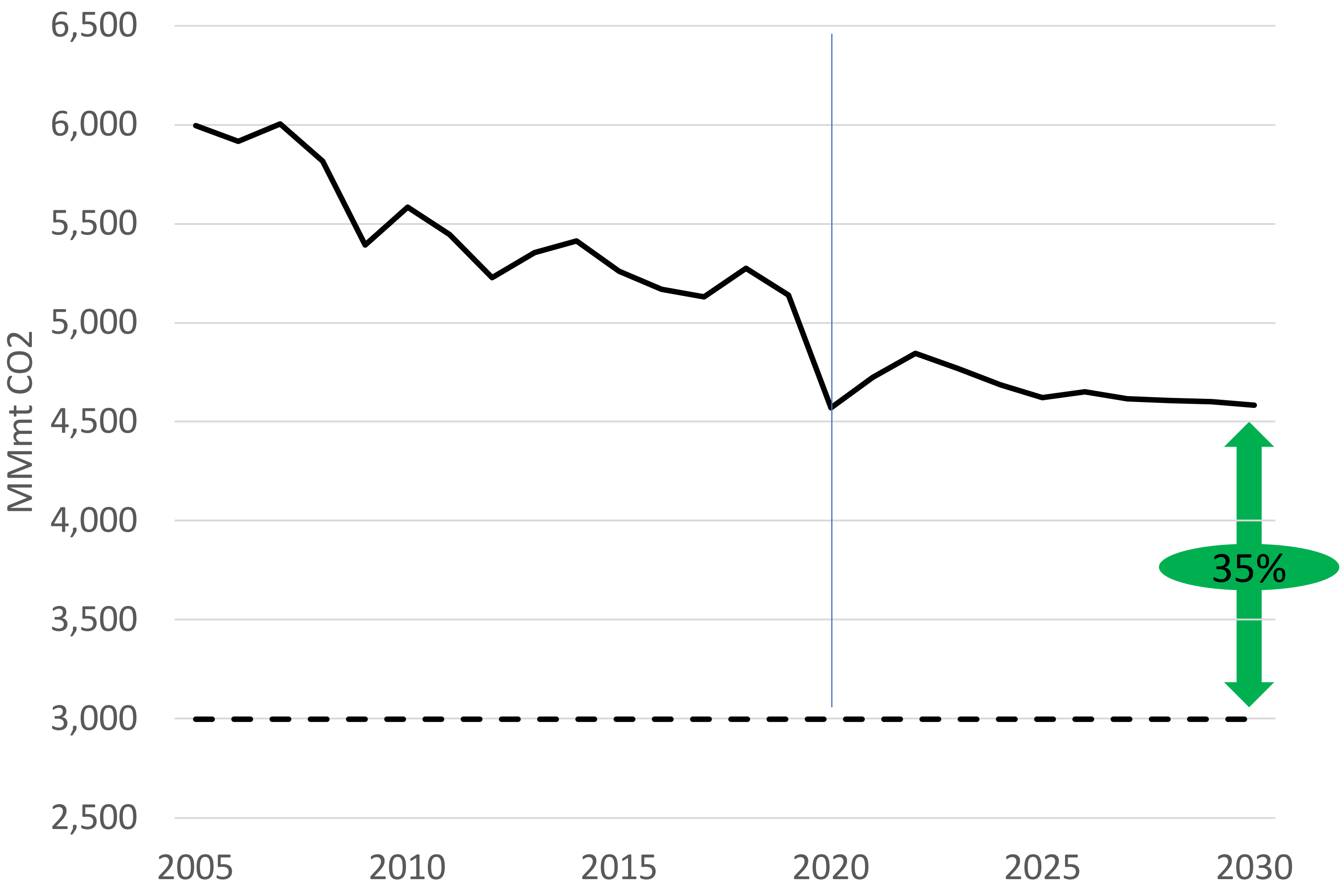
BRIEFING ROOM

FACT SHEET: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies

APRIL 22, 2021 • STATEMENTS AND RELEASES

Building on Past U.S. Leadership, including Efforts by States, Cities, Tribes, and Territories, the New Target Aims at 50-52 Percent Reduction in U.S. Greenhouse Gas Pollution from 2005 Levels in 2030

Emission Reduction Required



EIA Annual Energy Outlook (2020)

What are the macroeconomic impacts?

Carbon Pricing and Employment

- Finds evidence of sectoral shifts from dirty to clean production
  - Yamazaki (2017)
  - Azevedo, Wolff, and Yamazaki (2020)
- Empirical evidence finds little impact on aggregate employment

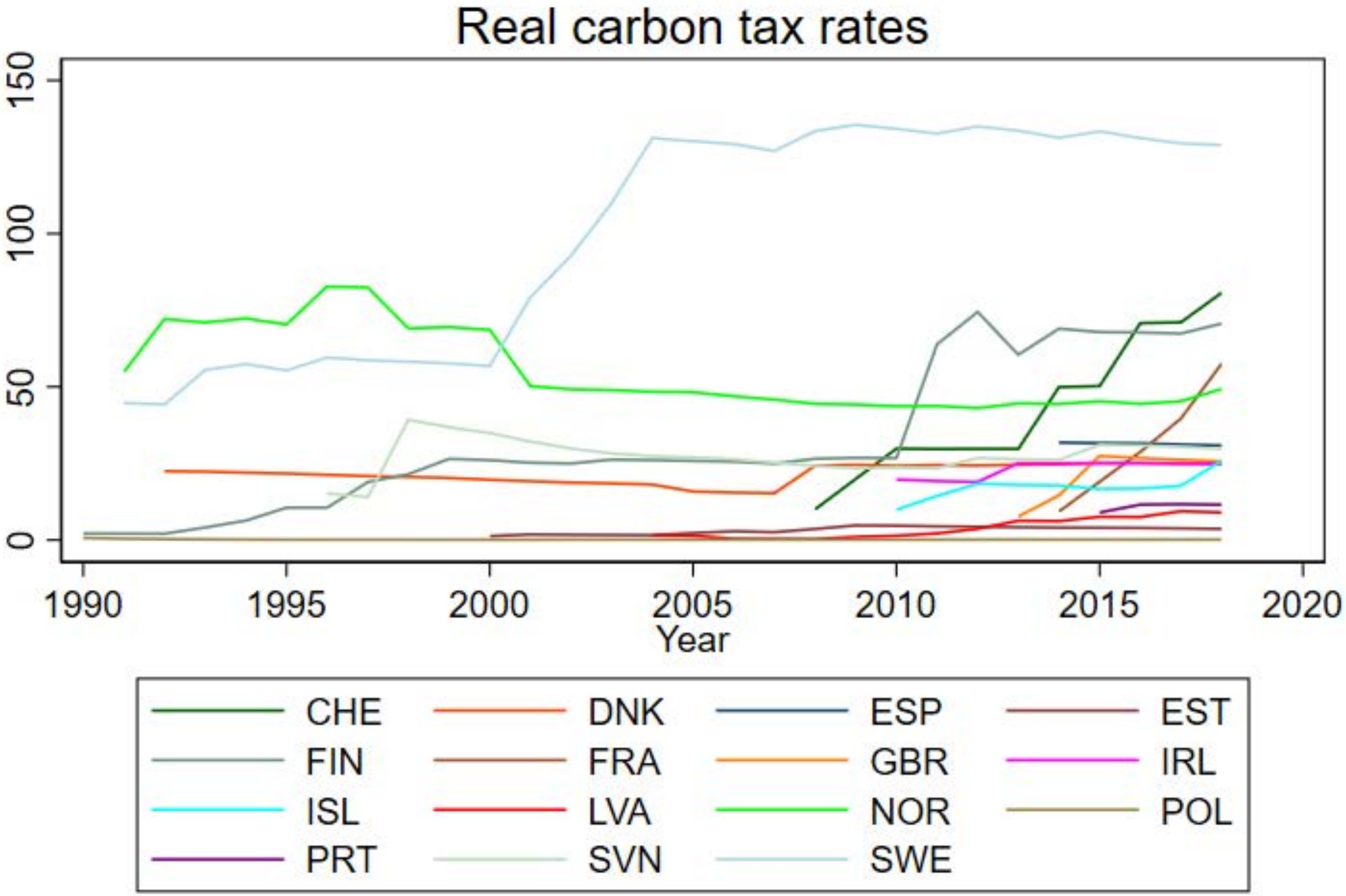
Evidence from European Carbon Taxes

Carbon tax history for the 15 countries with carbon taxes

Data source: World Bank (carbon price data in press)

Carbon tax rates are real local currency, scaled to 2018 USD using 2018 PPP

GDP growth: World Bank (except as noted below)



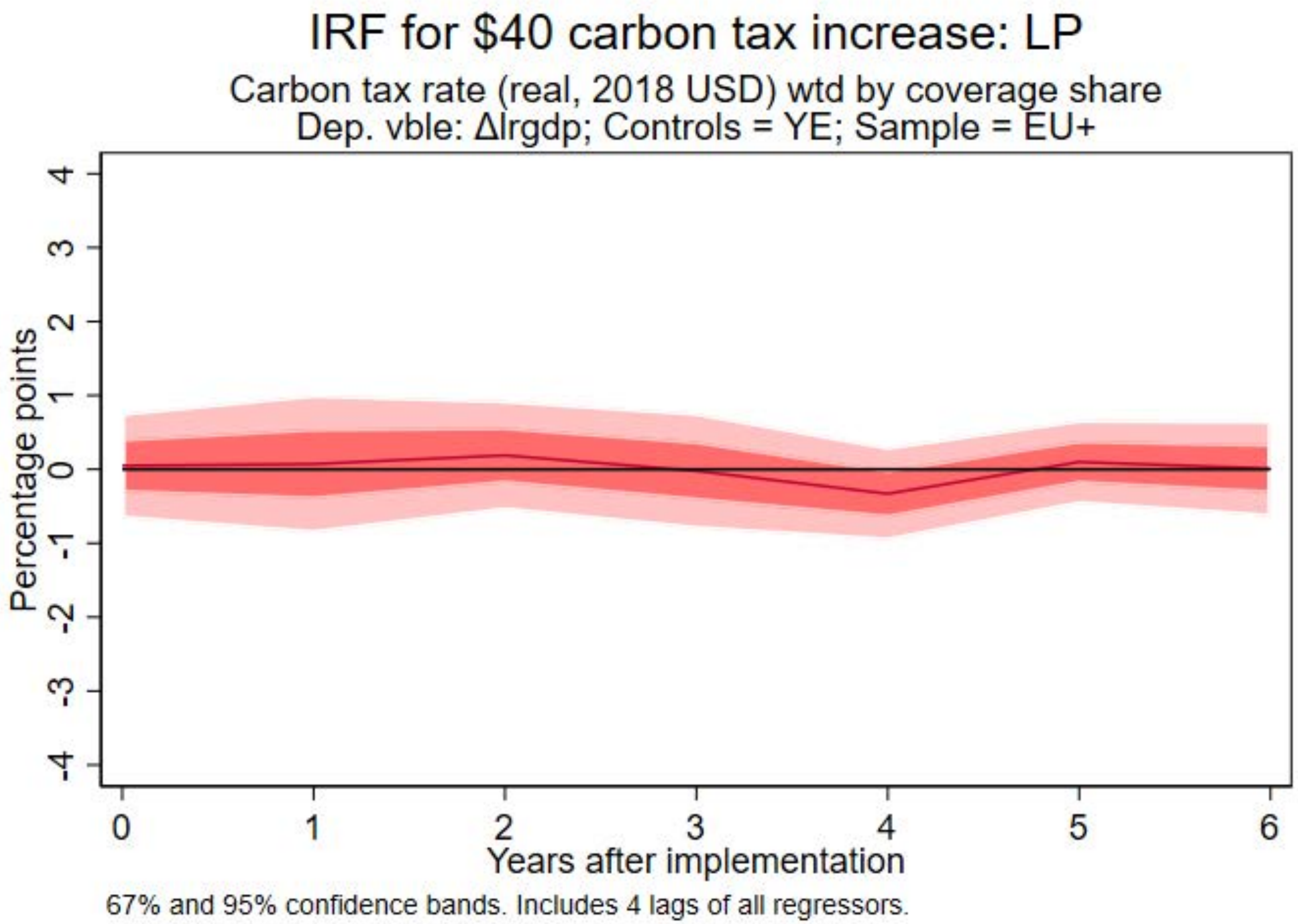
Real rate in local currency, normalized to 2018 USD

Metcalf and Stock (AEJ: Macro, 2023)

Example of Empirical Finding:

Sample: **EU+**

Method: **Linear Projection Restricted**



Metcalf and Stock (AEJ: Macro, 2023)

Carbon Pricing and Employment

- Finds evidence of sectoral shifts from dirty to clean production
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- Empirical evidence finds little impact on aggregate employment

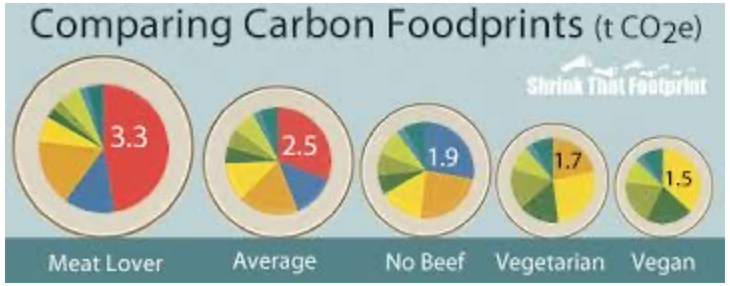
- Empirical work does not address the underlying mechanisms
- What about general equilibrium models?

General Equilibrium Models and Employment

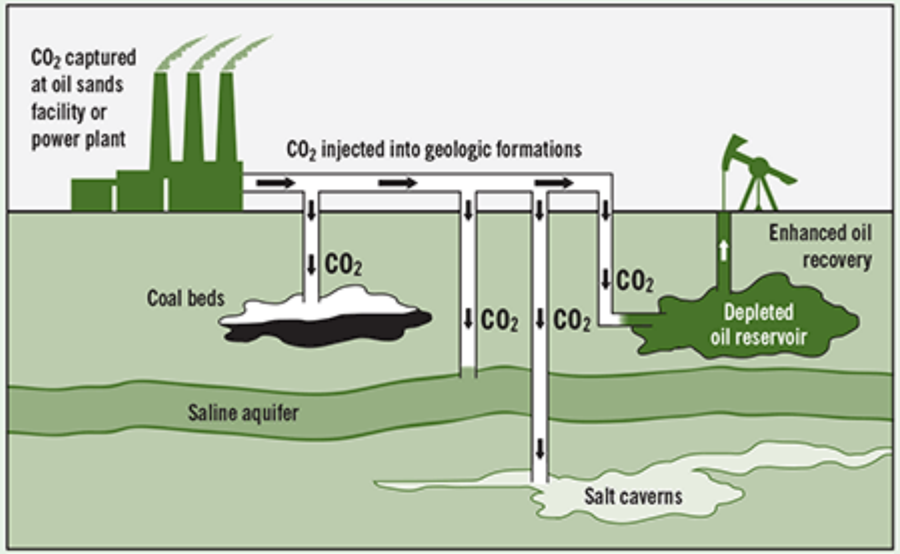
- Mainstream models historically assume full employment
  - They can model sectoral shifts but not changes in aggregate employment
  - Models typically do not assume involuntary unemployment
- Newer models assume frictional unemployment based on Mortensen and Pissarides (1994)
  - Hafstead and Williams (2018)
  - Castellanos and Heutel (2019), Gibson and Heutel (2020)
  - Aubert and Chiroleu-Assouline (2019)

- These models generally find adverse macro output and/or consumption impacts of a carbon tax

How to Reduce Emissions...



Change Consumption



Abate Emissions

Change Production Technologies

New Firms Using New Technologies

Finkelstein Shapiro and Metcalf (2021)

- We focus on three interacting dimensions of environmental policy and …

1. Employment
   - See above
2. Firm Creation
   - Kreickmeier and Richter (2018)
   - Annicchiarico, Correani, and Di Dio, 2018)
3. Technology Adoption
   - Acemoglu et al. (2012)

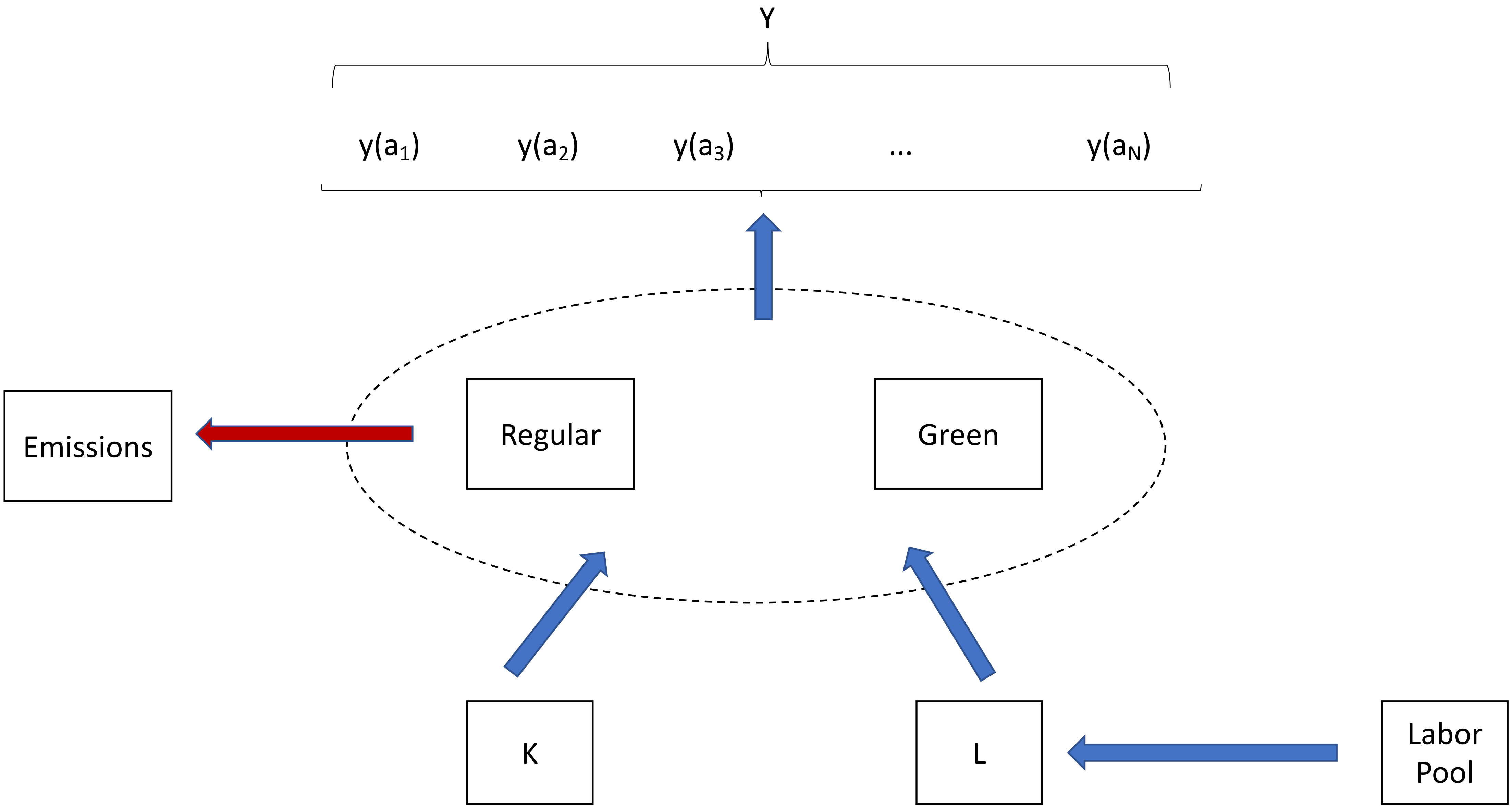
Key Model Elements Captured in Model

- Technology adoption decisions by firms
- Endogenous firm entry
- Household job-search

- Pollution

Structure of Final Goods Production

- Firm entrants incur sunk cost of entry
  - Exogenous exit probability
- Upon entry, they draw random productivity, $a \in [a_{min}, \infty)$, based on distribution, $G(a)$.
- Given its productivity draw, each firm
  - Produces a single output variety, ω, in the amount $y_t(\omega)$.
  - Chooses a technology for production: regular (r) or green (g).
- Green technology entails zero emissions but incurs a fixed cost of adoption
- Firms hire labor and capital and may generate pollution



Y
y(a1) y(a2) y(a3) … y(aN)
Emissions
Regular
Green
K
L
Labor Pool

Dixit-Stiglitz Product Differentiation Model

$$Y_t = \left(\int_{\omega \in \Omega} y_t(\omega)^{\frac{\varepsilon - 1}{\varepsilon}} d\omega \right)^{\frac{\varepsilon}{\varepsilon - 1}}, \qquad \varepsilon > 1$$

$$P_t = \left(\int_{\omega \in \Omega} p_t(\omega)^{1-\varepsilon} d\omega \right)^{\frac{1}{1-\varepsilon}}$$

Final Goods Firm Structure

- Firms are simultaneously choosing to enter, select technology, and determine output
- Decompose technology adoption from production through a fictional firm producing r or g intermediate goods. Profits for final goods producers based on technology choice are

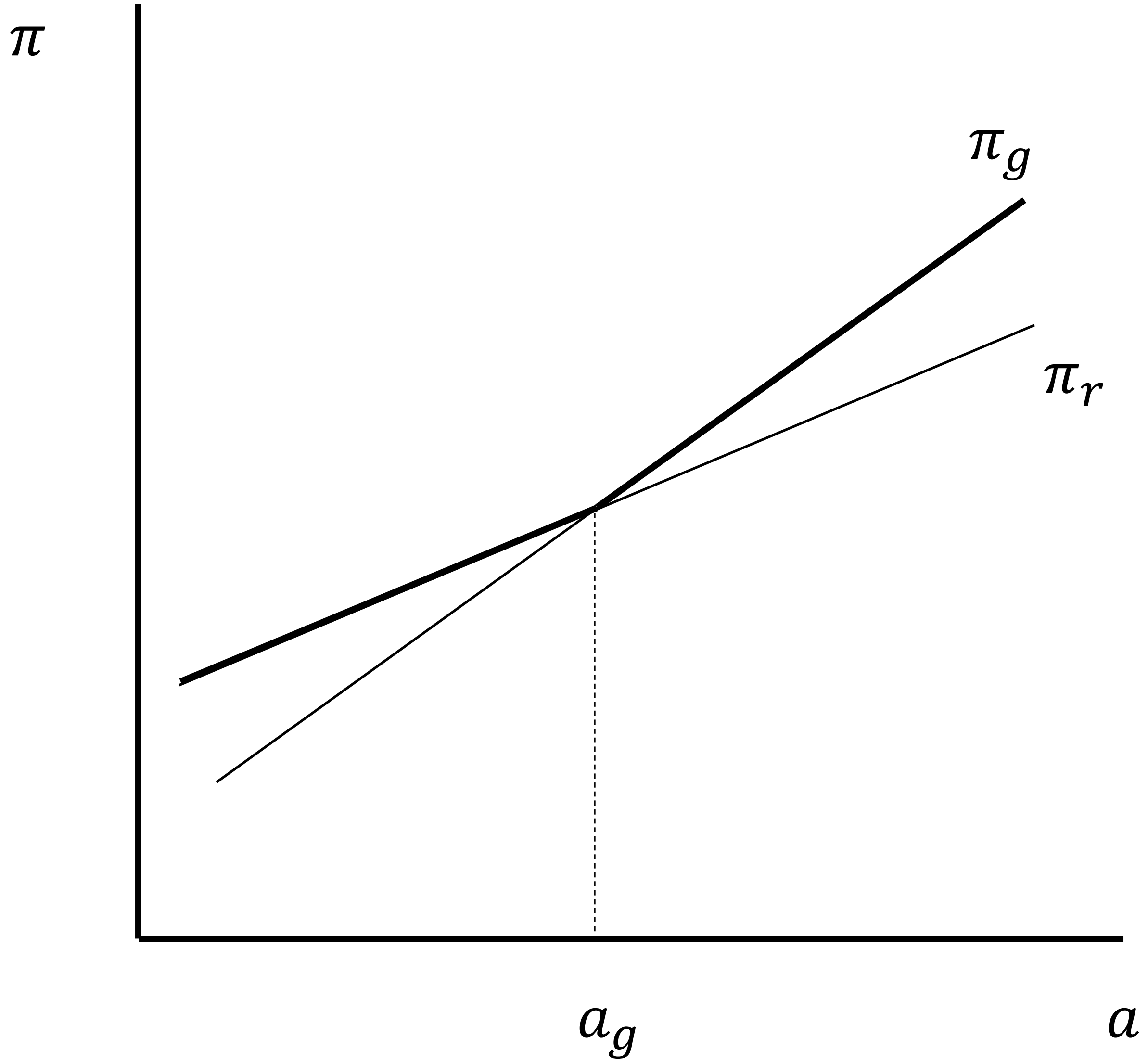
$$\pi_{r,t}^{y}(a) = \left[\underbrace{\frac{p_{r,t}(a)}{P_t}}_{\rho_{r,t}(a)} - \frac{mc_{r,t}}{a}\right] y_{r,t}(a)$$

$$\pi_{g,t}^{y}(a) = \left[\underbrace{\frac{p_{g,t}(a)}{P_t}}_{\rho_{g,t}(a)} - \frac{mc_{g,t}}{a}\right] y_{g,t}(a) - \varphi_g$$

Technology Choice

- Firms select $\begin{cases} g & a \geq \ a_{g,t} \\ r & a < \ a_{g,t} \end{cases}$, where $\pi^{y}_{r,t}(a_{g,t}) = \pi^{y}_{g,t}(a_{g,t})$.

Technology Choice



Firm Evolution and Expected Profits

$$N_t = (1-\delta)\left(N_{t-1} + N_{e,t-1}\right)$$

$$N_{r,t} = G\left(a_{g,t}\right)N_t$$
$$N_{g,t} = \left(1 - G(a_{g,t})\right)N_t$$

$$\tilde{\pi}_t^y = \frac{N_{r,t}}{N_t}\tilde{\pi}_{r,t}^y + \frac{N_{g,t}}{N_t}\tilde{\pi}_{g,t}^y$$

Intermediate Good Production

Job Posti

Vacancies

$$D(x_t)mc_{r,t}H\left(n_{r,t},k_{r,t}\right)-w_{r,t}n_{r,t}-\psi_r v_{r,t}-\tau_t e_t-\Gamma_t$$
$$D(x_t)mc_{g,t}H\left(n_{g,t},k_{g,t}\right)-w_{g,t}n_{g,t}-\psi_g v_{g,t}$$

Climate Damages

$$D(x_t)\leq 1,\qquad D(0)=1, D'<0$$
$$x_t=\ \rho_x x_{t-1}+e_t$$

Job Filling Probability

$$k_{g,t}+k_{r,t}=k_t=I_t+(1-\delta)k_{t-1}$$
$$n_{r,t}=(1-\varrho)n_{r,t-1}+v_{r,t}q(\theta_{r,t})$$
$$n_{g,t}=(1-\varrho)n_{g,t-1}+v_{g,t}q(\theta_{g,t})$$

$$\Gamma_t=\gamma\mu_t^{\eta}D(x_t)H\left(n_{r,t},k_{r,t}\right)$$
$$e_t=(1-\mu_t\ )\left[D(x_t)H\left(n_{r,t},k_{r,t}\right)\right]^{1-\nu}$$

Households

- Welfare for representative household

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \big(u(c_t) - h(lfp_{g,t}, lfp_{r,t})\big)$$

Evolution of Firms and Employment

- Employment and labor force participation:

$$n_{j,t} = (1-\varrho)n_{j,t-1} + s_{j,t} f\left(\theta_{j,t}\right), \qquad j = r, g$$

$$lfp_{j,t} = n_{j,t} + \left(1 - f\left(\theta_{j,t}\right)\right) s_{j,t}, \qquad j = r, g$$

- Number of final good firms

$$N_{t+1} = (1-\delta)\left[N_t + N_{e,t}\right]$$

Equilibrium and matching

- Matching process determines wage and hiring rates
- Market clearing in intermediate goods markets
- Normalize aggregate output price
- Resource Constraint

Model Simulation

- Emissions tax to reduce LR emissions by 35 percent
- Gradually implemented over 20 quarters

- Turn off features of model to understand forces at work
  - No firm entry
  - No firm entry and no technology adoption (similar to previous models)

Steady State Changes

Variable	Benchmark Model Values		Percent Change Rel. to Baseline
	Before Tax (Baseline)	After Tax	
Total Output	6.974	7.005	0.448
Consumption	4.517	4.533	0.334
Empl. r	0.104	0.085	-18.579
Empl. g	0.488	0.511	4.566
Total Empl.	0.592	0.595	0.503
Real Wage r	6.153	6.172	0.313
Real Wage g	5.277	5.293	0.313
Capital k_r	8.175	6.677	-18.325
Capital k_g	32.699	34.298	4.891
Firms (N)	592.991	587.183	-0.979
g Firms (N_g)	246.764	282.087	14.315
Ave. Idiosync. Prod. $\tilde{a}_r$	1.099	1.084	-1.398
Ave. Idiosync. Prod. $\tilde{a}_g$	1.824	1.763	-3.362
Overall Ave. Firm Prod.	1.401	1.410	0.657
			Percentage-Pt. Change Rel. to Baseline
Unempl. Rate	6.000%	6.034%	0.034
LFP Rate	63.000%	63.340%	0.340
Abate. Rate μ	0.000%	25.080%	25.080
Share of g-Firm Output	80.000%	83.539%	3.539
Share of g Firms	41.610%	48.041%	6.427
Tax Rev./Output	0.000%	0.180%	0.180

US Treasury (2016) estimate: 0.8 – 0.9% of GDP

Unpacking Results

Variable	Benchmark Model
	(1)
	Percent Change Rel. to Baseline
Emissions e	-35
Total Output	0.448
Consumption	0.334
Empl. r	-18.579
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Total Empl.	0.503
Real Wage r	0.313
Real Wage g	0.313
Capital k_r	-18.325
Capital k_g	4.891
Firms (N)	-0.979
g Firms (N_g)	14.315
Welfare Gain (% of Consumption)	**-0.018**
	Percentage-Pt. Change Rel. to Baseline
Unempl. Rate	0.034
LFP Rate	0.340
Abate. Rate μ	25.080
Share of g-Firm Output	3.539
Share of g Firms	6.427
Tax Rev./Output	0.180

Cut emissions by 20%:
Tax Rev/GDP=1.0%

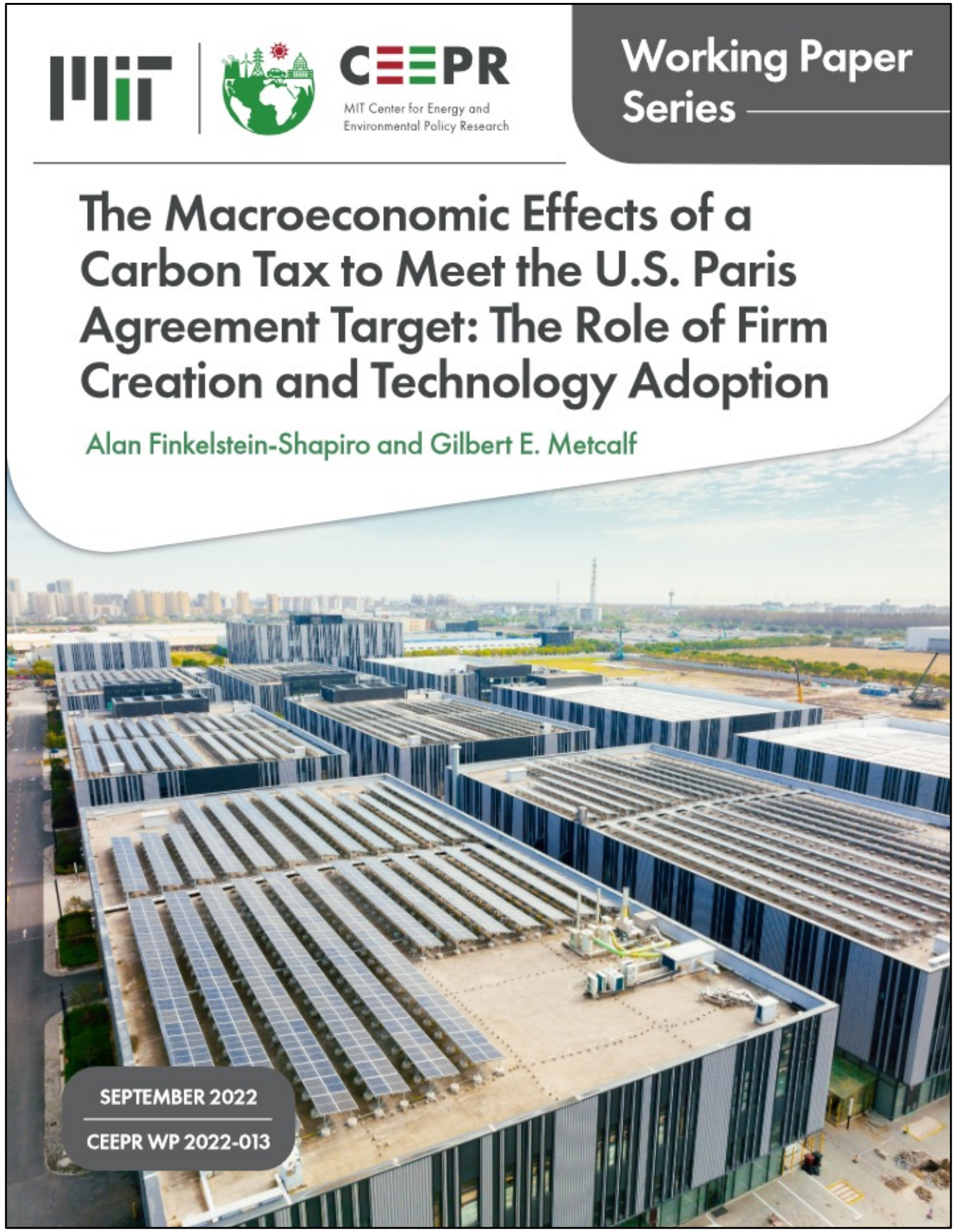
What Drives Results

- Input Reallocation Effect
  - Inputs shifted from higher cost to lower cost production technologies

- Technological Composition Effect
  - Production shifting from lower productivity to higher productivity sectors
  - While average productivity w/in sectors falls, overall productivity rises

Summing Up

- Failure to account for firm entry/exit and technology adoption distorts labor market outcomes
- More realistic market structure yields positive impacts:
  - Negates adverse impacts on GDP and employment
  - Lower carbon tax needed to achieve desired emission reduction
- Cost of achieving the U.S. Paris Agreement goal modest (to zero), once one allows for innovation and firm entry/exit



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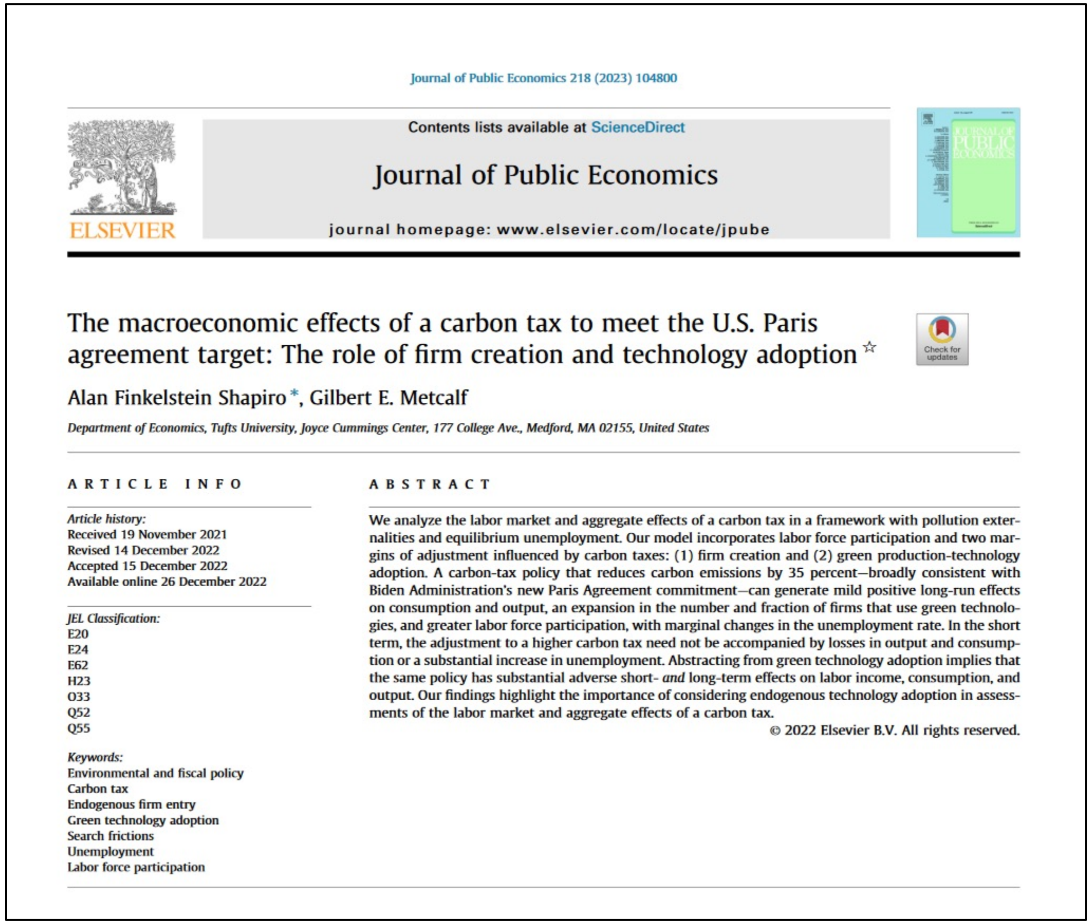

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The macroeconomic effects of a carbon tax to meet the U.S. Paris agreement target: The role of firm creation and technology adoption ☆

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ABSTRACT

We analyze the labor market and aggregate effects of a carbon tax in a framework with pollution externalities and equilibrium unemployment. Our model incorporates labor force participation and two margins of adjustment influenced by carbon taxes: (1) firm creation and (2) green production-technology adoption. A carbon-tax policy that reduces carbon emissions by 35 percent—broadly consistent with Biden Administration's new Paris Agreement commitment—can generate mild positive long-run effects on consumption and output, an expansion in the number and fraction of firms that use green technologies, and greater labor force participation, with marginal changes in the unemployment rate. In the short term, the adjustment to a higher carbon tax need not be accompanied by losses in output and consumption or a substantial increase in unemployment. Abstracting from green technology adoption implies that the same policy has substantial adverse short- *and* long-term effects on labor income, consumption, and output. Our findings highlight the importance of considering endogenous technology adoption in assessments of the labor market and aggregate effects of a carbon tax.

Ongoing Work

- Allow subsidies for clean technologies
- Heterogeneous labor force
  - Green and regular workers
  - High and low-skilled workers
- Model the impacts of the Inflation Reduction Act

Thank you!

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