Labor Mobility with Environmental Regulation

MIBB

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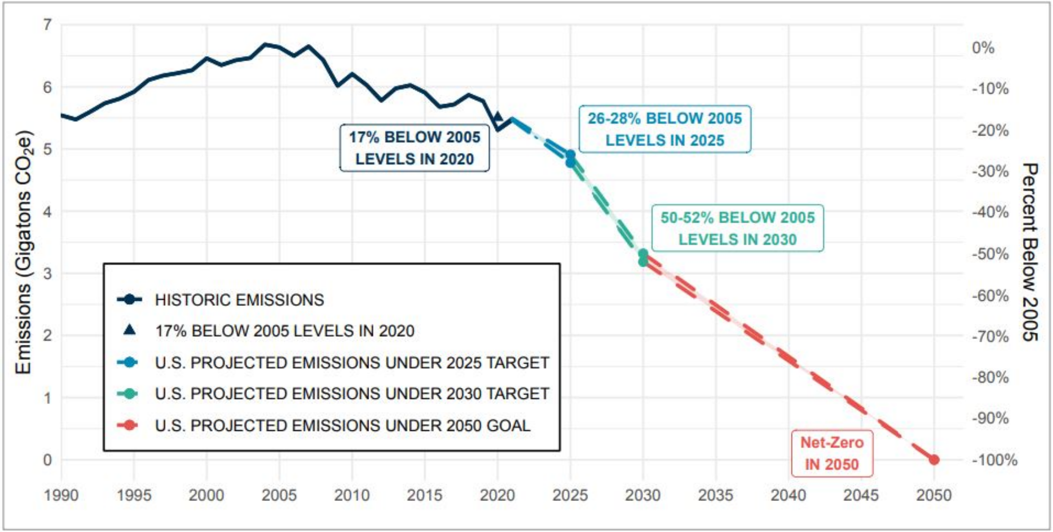
Department of Economics
University of Copenhagen

Motivation



Emissions (Gigatons CO_2e)
Percent Below 2005
7
6
5
4
3
2
1
0
0%
-10%
-20%
-30%
-40%
-50%
-60%
-70%
-80%
-90%
-100%
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
17% BELOW 2005 LEVELS IN 2020
26-28% BELOW 2005 LEVELS IN 2025
50-52% BELOW 2005 LEVELS IN 2030
Net-Zero IN 2050
HISTORIC EMISSIONS
17% BELOW 2005 LEVELS IN 2020
U.S. PROJECTED EMISSIONS UNDER 2025 TARGET
U.S. PROJECTED EMISSIONS UNDER 2030 TARGET
U.S. PROJECTED EMISSIONS UNDER 2050 GOAL

Political hesistancy

The 2015 Paris Agreement

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The Yellow Vests

Contents

- Research question, Contribution and Related Literature
- Data
- Model
- Estimation
- Counterfactual simulations
- Possible extensions
- Weak points

Research question, Contribution and Related Literature

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  - To what extent are costs reduced when the policy is announced in advance or phased in gradually?
- How: Set up a general equilibrium dynamic discrete choice model with heterogeneous workers choosing which sector to work in and representative firms emitting greenhouse gasses from burning fossil fuels. Structurally estimate the model to capture historical patterns of labor market choices.

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- Structural approach circumvents identification issues of reduced-form papers.

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  - **Reduced form evidence** of the effects of environmental regulation on labor market earnings and job loss (Walker 2013; Yip 2018).
  - **Structural evidence** of the effects of carbon taxes on labor markets (Hafstead and Williams 2018) and income groups (Goulder et al. 2019).
  - **Dynamic discrete choice programming models** of the labor market. (Dix-Carneiro 2014; Ashournia 2018; Traiberman 2019; Humlum 2019) building on early papers by Rust (1987) and Keane and Wolpin (1997).

Related literature (1/2)

Reduced form evidence of Yip (2018):

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⇒ I include multiple dimensions of heterogeneity in a different model framework.

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- Prices on energy (not certain yet, could be backed out from unit values)

Data patterns (1/2)

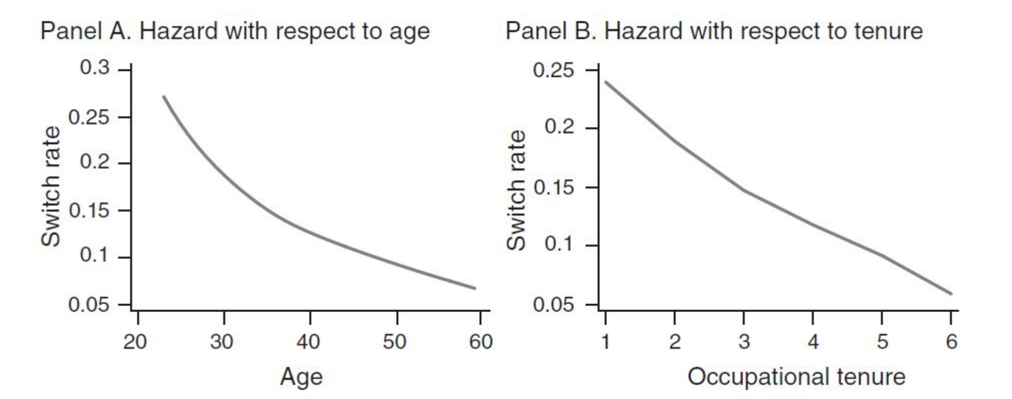

Figure 1: From Traiberman (2019)

Data patterns (2/2)

Average Yearly Transition Rates

From ↓ , to →	(0)	(1)	(2)	(3)	(4)	(5)
(0)	0.4794	0.0141	0.1053	0.0436	0.1046	0.2531
(1)	0.0409	0.8447	0.0281	0.0228	0.0265	0.0370
(2)	0.0294	0.0017	0.9090	0.0080	0.0249	0.0271
(3)	0.0290	0.0042	0.0208	0.9009	0.0191	0.0261
(4)	0.0227	0.0016	0.0226	0.0063	0.9144	0.0324
(5)	0.0182	0.0009	0.0075	0.0026	0.0111	0.9596

Notes. Sectors: (0) unemployment; (1) agriculture/mining; (2) manufacturing; (3) construction; (4) trade/utilities/transportation/communication; (5) services.

Figure 2: From Ashournia (2018)

Model

Firms and emissions

One representative firm for each sector s in each year t produces using four inputs:

- Human capital, H, with price r^H
- Physical capital, K, with price r^K
- Clean energy, E, with price p^E
- Dirty energy, O, with price p^O and carbon tax τ_s

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It has the production function

$$Y = AH^{\alpha_1} K^{\alpha_2} (\text{Energy})^{\alpha_3}, \qquad \text{Energy} \equiv \left(E_{st}^{\theta_s} + O_{st}^{\theta_s} \right)^{\frac{1}{\theta_s}} \tag{1}$$

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and emits carbon dioxide emissions Z according to

$$Z = \eta_s O. \tag{2}$$

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Utility is the sum of three parts

- Wages, w_{ist}
- Sector switching costs, $M(s_t, s_{t-1}, \Omega_{it})$
- Sectoral preference shocks (unobserved to the econometrician), ε_{ist}

Bellman equation and state space

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$$V_t(\Omega_{it}) = \max_s V_{st}\left(\Omega_{it}\right). \tag{3}$$

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$$V_{st}(\Omega_{it}) = \begin{cases} w_{ist} - M(s_t, s_{t-1}, \Omega_{it}) + \varepsilon_{ist} + \rho E_\varepsilon\left[V_{t+1}\left(\Omega_{it+1}\right)|d_{ist}\right] & \text{for } a_{it} < 65 \\ w_{ist} - M(s_t, s_{t-1}, \Omega_{it}) + \varepsilon_{ist} & \text{for } a_{it} = 65 \end{cases} \tag{4}$$

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The state space includes age, previous sector, education, tenure and the expectation of future skill prices:

$$\Omega_{it} = \left\{a_{it}, s_{it-1}, \text{educ}_i, \text{ten}_{it}, \left\{r_{st+\iota}\right\}_{\iota=0}^{65-a_{it}}\right\}. \tag{5}$$

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- Human capital function:

$$H_s(a_{it}, \text{educ}_i, \text{ten}_{it}, s_{it-1}) \equiv \exp\Big(\beta_s^0 a_{it} + \beta_s^1 (a_{it})^2 + \beta_s^{educ}\mathbf{educ}_i + \beta_s^5 \text{ten}_{it}\mathbf{1}(s = s_{it-1})\Big) \tag{7}$$

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- Sector-specific knowledge (tenure):

$$\text{ten}_{it+1} = \begin{cases} \text{ten}_{it} + 1 & \text{if} \quad s_{it} = s_{it-1} \\ 1 & \text{if} \quad s_{it} \neq s_{it-1} \end{cases} \tag{8}$$

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with

$$m_1(s_t, s_{t-1}) = \exp\left(\xi^{out}_{s_{t-1}} + \xi^{in}_{s_t}\right). \tag{10}$$

$$m_2(a_{it}, \text{educ}_i) = \exp\left(\kappa_0 a_{it} + \kappa_1 (a_{it})^2 + \boldsymbol{\kappa}_{\text{educ}} \textbf{educ}_i\right) \tag{11}$$

Solving the model

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- Perfect foresight of skill prices $\{r_{st+\iota}\}_{\iota=0}^{65-a_{it}}$ as in Lee (2005).
- Equilibrium skill prices $\{r_{st+\iota}\}_{\iota=0}^{65-a_{it}}$ are determined in equilibrium,

$$H_{st}^{supply}(\{\boldsymbol{r}_{t+\iota}\}_{\iota=0}^{65-30}) = H_{st}^{demand}(r_{st}) \tag{13}$$

Closing the model

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- Cobb-Douglas utility of consumption

$$u(C_{1t}, \ldots, C_{st}, \ldots, C_{S-1t}) = \prod_{s=1}^{S-1} C_{st}^{\mu_s}. \tag{14}$$

giving, for non-tradeables,

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- Assumption on the supply of physical capital needed too.

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Estimation (1/2)

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  - Dirty energy emission intensity η_s

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  - From the first order conditions of the firm's problem (and adding an error term):

$$\log\left(\frac{E_{st}}{O_{st}}\right) = \frac{1}{\theta_s - 1}\log\left(\frac{p_t^E}{\eta_s\tau_{st} + p_s^O}\right) + \epsilon_{st} \qquad \forall\ t \tag{16}$$

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- Initial period is 1996, terminal period is 2016
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- Solve model for a given set of parameters, calculate likelihood function and optimize.

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  - Entering cohorts in the future have the same composition as entering cohorts in 2016

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- Make foreign production more sophisticated for "carbon leakage" effects
- Different consumption shares for different workers (Känzig 2021)

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- External validity (Denmark vs. US)?
- Indirect links between firms are not present. Electricity (clean energy) price will go up when carbon tax does.
- Educational choice is exogenous in the model.

Thank you.

Feedback and comments: jl@econ.ku.dk

Appendix

Closed form solutions

- Closed-form solutions for continuation values

$$E_{\varepsilon}\left[V_t(\Omega_{it})\right] = \sigma \log\left(\sum_{s} \exp\left(\frac{w_{ist} - M(s_t, s_{t-1}, \Omega_{it}) + \rho E_{\varepsilon}\left[V_{t+1}(\Omega_{it+1}) | d_{ist}\right]}{\sigma}\right)\right). \tag{17}$$

Closed form solutions

- Closed-form solutions for continuation values

$$E_\varepsilon\left[V_t(\Omega_{it})\right] = \sigma \log\left(\sum_s \exp\left(\frac{w_{ist} - M(s_t, s_{t-1}, \Omega_{it}) + \rho E_\varepsilon\left[V_{t+1}(\Omega_{it+1})|d_{ist}\right]}{\sigma}\right)\right). \tag{17}$$

and conditional choice probabilities:

$$P(d_{ist} = 1|\Omega_{it}) = \frac{\exp\left(\frac{w_{ist} - M(s, s_{t-1}, \Omega_{it}) + \rho E_\varepsilon[V_{t+1}(\Omega_{it+1})|d_{ist}]}{\sigma}\right)}{\sum_j \exp\left(\frac{w_{ijt} - M(j, s_{t-1}, \Omega_{it}) + \rho E_\varepsilon\left[V_{t+1}(\Omega_{it+1})|d_{ijt}\right]}{\sigma}\right)}. \tag{18}$$

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- Equilibrium condition

$$H_{st}^{supply}(\{\boldsymbol{r}_{t+\iota}\}_{\iota=0}^{65-30}) = H_{st}^{demand}(r_{st})$$

$$\text{MASS}_t \sum_{\omega \in \widetilde{\Omega}_t} D_t(\omega) P\left(d_{\omega st} = 1 |\, \omega, \{\boldsymbol{r}_{t+\iota}\}_{\iota=0}^{65-30}\right) = \alpha_{st}^1 p_{st}^Y \frac{Y_{st}}{r_{st}} \qquad \forall\ s, t. \quad (19)$$