Labor Reallocation, Green Subsidies, and Unemployment

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Green subsidies are prevalent

- Many countries are adopting **green subsidies** as part of their decarbonization efforts
  - U.S.: The **Inflation Reduction Act** provides hundreds of billions of dollars in tax credits to green sectors and technologies
  - EU: >€800 billion in renewable electricity subsidies since 2008 (European Commission, 2022) and **Green Deal Industrial Plan**

Green subsidies and jobs

- The adoption of green subsidies comes at a time of **public concern** about the impact of environmental regulation on jobs
- Green subsidies might:
  - Benefit workers performing **environmentally related tasks**
  - Displace workers in **polluting sectors**
- A risk is that **displaced workers** cannot reallocate to another job and become **unemployed**
- How does a green subsidy affect **worker reallocation and unemployment**?
- How does a green subsidy **compare** to a carbon tax?

This paper: Employment impact of green subsidies

- Main research question: How do green subsidies affect:
  - Unemployment
  - The number of **green, fossil, and remaining “neutral"** jobs
- Develop a general equilibrium search model
  - Compare green subsidies to carbon taxes for different **financing mechanisms** and levels of **preexisting distortions**
- New **empirical evidence** using survey data for the U.S. on:
  - The **distribution** of green, fossil, and neutral jobs
  - Job-to-job **transition** probabilities

Literature (1)

1. Employment impact of environmental regulation
   - Econometric methods (Walker, 2013; Yip, 2018; Chen et al., 2020; Popp et al., 2021)
     - But: Endogenous employment in counterfactual (unregulated) sectors due to labor reallocation (Hafstead and Williams, 2018)
   - GE analyses
     - Carbon taxes (Hafstead and Williams, 2018; Aubert and Chiroleu-Assouline, 2019; Carbone et al., 2020; Fernández Intriago, 2021; Heutel and Zhang, 2021; Hafstead, Williams and Chen, 2022; Finkelstein Shapiro and Metcalf, 2023; Castellanos and Heutel, 2024)
     - Green subsidies (Shimer, 2013; Bistline, Mehrotra and Wolfram, 2023)

This paper: **GE analysis of green subsidies** in a microfounded model with search frictions

Literature (2)

2. Interaction of environmental regulation and the tax system

   - Full employment (Bovenberg and de Mooij, 1994; Bovenberg and van der Ploeg, 1994; Goulder, 1995; Parry, 1995; Bovenberg and Goulder, 1996; Fullerton, 1997; Parry, 1998; Fullerton and Metcalf, 2001; Bento and Jacobsen, 2007; Carbone and Smith, 2008; Kaplow, 2012; Barrage, 2019)
   - With unemployment (Carraro, Galeotti and Gallo, 1996; Bovenberg, 1997; Bovenberg and van der Ploeg, 1998a,b; Koskela and Schöb, 1999; Wagner, 2005; Hafstead and Williams, 2018)
     - But: Focus on carbon taxes

This paper: Employment impact of green subsidies with **involuntary unemployment** and **preexisting distortions**

Literature (3)

3. Empirical measurements of the number of green jobs

- **No standard definition** of a green job
- Typically: Jobs in **green sectors** are green
  (Curtis and Marinescu, 2022; Colmer, Lyubich and Voorheis, 2023; Curtis, O'Kane and Park, 2023)
- Recently: Jobs involving **green tasks** are green
  (Vona et al., 2018; Vona, Marin and Consoli, 2019; Chen et al., 2020; Popp et al., 2021)
  - Captures jobs in green and non-green sectors

This paper: **Task-based approach** to measure the number of green jobs in the U.S.

Literature (4)

4. Search literature

   - Search models and climate policy (Hafstead and Williams, 2018; Aubert and Chiroleu-Assouline, 2019; Fernández Intriago, 2021; Hafstead, Williams and Chen, 2022; Finkelstein Shapiro and Metcalf, 2023)
   - Matching function $\rightarrow$ Determines the number of hires
     - Many studies use a matching function with one job type
     - Hafstead and Williams (2018) develop a matching function characterized by matching within and across job types
     - Key parameter: ξ $\rightarrow$ Controls the degree of friction associated with matching between firms and workers of different types

This paper: **Estimate** ξ using the search model and account for an empirically relevant **neutral job type**

Outline

1. Empirical analysis
2. Model
3. Calibration
4. Employment impact of a subsidy
5. Conclusion

Occupation data

- **Longitudinal data on occupations** from the Survey of Income and Program Participation (SIPP)
  - SIPP: Representative survey of the U.S. population by the U.S. Census Bureau
  - Survey participants are asked each year about their monthly occupation
  - Two panels: 2013-2016 and 2017-2020 (8 years in total)

- **Classify** the occupations as “green”, “fossil”, or “neutral”

Classifying "green" jobs

- Define green jobs using a **task-based approach** (Vona et al., 2018)
  - Rooted in the labor economics literature (Autor, Levy and Murnane, 2003; Acemoglu and Autor, 2011; Autor, 2013)
  - Conceptualizes a job as a **collection of tasks**
  - Green job = Job involving green tasks
  - Intuition: Jobs in which workers devote time to environmental activities are green
- Advantage: Captures jobs benefiting from the green transition, irrespective of the sector
- **Green job := Job with $\geq$ 50% of green tasks**, weighted by task importance
- Sensitivity on threshold

Task data

- Occupation-level task data from the U.S. Occupational Information Network (O*NET) database
- For 974 occupations (8-digit O*NET-SOC level):
  - **Task descriptions** (based on employee surveys, occupational experts, desk research)
  - **Task importance scores** (based on employee surveys and occupational experts)
  - **Task classification as green or non-green**
    - Green task = Task created from green economy activities and technologies

Green task classification

Examples of O*NET jobs with a weighted green task share ≥ 0.5

O*NET code	Title	Total tasks	Green tasks	Weighted green task share
17-2081.00	Environmental Engineers	28	28	1
19-2041.01	Climate Change Analysts	14	14	1
19-2041.02	Environmental Restoration Planners	22	22	1
19-2041.03	Industrial Ecologists	38	38	1
47-2231.00	Solar Photovoltaic Installers	26	26	1
47-4099.02	Solar Thermal Installers and Technicians	21	21	1
49-9081.00	Wind Turbine Service Technicians	13	13	1
49-9099.01	Geothermal Technicians	24	24	1

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Green task examples of “47-2231.00 - Solar Photovoltaic Installers"

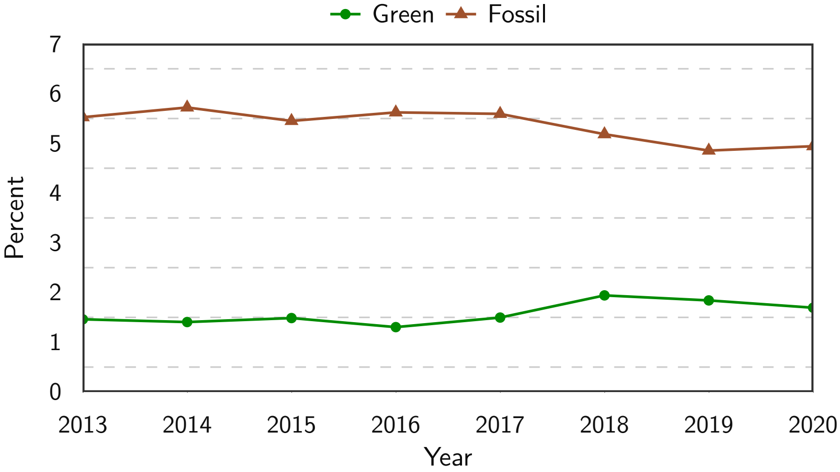
- “**Install photovoltaic (PV) systems** in accordance with codes and standards, using drawings, schematics, and instructions."
- ‘Perform routine photovoltaic (PV) **system maintenance** on modules, arrays, batteries, power conditioning equipment, safety systems, structural systems, weather sealing, or balance of systems equipment."
- “Visually **inspect and test** photovoltaic (PV) modules or systems."

Classifying "fossil" jobs

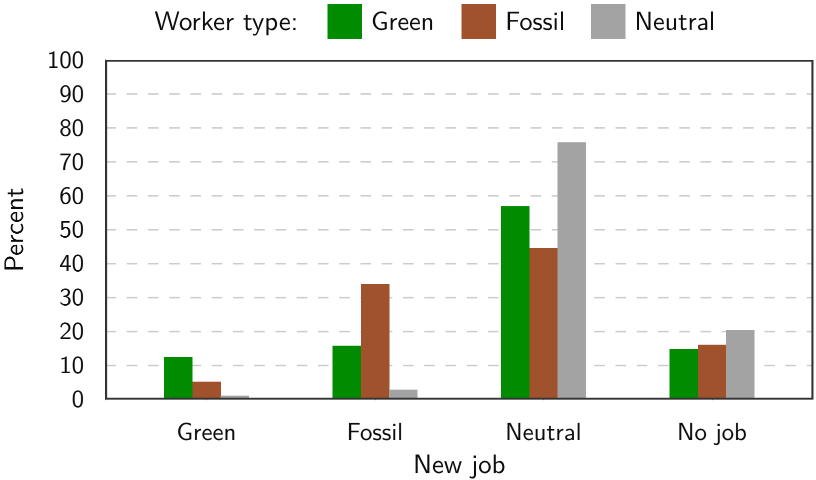
- No fossil task data - define fossil jobs as jobs disproportionately found in polluting sectors
- Procedure:
  1. Identify the 5% most **emissions-intensive sectors** in SIPP
     - Emissions data: EPA
     - Sector-level employment data: BLS
  2. **Fossil job** $:=$ Job ≥ 8 times more likely to be found in one of these sectors
- Fossil workers $\rightarrow$ Workers at risk of losing their job because of their sector

Fossil jobs   Sensitivity

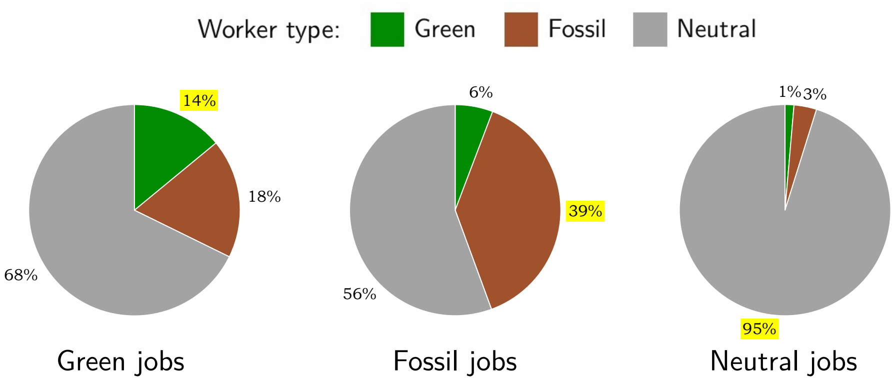
Green jobs have increased slightly, but most jobs are neutral



Fossil workers are more likely to transition to a neutral job than a green job



Distribution of workers starting each job



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Model overview

- General equilibrium search model that builds on Shimer (2010) and Hafstead and Williams (2018)
- $t = \{0, 1, 2, ...\}$ months (suppressed henceforth for legibility)
- Worker $i = \{\text{green, fossil, neutral}\}$
- Firm $j = \{\text{green, fossil, neutral}\}$

Firms

- Firms hire workers for **recruitment** and **production**
  - **Recruitment** allows the firm to hire more workers
  - **Production** generates **output** using a linear function of labor
- **Fossil firms generate emissions** in proportion to output

Firm's problem

Workers

- Workers get utility from consumption C and disutility from working h_j hours:

$$U(C, h_i) = \log(C) - \psi \frac{\chi}{1+\chi} h_i^{\frac{1+\chi}{\chi}},$$

where ψ is disutility from work and χ is the Frisch elasticity of labor supply

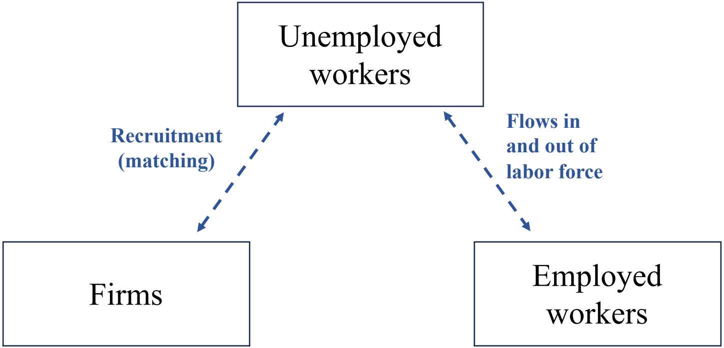
FOC

Government

- A government has access to an excise **emissions tax** and an excise **subsidy** on green firms' output
- The government collects revenue from a labor income tax, payroll tax and emissions tax, and returns it as transfers, unemployment benefits, and subsidy payments

BC

Labor market



Matching and ξ_j

$$\# \text{ hires}_{ij} = \text{f}(r_j, \sum_j r_j, u_i, \sum_i u_i, \xi_j)$$

- r_j = Recruitment effort by firm j
- u_i = Number of unemployed workers of type i
- $\xi_j \in [0, 1]$ = **Friction associated with cross-type matching**

Appendix

Matching and ξ_j

$$\# \text{ hires}_{ij} = \text{f}(r_j, \sum_j r_j, u_i, \sum_i u_i, \xi_j)$$

- $\xi_j = 0 \rightarrow$ Firm j can only recruit workers of type j (no cross-type matching)

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- $\xi_j = 1 \rightarrow$ Workers i and $j \neq i$ are equally likely to match with firm j (matching does not depend on a worker's type)

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- $\xi_j = 1 \rightarrow$ Workers i and $j \neq i$ are equally likely to match with firm j (matching does not depend on a worker's type)
- $\xi_j \in (0, 1) \rightarrow$ The share of cross-type matches for firm j is proportional to ξ_j (holding all variables constant)

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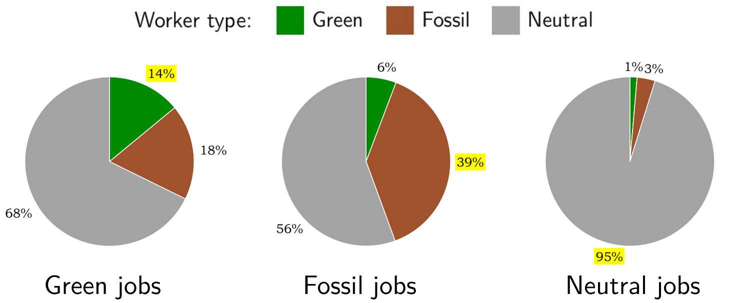
Solving for ξ_j in the no-policy benchmark



Solving the model to match the within-job type movement yields benchmark values of ξ_j:

$$\xi_j = \begin{cases} 0.87 & \text{for } j = \text{green}, \\ 0.58 & \text{for } j = \text{fossil}, \\ 1^* & \text{for } j = \text{neutral}. \end{cases}$$

*Capped at 1

Remaining calibration

Direct calibration		
Quit rate	π	0.037
Bargaining power of employer	η	0.5
Matching elasticity	γ	0.5
Discount rate	β	0.997
Frisch elasticity of labor supply	χ	1
Elasticity in the bottom consumption nest	σ^{fg}	0.75
Elasticity in the top consumption nest	σ^{C}	0.5
Labor income tax	τ^{L}	0.29
Payroll tax	τ^{P}	0.15
No-policy steady state calibration		
Cross-type matching friction for firm $j \in \{\texttt{f},\texttt{g},\texttt{z}\}$	ξ_j	0.58, 0.87, 1
Matching efficiency for firm $j \in \{\texttt{f},\texttt{g},\texttt{z}\}$	μ_j	4.18, 3.87, 3.84
Labor productivity	ζ	3.20
Disutility of work	ψ	5.93
CES share of good $r \in \{\texttt{f},\texttt{g},\texttt{z},\texttt{fg}\}$	ϱ_r	0.73, 0.27, 0.93, 0.07
Unemployment benefits for worker $i \in \{\texttt{f},\texttt{g},\texttt{z}\}$	b_i	0.25, 0.27, 0.28
Emissions factor of fossil firms	ϵ	0.0075

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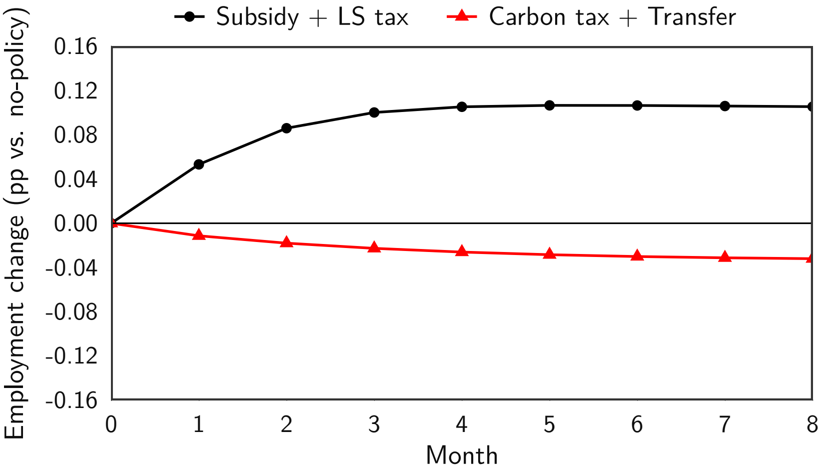
Policies

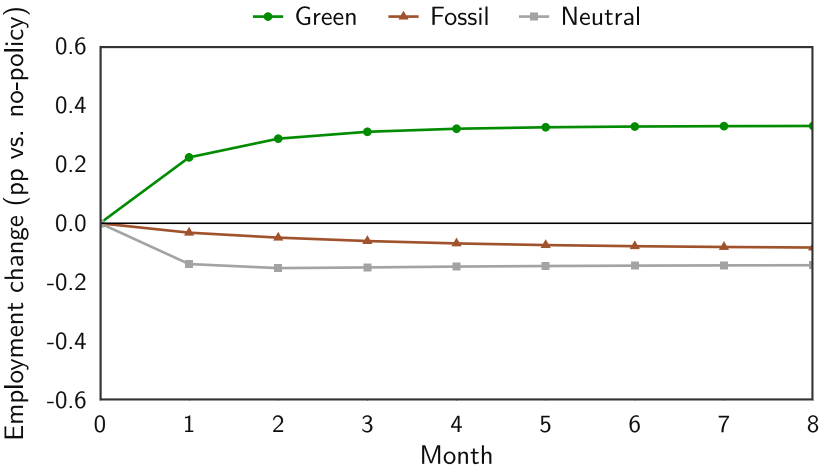
1. Subsidy on green firms' output
   - Subsidy expenditure = IRA budget of $781 billion (Bistline, Mehrotra and Wolfram, 2023)
2. A tax on fossil firms' emissions
   - Same abatement level as the subsidy

- Compare outcomes to a no-policy benchmark

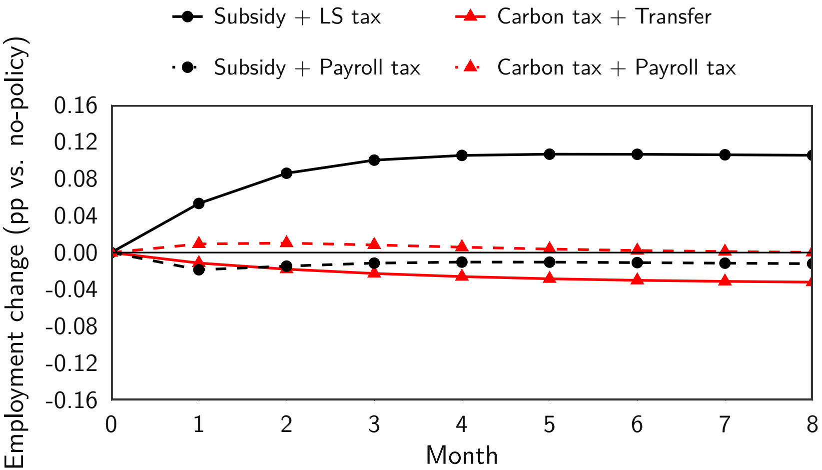
A subsidy can generate higher employment vs. a carbon tax...



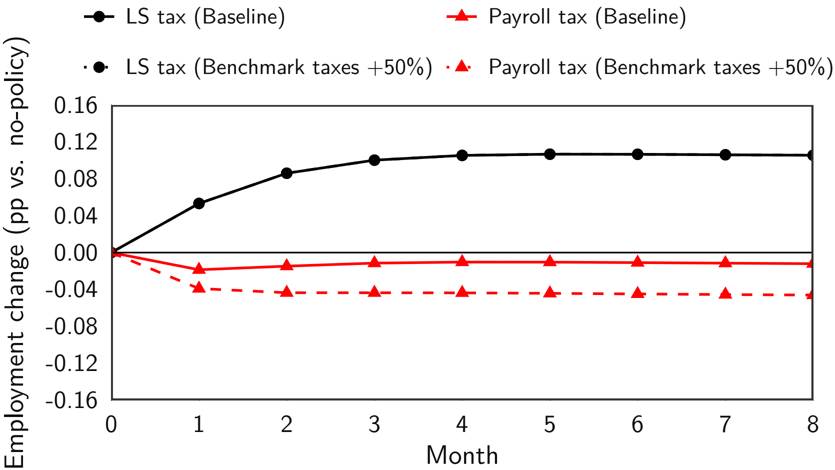
... as a result of large green job gains



The job gains disappear if the subsidy is financed by payroll taxes



Payroll taxes are even costlier when preexisting distortions are high



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Conclusion

- Green jobs have increased slightly in the U.S. ...
- ... But the majority of jobs are neutral

- Few fossil workers transition to a green job ...
- ... Instead, they are more likely to start a neutral job

- Green subsidies can generate better employment outcomes relative to a carbon tax ...
- ... But this result is sensitive to the choice of financing mechanism

Thank you!

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References I

Acemoglu, Daron, and David Autor. 2011. "Chapter 12 - Skills, Tasks and Technologies: Implications for Employment and Earnings." In Handbook of Labor Economics. Vol. 4, ed(s). David Card and Orley Ashenfelter, 1043–1171. Elsevier.

Aubert, Diane, and Mireille Chiroleu-Assouline. 2019. "Environmental tax reform and income distribution with imperfect heterogeneous labour markets." European Economic Review, 116: 60–82.

Autor, David H. 2013. "The "task approach" to labor markets: an overview." Journal for Labour Market Research, 46(3).

Autor, David H., Frank Levy, and Richard J. Murnane. 2003. "The Skill Content of Recent Technological Change: An Empirical Exploration." The Quarterly Journal of Economics, 118(4): 1279–1333.

Barrage, Lint. 2019. "Optimal Dynamic Carbon Taxes in a Climate–Economy Model with Distortionary Fiscal Policy." The Review of Economic Studies, 87(1): 1–39.

Bento, Antonio M., and Mark Jacobsen. 2007. "Ricardian rents, environmental policy and the 'double-dividend' hypothesis." Journal of Environmental Economics and Management, 53(1): 17–31.

Bistline, John, Neil Mehrotra, and Catherine Wolfram. 2023. "Economic Implications of the Climate Provisions of the Inflation Reduction Act." Working Paper 31267, National Bureau of Economic Research.

Bovenberg, A. Lans. 1997. "Environmental policy, distortionary labour taxation and employment: pollution taxes and the double dividend." In New Directions in the Economic Theory of the Environment. Ed(s). Carlo Carraro and Domenico Siniscalco, 69–104. Cambridge University Press.

Bovenberg, A. Lans, and Frederick van der Ploeg. 1994. "Environmental policy, public finance and the labour market in a second-best world." Journal of Public Economics, 55(3): 349–390.

Bovenberg, A. Lans, and Frederick van der Ploeg. 1998a. "Tax Reform, Structural Unemployment and the Environment." The Scandinavian Journal of Economics, 100(3): 593–610.

Bovenberg, A. Lans, and Frederick van der Ploeg. 1998b. "Consequences of Environmental Tax Reform for Unemployment and Welfare." Environmental & Resource Economics, 12(2): 137–150.

Bovenberg, A. Lans, and Lawrence H. Goulder. 1996. "Optimal Environmental Taxation in the Presence of Other Taxes: General- Equilibrium Analyses." The American Economic Review, 86(4): 985–1000.

Bovenberg, A. Lans, and Ruud A. de Mooij. 1994. "Environmental Levies and Distortionary Taxation." The American Economic Review, 84(4): 1085–1089.

References II

Carbone, Jared C., and V. Kerry Smith. 2008. "Evaluating policy interventions with general equilibrium externalities." Journal of Public Economics, 92(5): 1254–1274.

Carbone, Jared C., Nicholas Rivers, Akio Yamazaki, and Hidemichi Yonezawa. 2020. "Comparing Applied General Equilibrium and Econometric Estimates of the Effect of an Environmental Policy Shock." Journal of the Association of Environmental and Resource Economists, 7(4): 687–719.

Carraro, Carlo, Marzio Galeotti, and Massimo Gallo. 1996. "Environmental taxation and unemployment: Some evidence on the 'double dividend hypothesis' in Europe." Journal of Public Economics, 62(1): 141–181. Proceedings of the Trans-Atlantic Public Economic Seminar on Market Failures and Public Policy.

Castellanos, Kenneth A, and Garth Heutel. 2024. "Unemployment, Labor Mobility, and Climate Policy." Journal of the Association of Environmental and Resource Economists, 11(1): 1–40.

Chen, Ziqiao, Giovanni Marin, David Popp, and Francesco Vona. 2020. "Green Stimulus in a Post-pandemic Recovery: the Role of Skills for a Resilient Recovery." Environmental & Resource Economics, 76(4): 901–911.

Colmer, Jonathan, Eva Lyubich, and John Voorheis. 2023. "Nice Work if You Can Get It? The Distribution of Employment and Earnings During the Early Years of the Clean Energy Transition." Working Paper.

Curtis, E. Mark, and Ioana Marinescu. 2022. "Green Energy Jobs in the US: What Are They, and Where Are They?" Working Paper 30332, National Bureau of Economic Research.

Curtis, E. Mark, Layla O'Kane, and R. Jisung Park. 2023. "Workers and the Green-Energy Transition: Evidence from 300 Million Job Transitions." Working Paper 31539, National Bureau of Economic Research.

Dierdorff, Erich C., Jennifer J. Norton, Donald W. Drewes, Christina M. Kroustalis, David Rivkin, and Phil Lewis. 2009. "Greening of the World of Work: Implications for O*NET-SOC and New and Emerging Occupations." Prepared for U.S. Department of Labor Employment and Training Administration Office of Workforce Investment Division of Workforce System Support Washington, DC.

European Commission and Directorate-General for Energy and Badouard, T and Bon Mardion, J and Bovy, P and Casteleyn, M and Eyhorn, D and Fonteneau, T and Lemoine, P. 2022. Study on energy subsidies and other government interventions in the European Union – Final report – 2022 edition. Publications Office of the European Union.

Fernández Intriago, Luis A. 2021. "Carbon Taxation, Green Jobs, and Sectoral Human Capital." Working Paper.

References III

Finkelstein Shapiro, Alan, and Gilbert E. Metcalf. 2023. "The macroeconomic effects of a carbon tax to meet the U.S. Paris agreement target: The role of firm creation and technology adoption." Journal of Public Economics, 218: 104800.

Fullerton, Don. 1997. "Environmental Levies and Distortionary Taxation: Comment." The American Economic Review, 87(1): 245–251.

Fullerton, Don, and Gilbert E. Metcalf. 2001. "Environmental controls, scarcity rents, and pre-existing distortions." Journal of Public Economics, 80(2): 249–267.

Goulder, Lawrence H. 1995. "Effects of Carbon Taxes in an Economy with Prior Tax Distortions: An Intertemporal General Equilibrium Analysis." Journal of Environmental Economics and Management, 29(3): 271–297.

Hafstead, Marc A.C., and Roberton C. Williams. 2018. "Unemployment and environmental regulation in general equilibrium." Journal of Public Economics, 160: 50–65.

Hafstead, Marc A. C., Roberton C. Williams, and Yunguang Chen. 2022. "Environmental Policy, Full-Employment Models, and Employment: A Critical Analysis." Journal of the Association of Environmental and Resource Economists, 9(2): 199–234.

Heutel, Garth, and Xin Zhang. 2021. "Efficiency wages, unemployment, and environmental policy." Energy Economics, 104: 105639.

Kaplow, By Louis. 2012. "Optimal Control of Externalities in the Presence of Income Taxation." International Economic Review, 53(2): 487–509.

Koskela, Erkki, and Ronnie Schöb. 1999. "Alleviating unemployment:: The case for green tax reforms." European Economic Review, 43(9): 1723–1746.

Merz, Monika. 1995. "Search in the labor market and the real business cycle." Journal of Monetary Economics, 36(2): 269–300.

Parry, Ian. 1998. "A Second-Best Analysis of Environmental Subsidies." International Tax and Public Finance, 5(2): 153–170.

Parry, Ian W.H. 1995. "Pollution Taxes and Revenue Recycling." Journal of Environmental Economics and Management, 29(3): S64–S77.

Popp, David, Fransesco Vona, Giovanni Marin, and Ziqiao Chen. 2021. "The Employment Impact of a Green Fiscal Push: Evidence from the American Recovery and Reinvestment Act." Brookings Papers on Economic Activity, 1–49.

Shimer, Robert. 2010. Labor Markets and Business Cycles. Princeton University Press.

Shimer, Robert. 2013. "A Framework for Valuing the Employment Consequences of Environmental Regulation." Working Paper.

References IV

Vona, Francesco, Giovanni Marin, and Davide Consoli. 2019. "Measures, drivers and effects of green employment: evidence from US local labor markets, 2006–2014." Journal of Economic Geography, 19(5): 1021–1048.

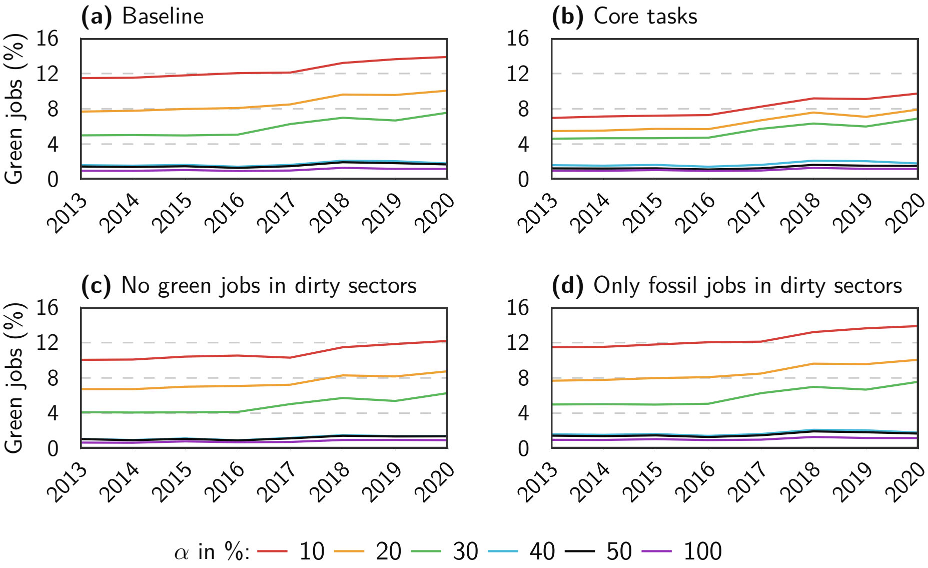
Vona, Francesco, Giovanni Marin, Davide Consoli, and David Popp. 2018. "Environmental Regulation and Green Skills: An Empirical Exploration." Journal of the Association of Environmental and Resource Economists, 5(4): 713–753.

Wagner, Thomas. 2005. "Environmental policy and the equilibrium rate of unemployment." Journal of Environmental Economics and Management, 49(1): 132–156.

Walker, W. Reed. 2013. "The Transitional Costs of Sectoral Reallocation: Evidence from the Clean Air Act and the Workforce." The Quarterly Journal of Economics, 128(4): 1787–1836.

Yip, Chi Man. 2018. "On the labor market consequences of environmental taxes." Journal of Environmental Economics and Management, 89: 136–152.

Green job share by sensitivity test (panels) and α (lines)



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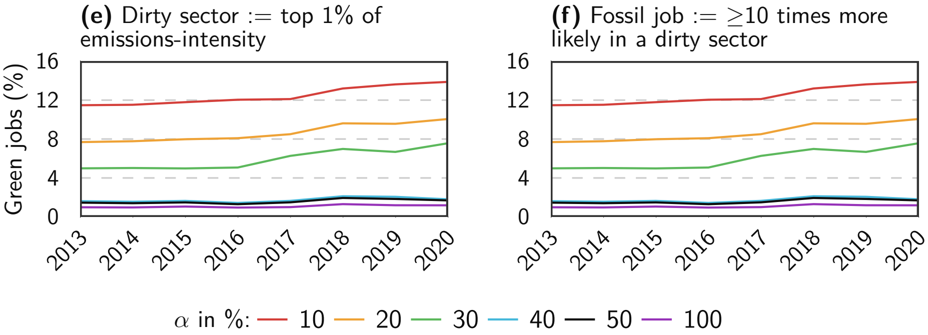
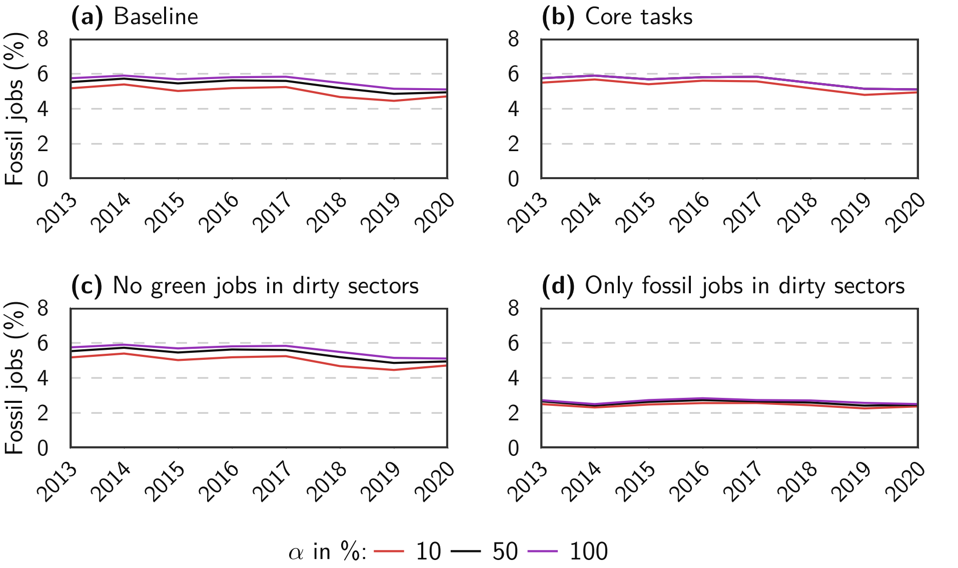


Fossil job share by sensitivity test (panels) and α (lines)



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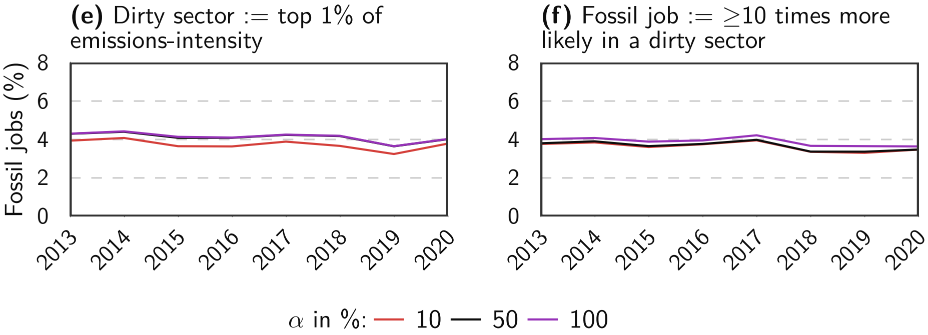
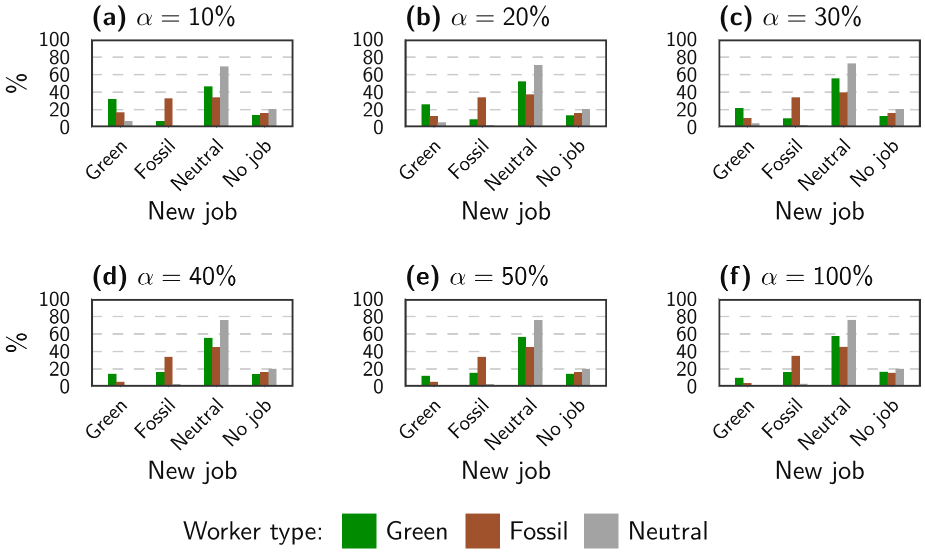
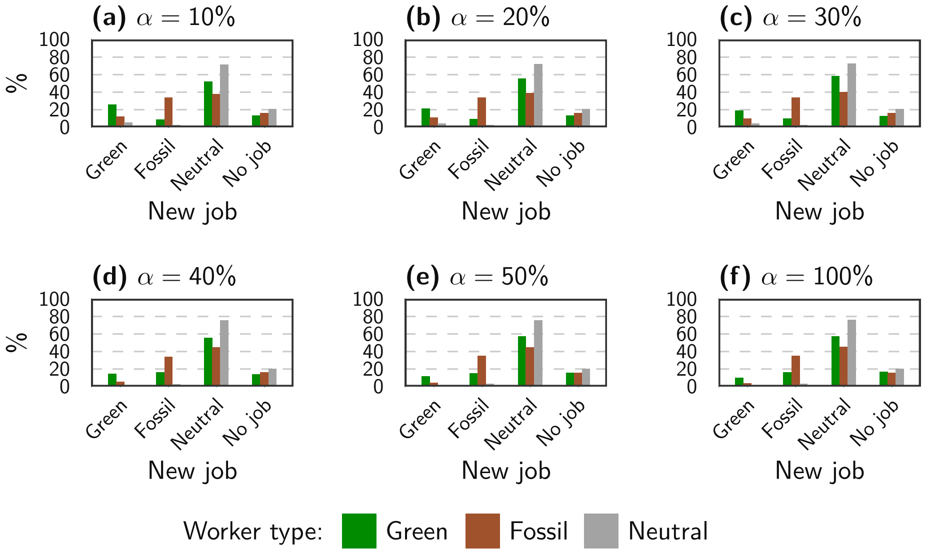


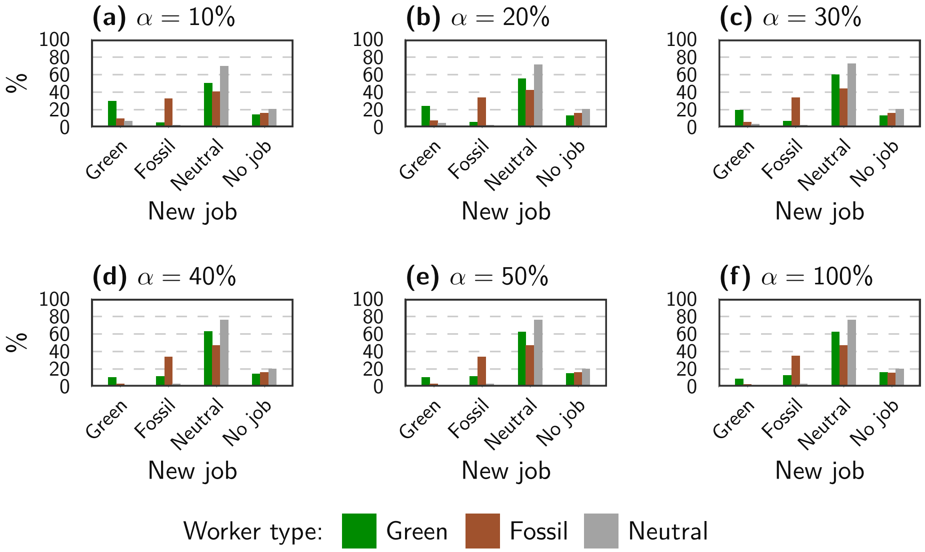
Job-finding probability by α, type of job, and worker type



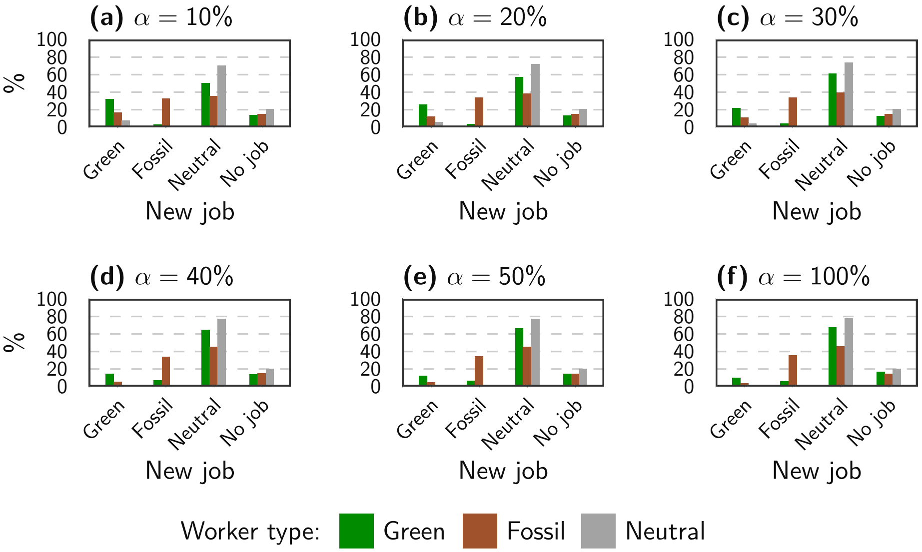
Job-finding probability by α, type of job, and worker type (only core tasks)



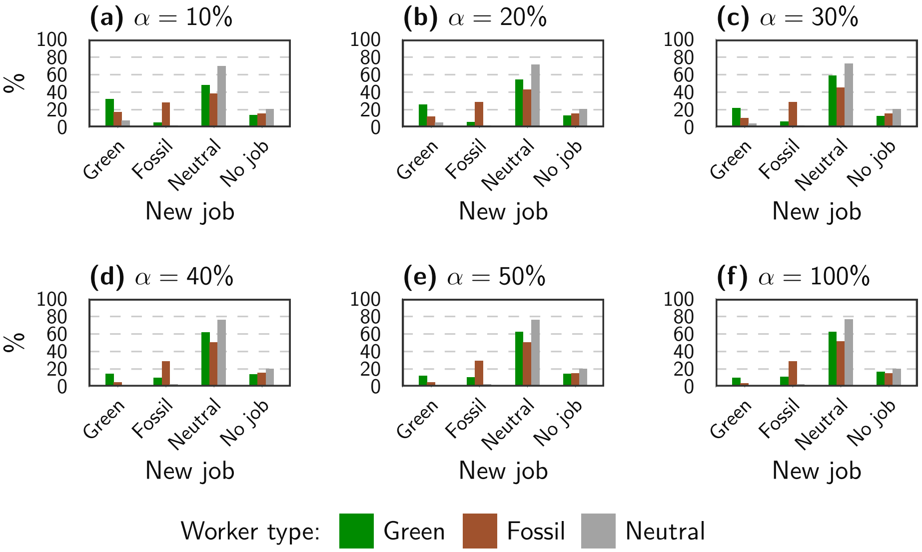
Job-finding probability by α, type of job, and worker type (no green jobs in dirty sectors)



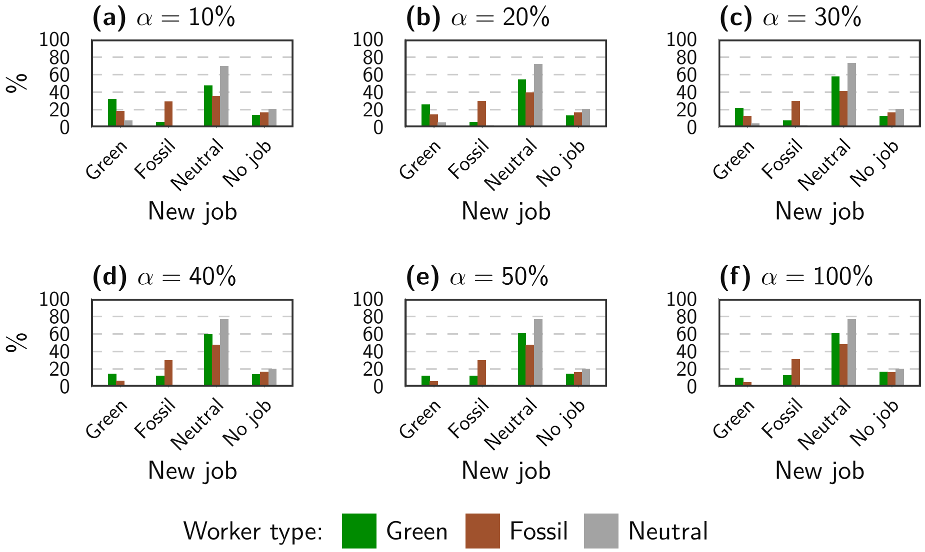
Job-finding probability by α, type of job, and worker type (only fossil jobs in dirty sectors)



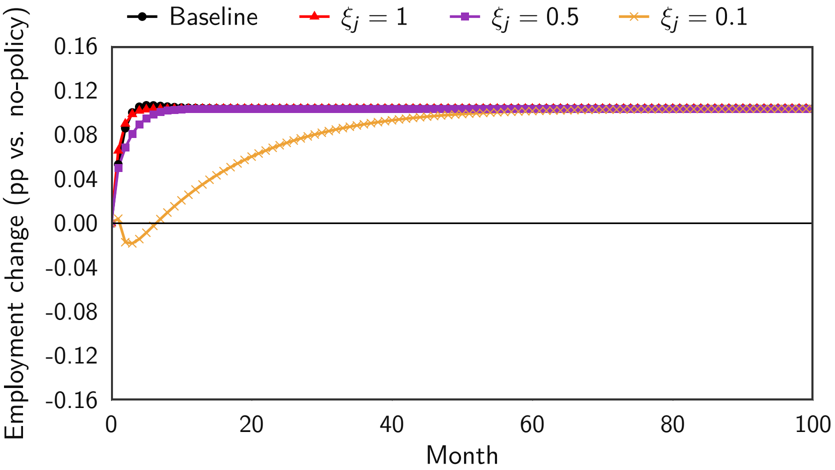
Job-finding probability by α, job, and worker type (1% emissions-intensity cutoff)



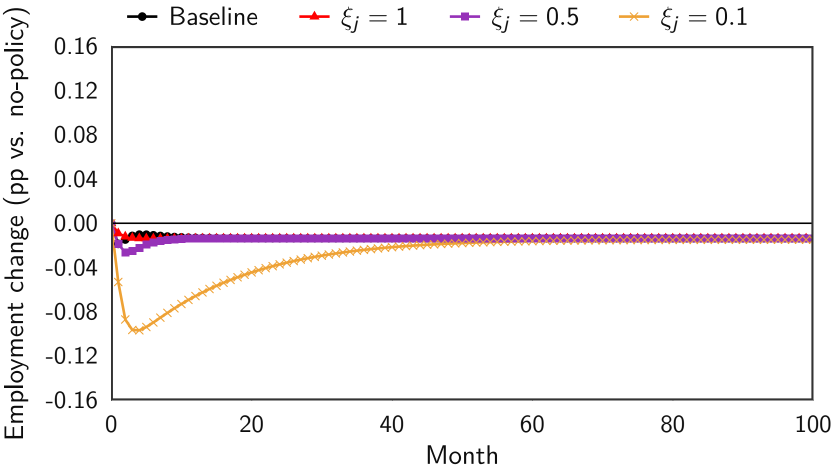
Job-finding probability by α, job, and worker type (fossil job $\geq$10 times in dirty sector)



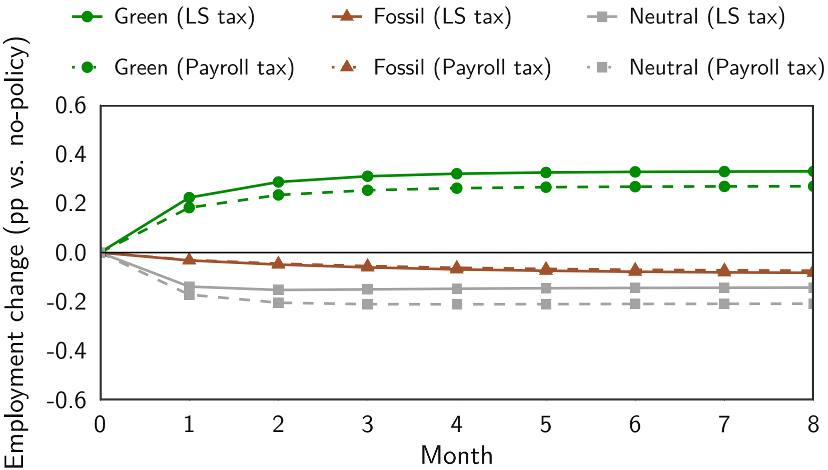
Subsidy with lump sum taxes for various ξ_j



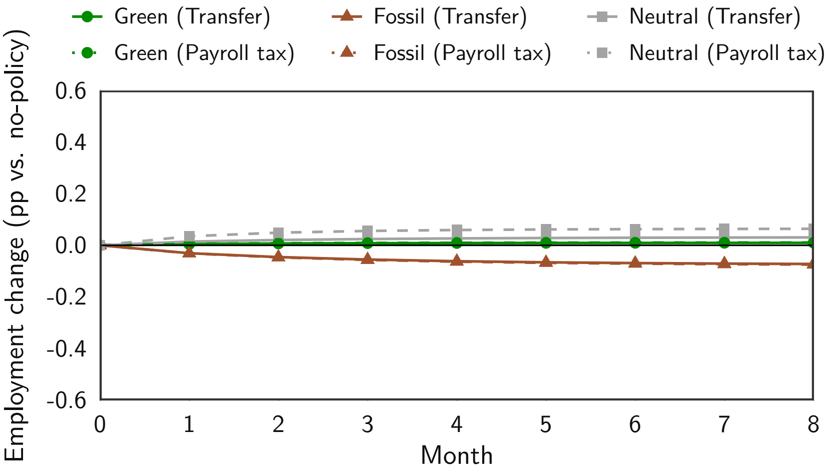
Subsidy with payroll taxes for various ξ_j



Payroll taxes increase the cost of hiring, reducing green job gains



Smaller employment change from a carbon tax



Steady state changes from a subsidy (in % relative to no-policy)

	Gross price p_j	Output y_j	Recruitment $\upsilon_j q_j h_j$	Employment n_j
Green	0	19.8	19.5	19.5
Fossil	30.1	-1.7	-1.9	-1.9
Neutral	30.1	0.0	-0.2	-0.2

Steady state changes from a carbon tax (in % relative to no-policy)

	Gross price p_j	Output y_j	Recruitment $\upsilon_j q_j h_j$	Employment n_j
Green	0	0.53	0.58	0.58
Fossil	0.03	-1.68	-1.63	-1.63
Neutral	0.00	-0.02	0.04	0.04

Changes from a subsidy (in % relative to no-policy)

		Firm-level			Worker-level	
		Number of recruiters	Recruitment productivity	Hours worked	Job-finding probability	After-tax real wage
Green	$t = 0$	345.0	-8.6	12.3	16.9	7.475
	SS	21.6	-1.9	0.2	1.9	0.448
Fossil	$t = 0$	-21.0	3.5	-0.6	-3.2	-0.090
	SS	-0.2	-1.9	0.2	1.9	0.449
Neutral	$t = 0$	-2.5	-1.9	0.1	1.5	0.406
	SS	1.5	-1.9	0.2	1.9	0.448

Employment change by policy instrument and parameter (in pp relative to no-policy)

	Subsidy + LS tax	Subsidy + Payroll tax	Carbon tax + Transfer	Carbon tax + Payroll tax
Baseline	0.104	-0.014	-0.034	-0.001
q_j up by 50%	0.155	-0.025	-0.050	-0.002
q_j down by 50%	0.048	-0.005	-0.016	-0.001
$\eta = 0.7$	0.226	-0.050	-0.072	-0.003
$\eta = 0.3$	0.041	-0.004	-0.014	-0.001
$\gamma = 0.75$	0.052	-0.006	-0.017	-0.001
$\gamma = 0.25$	0.155	-0.024	-0.049	-0.003
$\chi = 2$	0.078	-0.009	-0.024	-0.001
$\chi = 0.5$	0.121	-0.019	-0.041	-0.002
$\sigma^{fg} = 0.9$	0.065	-0.007	-0.032	-0.001
$\sigma^{fg} = 0.6$	0.253	-0.047	-0.036	-0.002
$\sigma^{C} = 0.6$	0.166	-0.030	-0.030	-0.001
$\sigma^{C} = 0.4$	0.075	-0.008	-0.038	-0.002

Subsidy, recruitment effort change, hour change from a subsidy by financing mechanism

	% change in recruitment effort		% change in hours		Subsidy rate	
	LS	Payroll	LS	Payroll	LS	Payroll
Baseline	1.74	-0.48	0.198	-0.014	0.30	0.25
q_j up by 50%	2.76	-0.69	0.175	-0.015	0.31	0.24
q_j down by 50%	0.66	-0.32	0.223	-0.014	0.30	0.25
$\eta = 0.7$	4.19	-1.17	0.148	-0.017	0.31	0.24
$\eta = 0.3$	0.51	-0.30	0.224	-0.014	0.29	0.25
$\gamma = 0.75$	2.65	-0.55	0.223	-0.014	0.30	0.25
$\gamma = 0.25$	0.84	-0.38	0.173	-0.014	0.31	0.24
$\chi = 2$	1.23	-0.39	0.293	-0.020	0.31	0.25
$\chi = 0.5$	2.09	-0.59	0.121	-0.010	0.29	0.25
$\sigma^{fg} = 0.9$	1.08	-0.28	0.120	-0.007	0.17	0.15
$\sigma^{fg} = 0.6$	4.21	-1.36	0.551	-0.050	1.01	0.57
$\sigma^{C} = 0.6$	2.71	-0.95	0.339	-0.031	0.53	0.37
$\sigma^{C} = 0.4$	1.29	-0.28	0.139	-0.008	0.21	0.18

Outcomes from a non-distortionary subsidy by firm and parameter value

	Benchmark unemployment benefits			Benchmark flow value of unemployment				Benchmark fundamental surplus ratio				Employment change (pp)		
	g	f	z	g	f	z	mean	g	f	z	mean	g	f	z
Baseline	0.27	0.25	0.28	0.60	0.58	0.61	0.61	0.09	0.12	0.08	0.08	0.33	-0.09	-0.14
q_j up by 50%	0.29	0.28	0.29	0.62	0.61	0.62	0.62	0.06	0.08	0.05	0.05	0.34	-0.09	-0.10
q_j down by 50%	0.21	0.17	0.23	0.54	0.50	0.56	0.56	0.18	0.24	0.16	0.16	0.32	-0.09	-0.19
$\eta = 0.7$	0.30	0.29	0.31	0.63	0.62	0.63	0.63	0.04	0.05	0.04	0.04	0.35	-0.08	-0.04
$\eta = 0.3$	0.20	0.15	0.21	0.53	0.48	0.54	0.54	0.20	0.27	0.18	0.18	0.32	-0.09	-0.20
$\gamma = 0.75$	0.27	0.25	0.28	0.60	0.58	0.61	0.61	0.09	0.12	0.08	0.08	0.32	-0.09	-0.18
$\gamma = 0.25$	0.27	0.25	0.28	0.60	0.58	0.61	0.61	0.09	0.12	0.08	0.08	0.34	-0.09	-0.10
$\chi = 2$	0.16	0.14	0.17	0.60	0.58	0.61	0.61	0.09	0.12	0.08	0.08	0.34	-0.09	-0.17
$\chi = 0.5$	0.38	0.36	0.39	0.60	0.58	0.61	0.61	0.09	0.12	0.08	0.08	0.32	-0.08	-0.12
$\sigma^{fg} = 0.9$	0.27	0.25	0.28	0.60	0.58	0.61	0.61	0.09	0.12	0.08	0.08	0.23	-0.08	-0.08
$\sigma^{fg} = 0.6$	0.27	0.25	0.28	0.60	0.58	0.61	0.61	0.09	0.12	0.08	0.08	0.82	-0.10	-0.47
$\sigma^{C} = 0.6$	0.27	0.25	0.28	0.60	0.58	0.61	0.61	0.09	0.12	0.08	0.08	0.59	-0.09	-0.33
$\sigma^{C} = 0.4$	0.27	0.25	0.28	0.60	0.58	0.61	0.61	0.09	0.12	0.08	0.08	0.22	-0.08	-0.07

Job classification summary

- 11 green jobs
- 63 fossil jobs
- Remaining 403 jobs → neutral

Green task classification of O*NET

- O*NET reviews the literature and identifies **occupations** expected to
  1. Experience **task changes** from green economy activities and technologies; or
  2. Be **created** from green economy activities and technologies
- For each occupation, O*NET conducts desk research to identify all **tasks created from green economy** activities and technologies
  → **Green tasks**

Main text

“Green economy” definition used by O*NET

“The green economy encompasses the economic activity related to reducing the use of fossil fuels, decreasing pollution and greenhouse gas emissions, increasing the efficiency of energy usage, recycling materials, and developing and adopting renewable sources of energy." (Dierdorff et al., 2009, p. 3)

▸▸ Main text

Green jobs

O*NET code	Title	Total tasks	Green tasks	Weighted green task share
11-1011.03	Chief Sustainability Officers	18	18	1
11-3051.02	Geothermal Production Managers	17	17	1
11-3051.03	Biofuels Production Managers	14	14	1
11-3051.04	Biomass Power Plant Managers	18	18	1
11-3051.06	Hydroelectric Production Managers	19	19	1
11-9041.01	Biofuels/Biodiesel Technology and Product Development Managers	19	19	1
11-9121.02	Water Resource Specialists	21	21	1
11-9199.09	Wind Energy Operations Managers	16	16	1
11-9199.10	Wind Energy Project Managers	15	15	1
11-9199.11	Brownfield Redevelopment Specialists and Site Managers	22	22	1
13-1199.01	Energy Auditors	21	21	1
13-1199.05	Sustainability Specialists	14	14	1
17-2081.00	Environmental Engineers	28	28	1
17-2081.01	Water/Wastewater Engineers	27	27	1
17-2141.01	Fuel Cell Engineers	26	26	1
17-2199.03	Energy Engineers	21	21	1
17-2199.10	Wind Energy Engineers	16	16	1
17-2199.11	Solar Energy Systems Engineers	13	13	1
17-3025.00	Environmental Engineering Technicians	26	26	1
19-1013.00	Soil and Plant Scientists	27	17	0.62
19-1031.01	Soil and Water Conservationists	33	33	1
19-2041.01	Climate Change Analysts	14	14	1
19-2041.02	Environmental Restoration Planners	22	22	1
19-2041.03	Industrial Ecologists	38	38	1

Green jobs (continued)

O*NET code	Title	Total tasks	Green tasks	Weighted green task share
19-3011.01	Environmental Economists	19	19	1
19-4091.00	Environmental Science and Protection Technicians, Including Health	26	26	1
41-3099.01	Energy Brokers	16	16	1
41-4011.07	Solar Sales Representatives and Assessors	13	13	1
47-1011.03	Solar Energy Installation Managers	15	15	1
47-2231.00	Solar Photovoltaic Installers	26	26	1
47-4041.00	Hazardous Materials Removal Workers	21	21	1
47-4099.02	Solar Thermal Installers and Technicians	21	21	1
47-4099.03	Weatherization Installers and Technicians	18	18	1
49-9081.00	Wind Turbine Service Technicians	13	13	1
49-9099.01	Geothermal Technicians	24	24	1
51-8099.01	Biofuels Processing Technicians	19	19	1
51-8099.03	Biomass Plant Technicians	16	16	1
51-8099.04	Hydroelectric Plant Technicians	21	21	1
51-9199.01	Recycling and Reclamation Workers	18	18	1
53-1021.01	Recycling Coordinators	23	23	1
53-7081.00	Refuse and Recyclable Material Collectors	16	16	1

Green jobs (SOC)

SOC code	Title	Weighted green task share
17-2081	Environmental Engineers	1
17-2141	Mechanical Engineers	0.53
19-2040	Environmental Scientists and Geoscientists	0.57
41-3099	Sales Representatives, Services, All Other	1
47-2231	Solar Photovoltaic Installers	1
47-4041	Hazardous Materials Removal Workers	1
47-4090	Miscellaneous Construction and Related Workers	0.67
49-9081	Wind Turbine Service Technicians	1
49-909X	Other installation, maintenance, and repair workers	0.5
51-9199	Production Workers, All Other	1
53-7081	Refuse and Recyclable Material Collectors	1

Fossil jobs

SOC code	Title
11-3051	Industrial Production Managers
11-9041	Architectural and Engineering Managers
17-2041	Chemical Engineers
17-2110	Industrial Engineers, Including Health and Safety
17-2121	Marine Engineers and Naval Architects
17-2131	Materials Engineers
17-2171	Petroleum Engineers
17-3020	Engineering Technicians, Except Drafters
19-2030	Chemists and Materials Scientists
19-4011	Agricultural and Food Science Technicians
19-4031	Chemical Technicians
43-5061	Production, Planning, and Expediting Clerks
47-5010	Derrick, Rotary Drill, and Service Unit Operators, Oil, Gas, and Mining
47-5021	Earth Drillers, Except Oil and Gas
47-5040	Mining Machine Operators
47-50XX	Other Extraction Workers
49-2091	Avionics Technicians
49-9010	Control and Valve Installers and Repairers
49-9043	Maintenance Workers, Machinery
49-9044	Millwrights
49-904X	Industrial and Refractory Machinery Mechanics
49-9096	Riggers
49-9098	Helpers–Installation, Maintenance, and Repair Workers
51-1011	First-Line Supervisors of Production and Operating Workers
51-2011	Aircraft Structure, Surfaces, Rigging, and Systems Assemblers
51-2031	Engine and Other Machine Assemblers

Main text

Fossil jobs (continued)

SOC code	Title
51-2041	Structural Metal Fabricators and Fitters
51-2090	Miscellaneous Assemblers and Fabricators
51-3020	Butchers and Other Meat, Poultry, and Fish Processing Workers
51-3091	Food and Tobacco Roasting, Baking, and Drying Machine Operators and Tenders
51-3093	Food Cooking Machine Operators and Tenders
51-3099	Food Processing Workers, All Other
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic
51-4022	Forging Machine Setters, Operators, and Tenders, Metal and Plastic
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic
51-4050	Metal Furnace Operators, Tenders, Pourers, and Casters
51-4070	Molders and Molding Machine Setters, Operators, and Tenders, Metal and Plastic
51-4111	Tool and Die Makers
51-4199	Metal Workers and Plastic Workers, All Other
51-6063	Textile Knitting and Weaving Machine Setters, Operators, and Tenders
51-6064	Textile Winding, Twisting, and Drawing Out Machine Setters, Operators, and Tenders
51-7041	Sawing Machine Setters, Operators, and Tenders, Wood
51-7042	Woodworking Machine Setters, Operators, and Tenders, Except Sawing
51-8031	Water and Wastewater Treatment Plant and System Operators
51-8090	Miscellaneous Plant and System Operators
51-9010	Chemical Processing Machine Setters, Operators, and Tenders
51-9020	Crushing, Grinding, Polishing, Mixing, and Blending Workers
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders
51-9051	Furnace, Kiln, Oven, Drier, and Kettle Operators and Tenders
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers

Fossil jobs (continued)

SOC code	Title
51-9111	Packaging and Filling Machine Operators and Tenders
51-9191	Adhesive Bonding Machine Operators and Tenders
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic
51-9196	Paper Goods Machine Setters, Operators, and Tenders
51-9197	Tire Builders
51-9198	Helpers–Production Workers
53-5011	Sailors and Marine Oilers
53-6031	Automotive and Watercraft Service Attendants
53-7021	Crane and Tower Operators
53-7051	Industrial Truck and Tractor Operators
53-7070	Pumping Station Operators
53-7199	Material Moving Workers, All Other

Dirty sectors

Census code	Census title
0370	Oil and gas extraction
0380	Coal mining
0390	Metal ore mining
0470	Nonmetallic mineral mining and quarrying
0480	Not specified type of mining
0490	Support activities for mining
0570	Electric power generation, transmission and distribution
0580	Natural gas distribution
0590	Electric and gas, and other combinations
0670	Water, steam, air-conditioning, and irrigation systems
0680	Sewage treatment facilities
0690	Not specified utilities
1070	Animal food, grain and oilseed milling
1080	Sugar and confectionery products
1090	Fruit and vegetable preserving and specialty food manufacturing
1170	Dairy product manufacturing
1180	Animal slaughtering and processing
1280	Seafood and other miscellaneous foods, n.e.c.
1290	Not specified food industries
1370	Beverage manufacturing
1390	Tobacco manufacturing
1480	Fabric mills, except knitting mills
1490	Textile and fabric finishing and fabric coating mills
1570	Carpet and rug mills
1870	Pulp, paper, and paperboard mills

Dirty sectors (continued)

Census code	Census title
2070	Petroleum refining
2090	Miscellaneous petroleum and coal products
2170	Resin, synthetic rubber, and fibers and filaments manufacturing
2180	Agricultural chemical manufacturing
2190	Pharmaceutical and medicine manufacturing
2270	Paint, coating, and adhesive manufacturing
2280	Soap, cleaning compound, and cosmetics manufacturing
2290	Industrial and miscellaneous chemicals
2380	Tire manufacturing
2390	Rubber products, except tires, manufacturing
2470	Pottery, ceramics, and plumbing fixture manufacturing
2480	Clay building material and refractories manufacturing
2490	Glass and glass product manufacturing
2570	Cement, concrete, lime, and gypsum product manufacturing
2590	Miscellaneous nonmetallic mineral product manufacturing
2670	Iron and steel mills and steel product manufacturing
2680	Aluminum production and processing
2690	Nonferrous metal (except aluminum) production and processing
2770	Foundries
2990	Not specified metal industries
3180	Engine, turbine, and power transmission equipment manufacturing
3390	Electronic component and product manufacturing, n.e.c.
3490	Electric lighting and electrical equipment manufacturing, and other electrical component manufacturing, n.e.c.

Dirty sectors (continued)

Census code	Census title
3570	Motor vehicles and motor vehicle equipment manufacturing
3580	Aircraft and parts manufacturing
3590	Aerospace products and parts manufacturing
3670	Railroad rolling stock manufacturing
3770	Sawmills and wood preservation
3780	Veneer, plywood, and engineered wood products
3990	Not specified manufacturing industries
4490	Petroleum and petroleum products merchant wholesalers
5090	Gasoline stations
5680	Fuel dealers
6270	Pipeline transportation

Firm's problem

- Let $\overline{\upsilon}_j$ be the **recruitment ratio**:
$$\overline{\upsilon}_j = \frac{\upsilon_j}{n_j}$$
- The firm's problem is to choose the recruitment ratio $\overline{\upsilon}_j$ that maximizes its value:
$$J(n_j) = \max_{\overline{\upsilon}_j} \left[p_j^y \zeta_j h_j n_j (1 - \overline{\upsilon}_j) - (1 + \tau^P) n_j h_j w_j + \mathbb{E}\left[p^a J(n_j') \right] \right],$$
where τ^P is a payroll tax, w_j is the wage, p^a is the price of an Arrow security, and
$$n_j' = n_j - \pi n_j + q_j \overline{\upsilon}_j h_j n_j,$$
with π being an exogenous quit rate and $q_j = \sum_i m_{ij} / \upsilon_j h_j$ the number of matches per recruitment effort

Main text

Firm FOC and envelope condition

- The FOC with respect to $\overline{v}_j$ gives

$$p_j^y \zeta = q_j \mathbb{E}\left[p^a J'_{n_j}\right],$$

where $J'_{n_j} := \partial J(n'_j)/\partial n_j$ is the value in the next period of employing a worker today

- Differentiating the Bellman equation with respect to the number of workers n_j gives the envelope condition

$$J_{n_j} = p_j^y \zeta h_j - \left(1 + \tau^P\right) h_j w_j + (1 - \pi)\mathbb{E}\left[p^a J'_{n_j}\right]$$

Household's problem

The household's problem is to choose the **consumption** and **next period's assets** a' that maximize lifetime utility:

$$V\left(a, n_{\mathcal{J}}, u_{\mathcal{J}}\right) = \max_{C,a'} \left[\sum_j n_j U\left(C, h_j\right) + \sum_i u_i U\left(C, 0\right) + \beta \mathbb{E}\left[V\left(a', n'_{\mathcal{J}}, u'_{\mathcal{J}}\right)\right]\right],$$

subject to

$$p^C C + p^a a' \leq \sum_j (1 - \tau^L) n_j w_j h_j + \sum_i u_i p^C b_j + a + p^C T,$$

$$n'_j = n_j - \pi n_j + \sum_i \phi_{ij} u_i \qquad \forall j,$$

$$u'_i = \pi n_i + u_i (1 - \sum_j \phi_{ij}) \qquad \forall i.$$

where p^C is the aggregate good price, τ^L is a labor income tax, b_j is unemployment benefits, T is a transfer, and $\phi_{ij} = m_{ij}/u_i$ is the probability of worker i matching with firm j Main text

HH FOCs, envelope conditions, and Euler equation

- The FOCs with respect to consumption and next period assets are

$$\frac{1}{C} = \lambda p^C,$$
$$\beta \mathbb{E}\left[V'_{a'}\right] = \lambda p^a, \tag{1}$$

where λ is the Lagrange multiplier for the budget constraint

- Differentiating the Bellman equation gives the envelope conditions

$$V'_{a'} = \lambda', \tag{2}$$
$$V_{n_j} = U(C, h_j) + \lambda(1 - \tau^L)w_j h_j + \beta\left((1-\pi)\mathbb{E}\left[V'_{n_j}\right] + \pi\mathbb{E}\left[V'_{u_j}\right]\right) \qquad \forall j,$$
$$V_{u_i} = U(C, 0) + \lambda p^C b + \beta\left(\mathbb{E}\left[V'_{u_i}\right] + \sum_j \phi_{ij}\left(\mathbb{E}\left[V'_{n_j}\right] - \mathbb{E}\left[V'_{u_i}\right]\right)\right) \qquad \forall i$$

- Combining (1) and (2) gives the **Euler equation** $p^a = \beta\frac{\lambda'}{\lambda}$

Government

- A government has access to an excise **emissions tax** τ^E and an excise **subsidy s** on green firms' output

$$p_j^y = \begin{cases} p_j - \tau^E \epsilon & \text{for } j = \text{fossil}, \\ p_j + s & \text{for } j = \text{green}, \\ p_j & \text{for } j = \text{neutral}, \end{cases}$$

where p_j is the gross price

- The government collects revenue from a labor income tax, payroll tax and emissions tax, and returns it as transfers, unemployment benefits, and subsidy payments

$$\left(\tau^L + \tau^P\right) \sum_j n_j w_j h_j + \tau^E e = T + \sum_i u_i p^C b_i + s y_g$$

Main text

Recruiting productivity, job finding probability, labor market tightness

$$q_j = \mu_j \left[\xi_j \theta^{-\gamma} + (1-\xi_j)\theta_{jj}^{-\gamma} \right]$$
$$\phi_{ij} = \mu_j \left[\xi_j \theta_j \theta^{-\gamma} + (1-\xi_j)\theta_{ij}^{1-\gamma}\delta_{ij} \right]$$

q_j = Recruiting productivity ($\sum_i m_{ij}/(\upsilon_j h_j)$)

φ_{ij} = Job finding probability ($\sum_i m_{ij}/u_i$)

θ_{ij} = Ratio of recruitment effort in sector to unemployed workers from sector i ($\upsilon_j h_j/u_i$)

θ_j = Ratio of recruitment effort in sector j to all unemployed workers ($\upsilon_j h_j/\overline{u}$)

$\overline{\theta}$ = Ratio of total recruitment effort to all unemployed workers ($\sum_j \upsilon_j h_j/\overline{u}$)

Main text

Nash bargaining

A worker and firm divide the match surplus $J_{n_j} + V_{n_j} - V_{u_j}$ according to Nash bargaining:

$$\max_{w_j, h_j} J_{n_j}^{\eta} \left[V_{n_j} - V_{u_j} \right]^{1-\eta} \quad \forall j$$

Solving gives the following respective equilibrium conditions for hours and wages:

$$(1+\tau^P)\psi h_j^{\frac{1}{\chi}} = (1-\tau^L)\lambda p_j^n \zeta \quad \forall j,$$

$$(1-\tau^L) h_j w_j = (1-\eta)\left[\frac{1-\tau^L}{1+\tau^P} p_j^n \zeta h_j\right]$$

$$+\eta\left[\frac{\psi \chi h_j^{1+\frac{1}{\chi}}}{\lambda(1+\chi)} + \overline{p} b_j + \beta \frac{\sum_i \phi_{ji}\left(V'_{n_i} - V'_{u_j}\right)}{\lambda}\right] \quad \forall j$$

Main text

Matching

$$m_{ij} = \mu_j \upsilon_j h_j u_i \left[\xi_j \underbrace{\left(\sum_k \upsilon_k h_k \right)}_{\text{Total recruitment}}^{-\gamma} \underbrace{\bar{u}}_{\text{Total unem.}}^{\gamma-1} + (1 - \xi_j) \underbrace{(\upsilon_j h_j)}_{\text{Firm } j\text{'s recruitment}}^{-\gamma} \underbrace{u_i}_{\text{Unem. of } i}^{\gamma-1} \delta_{ij} \right]$$

m_{ij} = Number of **matches** between firm j and workers of type i

μ_j = Matching efficiency

γ = Elasticity of matching wrt. unemployment

δ_{ij} = Kronecker delta equal to 1 if $i = j$ and 0 otherwise

k = Alias for j

$\xi_j \in [0, 1]$ = **Friction associated with cross-type matching**

Main text

Cross-type matching

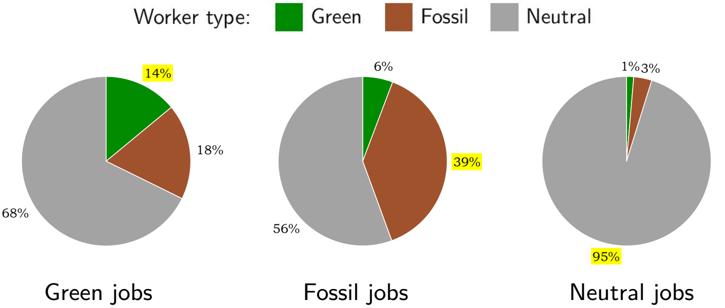
$$m_{ij} = \mu_j \upsilon_j h_j u_i \left[\xi_j \left(\sum_k \upsilon_k h_k \right)^{-\gamma} \overline{u}^{\gamma-1} + (1-\xi_j)(\upsilon_j h_j)^{-\gamma} u_i^{\gamma-1} \delta_{ij} \right]$$

- $\xi_j = 0 \rightarrow$ Firm j can only recruit workers of type j (no cross-type matching)
- $\xi_j = 1 \rightarrow$ Workers i and $j \neq i$ are equally likely to match with firm j (matching does not depend on a worker's type)
- $\xi_j \in (0, 1) \rightarrow$ The share of cross-type matches for firm j is proportional to ξ_j (holding all variables constant)

Solving for ξ_j in the no-policy benchmark (1)

- Let ω_j be the **share of matches for firm j with workers of type j**
- From the empirical analysis,

$$\omega_j = \begin{cases} 0.14 & \text{for } j = \text{green}, \\ 0.39 & \text{for } j = \text{fossil}, \\ 0.95 & \text{for } j = \text{neutral} \end{cases}$$



Solving for ξ_j in the no-policy benchmark (2)

- ω_j is linked to cross-type matching friction ξ_j by

$$\omega_j = \frac{m_{jj}}{\sum_i m_{ij}}, \tag{3}$$

where

$$m_{ij} = \mu_j \upsilon_j h_j u_i \left[\xi_j \left(\sum_k \upsilon_k h_k \right)^{-\gamma} \overline{u}^{\gamma-1} + (1-\xi_j)(\upsilon_j h_j)^{-\gamma} u_i^{\gamma-1} \delta_{ij} \right] \tag{4}$$

- Solving for ξ_j in the no-policy benchmark using (3), (4), and the estimated values of ω_j gives

$$\xi_j = \begin{cases} 0.87 & \text{for } j = \text{green}, \\ 0.58 & \text{for } j = \text{fossil}, \\ 1^* & \text{for } j = \text{neutral} \end{cases}$$

*Capped at 1