The Impact of a Carbon Tax on Labor Reallocation: The Role of Firm Heterogeneity and Energy Efficiency

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Motivation

- The consequences of the transition to a low-carbon economy on employment are uncertain, and empirical evidence is mixed
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What are the effects of a carbon tax on *labor reallocation* across firms, when accounting for firm *heterogeneity*?

This paper

1. Stylized facts on energy efficiency, emissions, and production using French administrative data for the manufacturing sector
   - Large within-sector dispersion in the energy mix and energy efficiency
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3. *Counterfactual:* quantify the reallocation of workers between heterogeneous firms following a change in a carbon tax

Related literature

- Mixed empirical evidence on the effect on employment of increased energy prices [Deschenes, 2011] [Dussaux, 2020] [Marin and Vona, 2021] [Fontaine and Marullaz, 2024] and environmental regulations [Martin et al., 2014] [Yamazaki, 2017] [Yip, 2018] [Dechezleprêtre et al., 2023] [Känzig and Konradt, 2023]

- CGE models to simulate the effects on aggregate output and employment [Goulder and Hafstead, 2018]
  Contribution: Detailed model of a frictional labor market with job-to-job mobility to study workers' reallocation

- Theoretical effects of a carbon tax with frictional labor market [Hafstead and Williams III, 2018] [Aubert and Chiroleu-Assouline, 2019] [Finkelstein Shapiro and Metcalf, 2023]
  Contribution: Reallocation across heterogeneous firms, firm dynamics, flexible elasticity of substitution, job-to-job mobility

- Firm heterogeneity in models of large firms and imperfect labor markets [Elsby and Michaels, 2013] [Elsby and Gottfries, 2022] [Bilal et al., 2022]
  Contribution: Focus on the energy transition by introducing heterogeneity in energy intensity and in energy mix

Road Map

Empirical Observations

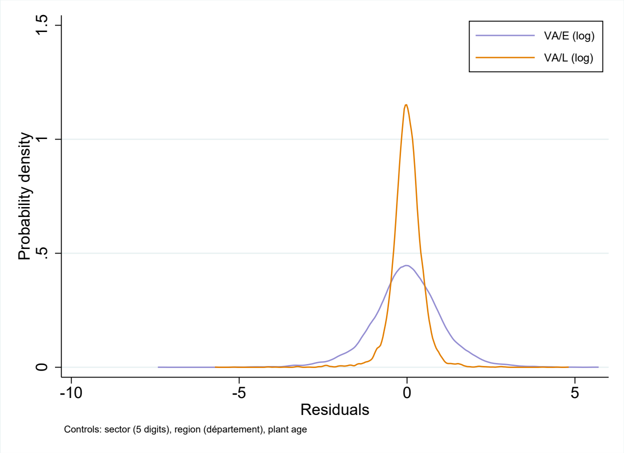
Theoretical Framework

Simulation

Conclusion

Energy efficiency is more dispersed than labor efficiency

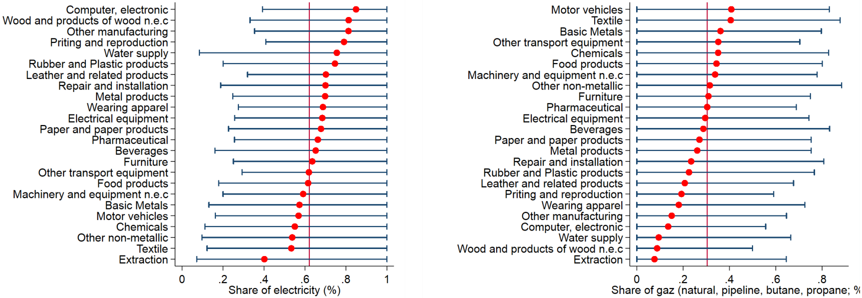
Figure 1: Distributions of value-added per head and per unit of energy



Note: The figure shows the residualized dispersion of value-added per worker and per unit of energy. All variables are in logarithm. Residualized density is obtained by regressing first our variables on a set of industry and region dummies. Source: EACEI and FARE (manufacturing sectors, years 2008-2019). Data Per head

The energy mix varies both across and within sectors

Figure 2: Dispersion of electricity and gas shares

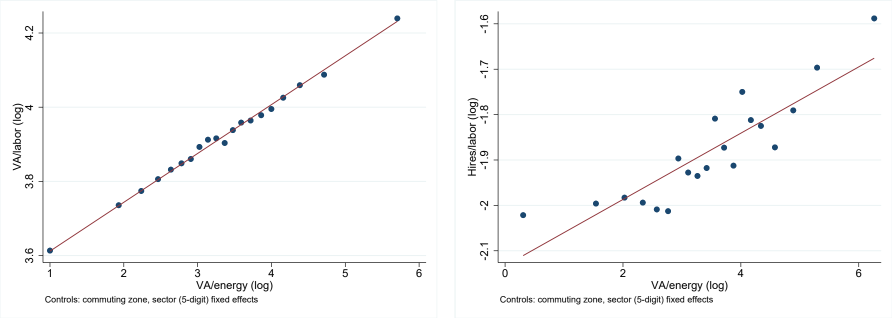


Source: The figure displays the average share of electricity (left) and gas (right) in the total energy mix of the plants, by sector. 95% confidence intervals are included. Source: EACEI (manufacturing sectors, years 2008-2019).

Emission intensity

Energy efficient firms are more productive and hire more

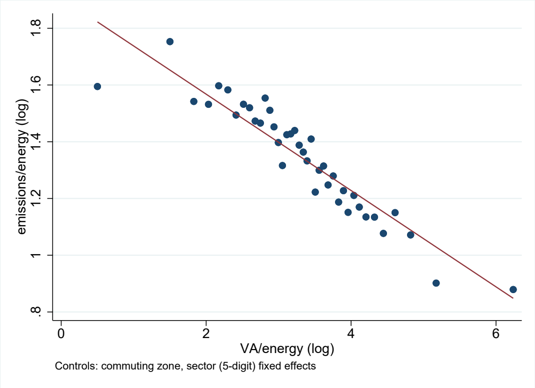
Figure 3: Relationship between the ratio of value-added to energy expenditures, labor productivity and hires



The figure displays the residualized correlation between energy efficiency, measured at the value-added to energy consumption ratio, and labor productivity (left panel), measured as value-added per head, and hires per head (right panel). All variables are in logarithm. The residualized correlation is obtained by regressing the dependent variable on the independent variable and a set of industry and employment zone dummies. Source: EACEI, FARE and DADS (manufacturing sectors, years 2013-2019).

Energy efficient firms emit less

Figure 4: Correlation between emissions per unit of energy and energy efficiency



Note: The figure displays the residualized correlation between emissions (CO_2) per unit of energy (TOE), and energy efficiency, measured at the value-added to energy consumption ratio. All variables are in logarithm. The residualized correlation is obtained by regressing the dependent variable on the independent variable and a set of industry and employment zone dummies. Source: EACEI and FARE (manufacturing sectors, years 2008-2019).

Road Map

Overview

Goal: Study the labor reallocation effects of a carbon tax on heterogeneous firms

- Firms differ in terms of energy efficiency, labor productivity, and energy mix
- Substitutability between energy and labor: production function is CES in energy and labor
- Frictional labor market with job-to-job mobility: search and matching model of multi-worker firms with diminishing MPL à la [Elsby and Gottfries, 2022]

⇒ The net MPL is a sufficient statistic for workers' and firms' behavior

Production and energy

Production:

$$y = \mu \left((\nu e)^{\rho} + \left((1-\nu) \ell^{\alpha} \right)^{\rho} \right)^{\frac{1}{\rho}}$$

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Therefore,

$$y - p_e e = \mu \left(1 - \left(\frac{\mu \nu}{p_e} \right)^{\frac{\rho}{1-\rho}} \right)^{-\frac{1-\rho}{\rho}} (1-\nu)\ell^{\alpha} = \Upsilon \left(p_e, \mu, \nu \right) \times \ell^{\alpha}$$

Elasticity

And the net *marginal revenue of labor* is:

$$m(p_e, \mu, \nu, \ell) = \alpha \Upsilon \left(p_e, \mu, \nu \right) \ell^{\alpha - 1}$$

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Energy mix:

$$e = \left(\beta_e e_d^{1-\frac{1}{\sigma}} + (1-\beta_e) e_c^{1-\frac{1}{\sigma}} \right)^{\frac{1}{1-\frac{1}{\sigma}}}$$

Therefore,

$$p_e = \left(\beta_e^{\sigma} ((1+\tau)p_d)^{1-\sigma} + (1-\beta_e)^{\sigma} p_c^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

Labor market

A search and matching model of large firms with OTJ search

m-solution: Optimal hiring and separation rates, and workers' optimal turnover decisions, are uniquely determined by the marginal product of labor $m = \alpha\Upsilon\ell^{\alpha-1}$
$\Rightarrow$ A carbon tax affects labor through m Environment Details Steady State

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Employed workers: choose the set of offers from other firms they are willing to accept if contacted Worker's problem Wage

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Firms: Control their size by choosing separation and hires, from both the pool of employed and unemployed workers Firm's problem

- $\Rightarrow$ Firms must choose between large output or small turnover
- $\Rightarrow$ In equilibrium, hiring firms' marginal values of a job are all equalized and are uniquely characterized by m

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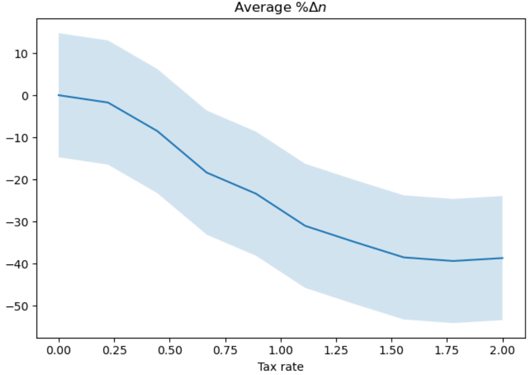
Effects of a carbon tax increase I

Labor

Figure 5: Average change in employment induced by a carbon tax



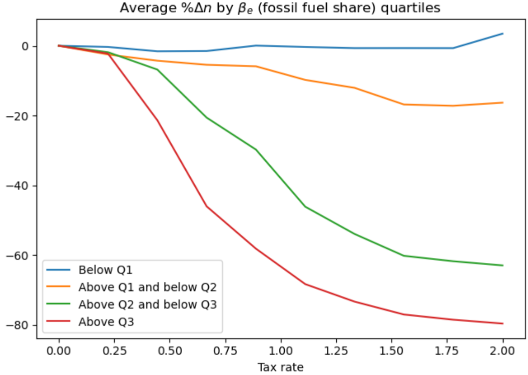
Note: The figure displays the average difference of the steady state firm's employment (in log) with the counterfactual tax rate indicated on the x-axis, relative to the no-tax scenario.

Mechanisms Calibration Equilibrium p_e

Effects of a carbon tax increase II

Labor

Figure 6: Average change in employment induced by a carbon tax, by energy mix



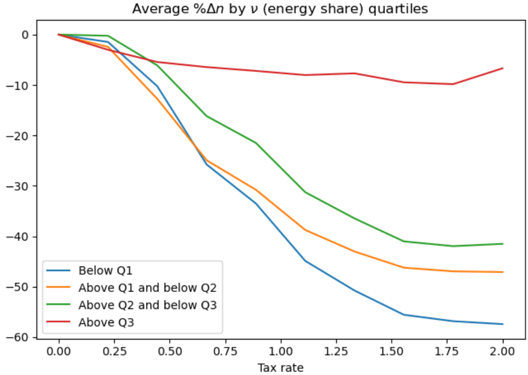
Note: The figure displays the average difference of the steady state firm's employment (in log) with the counterfactual tax rate indicated on the x-axis, relative to the no-tax scenario. The difference is split by energy mix (β_e) quartiles.

Wage By μ

Effects of a carbon tax increase III

Labor

Figure 7: Average change in employment induced by a carbon tax, by energy intensity

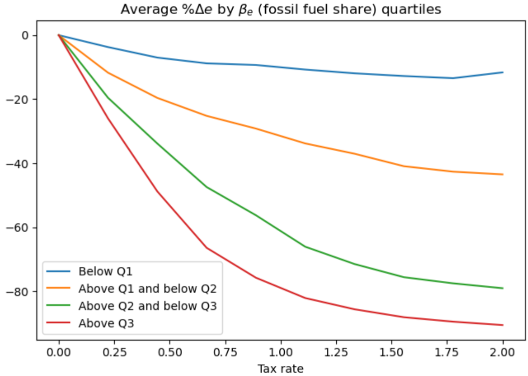


Note: The figure displays the average difference of the steady state firm's employment (in log) with the counterfactual tax rate indicated on the x-axis, relative to the no-tax scenario. The difference is split by energy intensity (ν) quartiles.

Effects of a carbon tax increase

Energy

Figure 8: Average change in energy consumption induced by a carbon tax, by energy mix



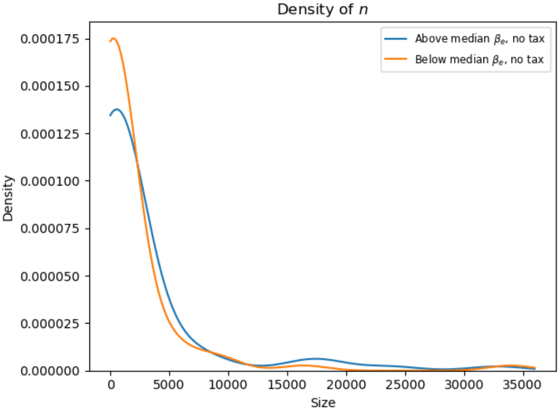
Note: The figure displays the average difference of the steady state firm's energy consumption (in log) with the counterfactual tax rate indicated on the x-axis, relative to the no-tax scenario. The difference is split by energy mix (β_e) quartiles.

By μ By ν p_e

Effects of a carbon tax increase

Size distribution

Figure 9: Density of n, by β_e and tax rate



Note: The figure displays the density of firm size, by energy mix (β_e) for $\tau = 0$ and $\tau = 89\%$.

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Effects of a carbon tax increase

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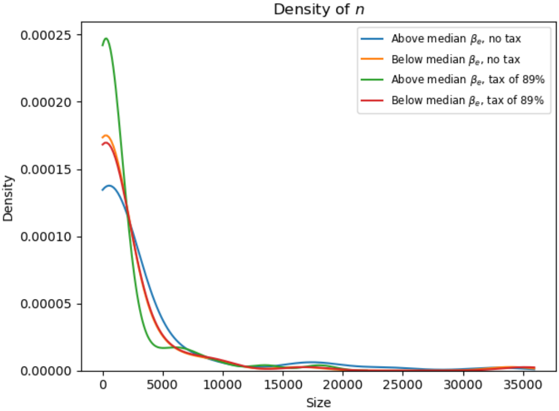

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- firms' energy intensity and energy mix play a key role in determining the effect of the shock: fossil-fuel-intensive firms are the most affected

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Thank you!

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Appendix

Road Map

Road Map

Data I

French manufacturing firms, 2005-2019

1. **Energy survey (EACEI):** Exhaustive coverage of large manufacturing plants ($>$ 250 employees) and representative sample of smaller manufacturing plants. Detailed variables on energy consumption (expenditures and quantities), disaggregated by fuel.

2. **Matched employer-employee data (DADS Postes):** Universe of jobs. Contains employment, hours, wages and worker flows at the job x establishment level.

3. **Balance-sheet data (FICUS-FARE):** Based on tax statements from the universe of French firms. Contains accounting data (revenue, value added, capital etc.) at the firm level

Data II

French manufacturing firms, 2005-2019

- We exclude the energy sources for which we don't have the consumption expenses (ex. biomass)
- We use electricity, steam, natural gas, other types of gas, coal, lignite, coke, petroleum coke, butane and propane, heavy fuel oil, heating oil
- Converted in a common energy measure (ton of oil equivalent)
- Emission factors are computed using *Base carbonne* (ADEME, 2022)

Data III

French manufacturing firms, 2005-2019

Table 1: Descriptive statistics

	Total	
	Mean (2008-2019)	2019
Number of establishments	9'073	8'984
Number of FTE workers (weighted)	1'893'264	2'058'488
Total value-added (weighted)	144'890'624	178'967'840
Total energy consumption (weighted)	33'909'148	36'088'188
Total emissions (weighted)	70'556'392	70'722'856
	Mean and variance	
	Mean (weighted)	SD (weighted)
Energy price	0.921	2.982
Electricity share	0.644	0.287
Gaz share	0.251	0.249
FTE Workers per establishment	104.9	464.7
Energy costs per unit of revenue	0.118	6.84
Labor costs per unit of revenue	0.816	51.99

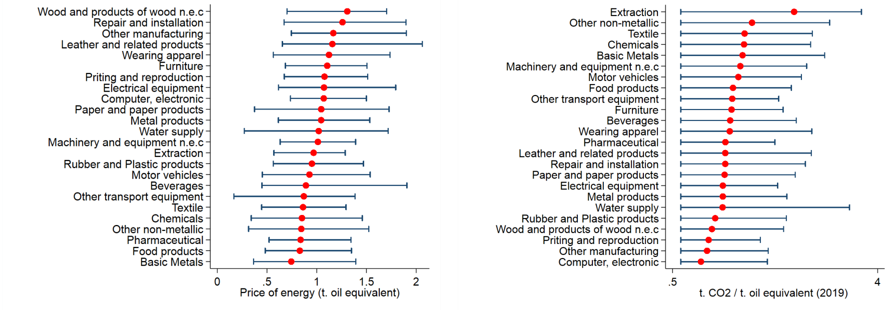
Notes: The mean per year is computed as the average, across all years, of the annual value. Value-added is in thousands of euros and emissions are in tons of CO2. Energy consumption is in tons of oil equivalent. Energy prices are in thousands of euros per TOE. Mean and standard deviations are measured over all establishments, across all years. Number of workers are counted as full-time equivalent.

Back

Road Map

Energy prices and emissions vary both within and across sectors

Figure 10: Dispersion of energy prices and emissions



Source: EACEI (manufacturing sectors, years 2008-2019).

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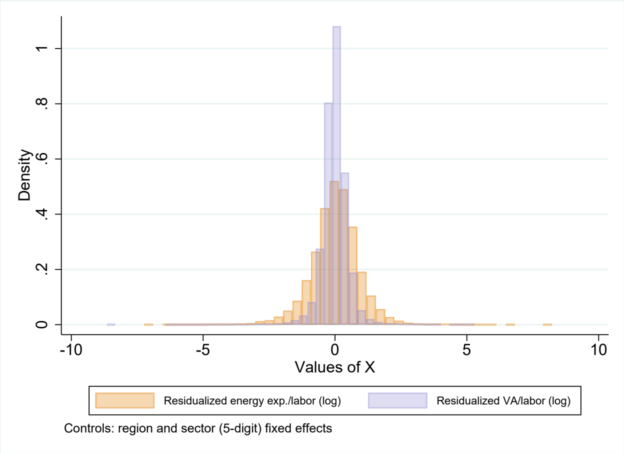
Energy expenditures per worker and value added per worker are substantially dispersed

Figure 11: Distributions of value-added per head and energy expenses per head



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Road Map

Energy

The **optimal energy level** satisfies

$$e(\ell) = \frac{1}{\nu}\left(\left(\frac{\mu\nu}{p_e}\right)^{-\frac{\rho}{1-\rho}} - 1\right)^{-\frac{1}{\rho}} (1-\nu)\ell^{\alpha}$$

The net **marginal** revenue of labor follows:

$$m(p_e, \mu, \nu, \ell) = \alpha \Upsilon\left(p_e, \mu, \nu\right)\ell^{\alpha-1}$$

The share of energy expenditures in output s_e:

$$s_e = \frac{p_e e}{y} = \left(\frac{\mu\nu}{p_e}\right)^{\frac{\rho}{1-\rho}}$$

The **elasticity of substitution** between energy and labor is not constant:

$$\sigma_{e\ell} = \frac{1}{1-\rho}\,\frac{1+\alpha\left(((1-\nu)\ell^{\alpha})/(\nu e)\right)^{\rho}}{\frac{1-\alpha\rho}{1-\rho}+\alpha\left(((1-\nu)\ell^{\alpha})/(\nu e)\right)^{\rho}} = \frac{\alpha+(1-\alpha)s_e}{\alpha(1-\rho)+(1-\alpha)s_e}$$

Back

Environment

Environment: Infinite, continuous time framework in which a mass N or workers, both unemployed (U) and employed ($L = N - U$), search for a new job with exogenous relative search intensity $o < 1$

Matching frictions: Standard increasing, continuous, constant-returns-to-scale matching function $M(U + o(N - U), V)$.

- Labor market tightness: $\theta \equiv \frac{V}{U+o(N-U)}$
- Vacancies reach job seekers at rate $\chi(\theta) \equiv M/V = M(1/\theta, 1)$
- Job arrival rate: $\lambda(\theta) \equiv M/(U + o(N - U)) = M(1, \theta)$ ($o\lambda(\theta)$ for employees)
- Probability for a firm of meeting a job seeker who is unemployed, conditional on a match is $\psi \equiv \frac{U}{U+o(N-U)}$

Hirings and separations. Firm's employment evolves according to:

$$d\ell = (h - \ell\rho_0 - \ell\delta - s)\, dt$$

Where the hiring flow $hdt = vq$ costs $c \times h$, and separations occur exogenously (ρ_0) and endogenously through workers quitting at rate δ, and firms costlessly firing at rate s.

Back

Wage determination

Wages are determined every period *ex-post* according to a bargaining game à la [Brügemann et al., 2019], in which the position of each worker within the firm is symmetric. The credible threat is a *temporary* suspension of negotiations.

⇒ Workers and firms bargain over the marginal *flow* surplus. This leads to

$$\beta\left(\alpha\Upsilon\ell^{\alpha-1} - w - w_\ell \ell + \omega_f\right) = (1-\beta)(w-\omega_e)$$

Where ω_f is the firm's exogenous delayed agreement cost per worker and ω_e is the workers' delayed agreement flow payoff.
Firms do not engage in wage escalation in response to their employees' receiving external offers. Therefore, all workers within a firm receive the same wage

$$w = \frac{\beta}{1-\beta(1-\alpha)}\underbrace{\alpha\Upsilon\ell^{\alpha-1}}_{\equiv m} + \underbrace{\beta\omega_f + (1-\beta)\omega_e}_{\equiv \omega_0}$$

Back

Firm's problem

Firms post vacancies to choose the hiring and separation rates to maximize their present discounted value:

$$r\Pi dt = \max_{h\geq 0, s\geq 0} \{(\Upsilon \ell^{\alpha} - w\ell - (\delta + \rho_0)\ell\Pi_\ell)\, dt - (c - \Pi_\ell)hdt - \Pi_\ell sdt\}$$

Optimal hires and separations must satisfy

$$(-c + \Pi_\ell)h^* = 0 \quad \text{and} \quad \Pi_\ell s^* = 0$$

The marginal value of a job to the firm $\Pi_\ell = J$ becomes:

$$rJ = \alpha\Upsilon\ell^{\alpha-1} - \frac{\partial w\ell}{\partial \ell} - \frac{\partial \delta\ell J}{\partial \ell} - \rho_0 \frac{\partial \ell J}{\partial \ell}$$

Back

Worker's problem

Workers monotonically rank firms based only on their workers' surplus $W(\ell, p_e, \mu, \nu) = \Omega(\ell, p_e, \mu, \nu) - \mathcal{U}$.
Therefore, the quit (δ) and vacancy-filling (q) rates are functions of W:

$$\delta(W) = o\lambda[1 - \Phi(W)] \quad \text{and} \quad q(W) = \chi[\psi + (1-\psi)\Gamma(W)]$$

where $\Phi(.)$ is the *offer* distribution of worker surpluses and $\Gamma(.)$ is the distribution of workers by surplus.

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The value of employment for a worker is:

$$r\Omega dt = \max\left\{ w + o\lambda \int_W (\tilde{W} - W) d\Phi(W) + (h^* - s^*)\Omega_\ell - \delta\ell\Omega_\ell - \rho_0\ell\Omega_\ell - (\frac{s^*}{\ell} + \rho_0)W, r\mathcal{U} \right\}$$

The value of unemployment is

$$r\mathcal{U} = b + \lambda \int \tilde{W} d\Phi(W)$$

Therefore, the worker's surplus is

$$rW = \max\left\{ w - b - \lambda \int \tilde{W} d\Phi(W) + s\lambda \int_W (\tilde{W} - W) d\Phi(W) \right.$$
$$\left. + W_\ell(h^* - s^*) - \delta\ell W_\ell - \rho_0\ell W_\ell - (\frac{s^*}{\ell} + \rho_0)W, 0 \right\}$$

m-solution I

The four idiosyncratic state variables, the firm's employment ℓ, total factor productivity μ, energy intensity ν, and energy price p_e, on which the different value functions depend, can be distilled into one single state variable: the firm's flow marginal product $m = \alpha \Upsilon \ell^{\alpha-1}$, which uniquely determine workers' and firms' decisions.

m-solution II

Workers' behavior: a higher marginal product implies a higher flow wage and a weakly higher path of future marginal product (under the proposed m-solution), which, in turn, imply a higher surplus $\Rightarrow$ all job-to-job switches involve worker transitions from low-m firms to high-m firms.
Therefore,

$$\delta(m) = o\lambda[1 - F(m)] \quad \text{and} \quad q(m) = \chi[\psi + (1 - \psi)G(m)]$$

Where $F(m) = \Phi[W(m)]$ and $G(m) = \Gamma[W(m)]$ are respectively the offer distribution and the worker distribution of marginal products.

m-solution III

Firms' behavior: Firms' behavior is characterized by a hiring region $m \in (m_h, m_u)$, where the firms' marginal values J are all equalized to the hiring cost c.

$$rJ(m) = \frac{1-\beta}{1-\beta(1-\alpha)} m - \omega_0 - [\delta(m) + \rho_0 - (1-\alpha) m \delta'(m)] J(m) + (1-\alpha)(\delta(m)+\rho_0) m J'(m) = rc$$

The upper bound of the hiring region defines the maximum marginal employment value, hence a job value for which there is no quit $\delta(m_u) = 0$, while the lower bound satisfies $\delta(m_h) = o\lambda$, that is employees accept any job offer.
Using $J(m) = c$, $J'(m) = 0$ and $J''(m) = 0$, one gets the equilibrium quit rate

$$\delta(m) = o\lambda + \frac{1}{c} \left\{ \frac{1-\omega_1}{\alpha}(m - m_h) - \left[\frac{1-\omega_1}{\alpha} m_h - \omega_0 - (r + \rho_0 + o\lambda) c \right] \left[\left(\frac{m}{m_h} \right)^{\frac{1}{1-\alpha}} - 1 \right] \right\}$$

Which is strictly decreasing and concave.

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Steady State I

Unemployment: Hiring from unemployment balances job destruction:

$$U_{BC}^{*} = \frac{\rho_0}{\lambda(\theta^*) + \rho_0} N$$

While aggregate employment implies

$$U_{JC}^{*} = N - \frac{\mathbb{E}\left[(\alpha\Upsilon)^{\frac{1}{1-\alpha}}\right]}{\int m^{\frac{1}{1-\alpha}} g(m;\theta) dm}$$

Jointly pinning down θ and U.

Steady State II

The distribution of workers: At the steady state, employed workers leaving firms with $\tilde{m} < m$ balance the workers joining firms with $\tilde{m} < m$:

$$(N - U^*)G(m)(\rho_0 + o\lambda(\theta^*)\bar{F}(m)) = U^*\lambda(\theta^*)F(m)$$

Therefore,

$$G(m) = \frac{\rho_0}{\rho_0 + o\lambda(\theta^*)(1 - F(m))}F(m)$$

Hiring and vacancy filling rate: In Steady-State, the hiring rate in firms at m exactly replaces separations and quits:

$$\eta(m) = \varrho_0 + \delta(m)$$

And the vacancy filling rate is determined by $G(m)$:

$$q(m) = \chi[\psi + (1 - \psi)G(m)]$$

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Mechanisms I

The effect of a carbon tax

An increase in carbon taxation affects output and employment through:

1. The substitutions within each firm
2. The change in the distribution of workers across firms
3. The change in the labor market tightness

Substitution between clean and dirty energy varies along the β_e distribution.
Substitution between energy and labor varies along the μ, ν and p_e distributions.

The MPL is affected through

$$\frac{\partial m}{\partial \tau} = \alpha \frac{\partial \Upsilon}{\partial \mu\nu/p_e} \frac{\partial \mu\nu/p_e}{\partial p_e} \frac{\partial p_e}{\partial \tau} \ell^{\alpha-1} = -\alpha(1-\nu)\mu\ell^{\alpha-1}(1-s_e)^{-\frac{1}{\rho}} s_e \frac{s_d}{1+\tau}$$

$\Rightarrow$ energy-intensive firms with a dirty energy mix are the most exposed to carbon tax increases.

Mechanisms II

The effect of a carbon tax

At the aggregate level, labor market tightness θ falls as the MPL decreases for all firms, which decreases vacancy postings. This slows down reallocation.

Energy-intensive firms with a dirty energy mix are the most affected: more workers end up with firms producing with less energy and a cleaner mix, amplifying the effect on the fall of emissions.

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Road Map

Calibration I

- **Labor market parameters:** [Elsby and Gottfries, 2022]
- **Internal calibration:** French manufacturing plants, 2018:
  - **Clean and dirty energy prices p_c, p_d:** Electricity and fossil fuel prices
  - **Energy mix β_e:** Drawn from a beta distribution that fits the empirical moment of $\beta_e = \left[\left(\frac{e_c}{e_d}\right)^{\frac{1}{\sigma}} \frac{p_c}{(1+\tau)p_d} + 1\right]^{-1}$
  - **Energy intensity ν:** Drawn from a beta distribution that fits the empirical moment of $\nu = \left(\left(s_e^{-1} - 1\right)^{\frac{1}{\rho}} \frac{e}{\ell^\alpha} + 1\right)^{-1}$
  - **TFP μ:** Drawn from a Weibull distribution that fits the empirical moment of $\mu = VA\,(1 - s_e)^{\frac{1-\rho}{\rho}} \frac{1}{(1-\nu)\ell^\alpha}$

Calibration II

Table 2: Parameters: external calibration

Parameters	Value	Description	Comments
ρ	-0.27	Elasticity of substitution between energy and labor ($\frac{1}{1-\rho}$)	[Bretschger and Jo, 2024]
σ	1.748	Elasticity of substitution between the different types of energy	[Stern, 2012]
r	0.004	Discount rate	[Elsby and Gottfries, 2022]
A	1.111	Matching efficiency	[Elsby and Gottfries, 2022]
ϵ	0.285	Matching elasticity	[Elsby and Gottfries, 2022]
o	0.148	Employed search intensity	[Elsby and Gottfries, 2022]
c	1.107	Per-worker hiring cost	[Elsby and Gottfries, 2022]
ρ_0	0.012	Exogenous separation rate	[Elsby and Gottfries, 2022]
ω_0	0.488	Flow breakdown payoff	[Elsby and Gottfries, 2022]
β	0.512	Worker bargaining power	[Elsby and Gottfries, 2022]
α	0.64	Returns to scale of (optimized) production	[Elsby and Gottfries, 2022]
N^f	1000	Number of firms	
N	21	Labor force size	[Elsby and Gottfries, 2022]
τ_0	0	Initial tax	
τ^{max}	2	Counterfactual tax: 10 tax rates from 0 to τ^{max}	Up to a 200% increase

Calibration III

Table 3: Parameters: internal calibration

Moment	**Value**	**Variable**	**Source**	**Parameter**
$E(p_d(i))$	0.98	Dirty energy price	EACEI 2018	p_d
$E(p_c(i))$	1.31	Electricity price	EACEI 2018	p_c
$\frac{e_d(i)}{e_c(i)}$	$E(\beta_e(i)) = 0.41$ $sd(\beta_e(i)) = 0.17$	Dirty energy consumption relative to clean energy consumption for each plant	EACEI 2018	Distribution $\beta_e(i)$
$s_e(i)$, $e(i)$	$E(\nu(i)) = 0.93$ $sd(\nu(i)) = 0.218$	Energy demand	FARE, EACEI 2018	Distribution $\nu(i)$
$VA(i)$	$E(\mu(i)) = 2065$ $sd(\mu(i)) = 31400$ $min(\mu(i)) = -304042$ $max(\mu(i)) = 550206$	VA	FARE 2018	Distribution $\mu(i)$

Calibration IV

Table 4: Estimated correlation between the heterogeneity parameters

	β_e	ν	μ
β_e	1	-0.25	0.002
ν	-0.25	1	-0.15
μ	0.002	-0.15	1

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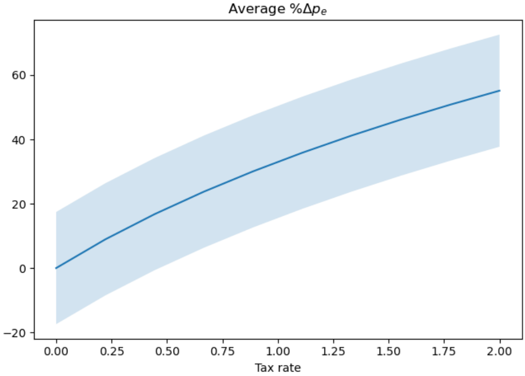
Effects of a carbon tax increase I

Figure 12: Average change in energy price induced by a carbon tax



Note: The figure displays the average difference of the steady state firm's energy price (in log) with the counterfactual tax rate indicated on the x-axis, relative to the no-tax scenario.

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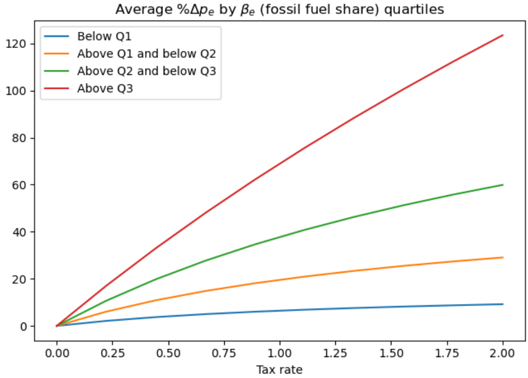
Effects of a carbon tax increase II

Figure 13: Average change in energy price induced by a carbon tax, by energy mix



Note: The figure displays the average difference of the steady state firm's energy price (in log) with the counterfactual tax rate indicated on the x-axis, relative to the no-tax scenario. The difference is split by energy mix (β_e) quartiles.

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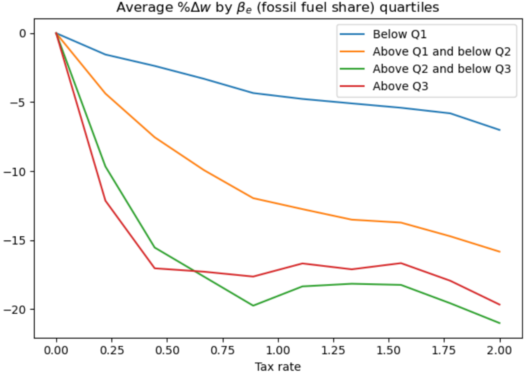
Effects of a carbon tax increase III

Figure 14: Average change in wage induced by a carbon tax, by energy mix



Note: The figure displays the average difference of the steady state firm's wage (in log) with the counterfactual tax rate indicated on the x-axis, relative to the no-tax scenario. The difference is split by energy mix (β_e) quartiles.

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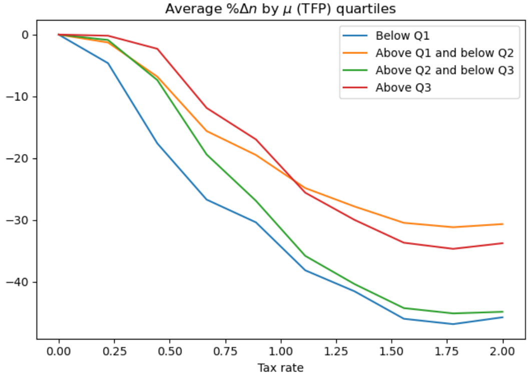
Effects of a carbon tax increase IV

Figure 15: Average change in employment induced by a carbon tax, by TFP



Note: The figure displays the average difference of the steady state firm's employment (in log) with the counterfactual tax rate indicated on the x-axis, relative to the no-tax scenario. The difference is split by TFP (μ) quartiles.

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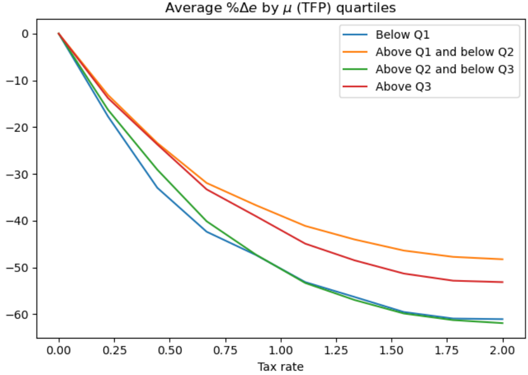
Effects of a carbon tax increase V

Figure 16: Average change in energy cons. induced by a carbon tax, by TFP



Note: The figure displays the average difference of the steady state firm's energy consumption (in log) with the counterfactual tax rate indicated on the x-axis, relative to the no-tax scenario. The difference is split by TFP (μ) quartiles.

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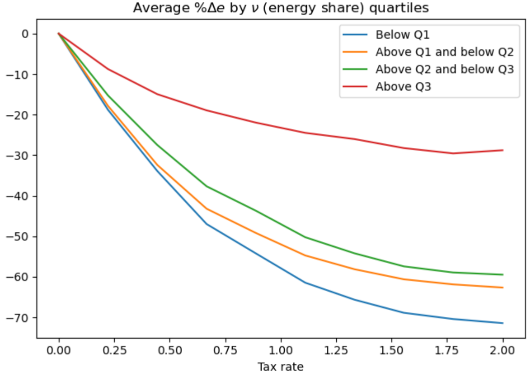
Effects of a carbon tax increase VI

Figure 17: Average change in energy cons. induced by a carbon tax, by energy intensity



Note: The figure displays the average difference of the steady state firm's energy consumption (in log) with the counterfactual tax rate indicated on the x-axis, relative to the no-tax scenario. The difference is split by energy intensity (ν) quartiles.

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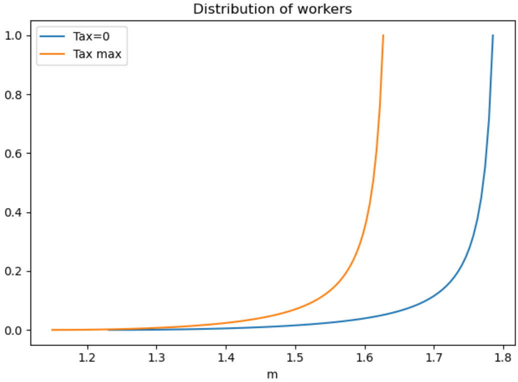
Effects of a carbon tax increase VII

Figure 18: Workers' distribution, by m



Note: The figure displays the distribution of workers across firms, by marginal product of labor m.

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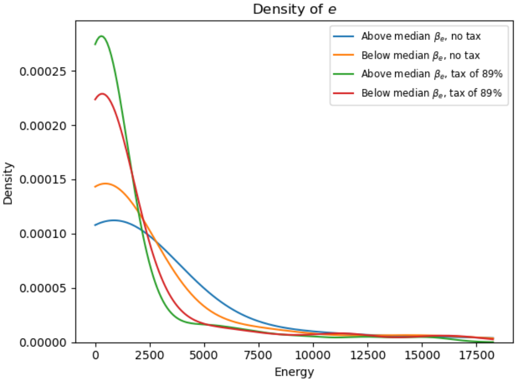
Effects of a carbon tax increase VIII

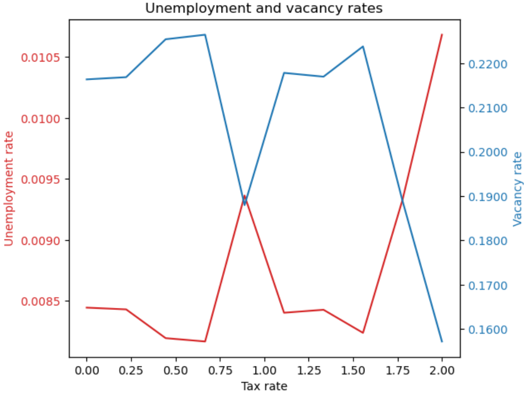
Figure 19: Density of e, by β_e and tax rate



Note: The figure displays the density of energy consumption, by energy mix (β_e) for $\tau = 0$ and $\tau = 89\%$.

Effects of a carbon tax increase IX

Figure 20: Unemployment and vacancy rate, by tax rate



Note: The figure displays the economy-wide unemployment and vacancy rates by tax rates.

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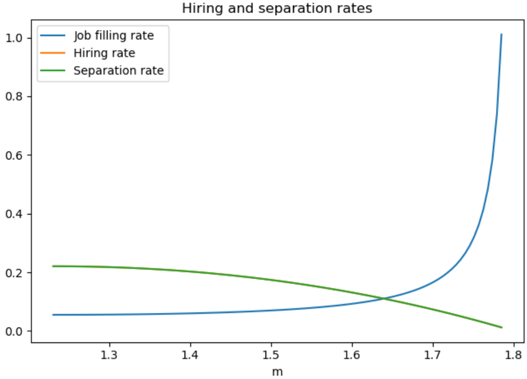
Equilibrium

Baseline Steady state (no tax)

Figure 21: Job filling rate, hiring rate and separation rate, by m



Note: The figure displays the job filling rate, the hiring rate and the separation rate, by marginal product of labor m.

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