The Impact of Energy Prices on Employment, Competitiveness and Environmental Performance: Evidence from French Manufacturing Plants

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4th IZA Conference on Labor Market Effects of Environmental Policies

Outline of the presentation

Energy prices and climate policy

- The **EU** committed to **ambitious climate policy targets** in the medium-long run
  - **2020 Climate and Energy Package** ⇒ 20% cut in GHG (wrt 1990), 20% of EU energy from renewables, 20% improvement in energy efficiency
  - **2030 Energy Strategy** (commitment of EU for **CoP21** in **Paris**, 2015) ⇒ 40% cut in GHG (wrt 1990), 27% of EU energy from renewables, 27% improvement in energy efficiency (wrt BAU)
- All in all the **impact** of climate policy is to **raise** the overall **price** of **fossil fuels** (e.g. Aldy and Pizer, 2015)
  - Induce **shift** towards (more expensive?) **renewable** energy ⇒ **increase** in average **energy prices**
  - Induce **energy saving technical change** and changes in the **input mix**

Climate policy vs EU competitiveness?

- **Unilateral** climate **policies** may **reduce** the **competitiveness** of EU-based industries that rely on energy
  - **Social** and **economic damage** ⇒ **job** losses in EU manufacturing sectors and negative impact on **income** and **GDP**
  - **Environmental damage** ⇒ **carbon leakage** (i.e. emissions are just displaced abroad) ⇒ if energy efficiency (and carbon intensity of energy mix) is worse abroad, carbon leakage would **even** result in **greater global GHG** emissions
- This **risk** is **acknowledged** by the **Commission** ⇒ e.g exemption from auctioning in Phase III of EU-ETS (2013-2020) for selected leakage-exposed industries

Our contribution

1. Our paper contributes to the growing **firm-level** literature on **evaluation of environmental policies** considering energy prices rather than EU-ETS, tax discontinuities or the CAA (Walker, 2013; Greenstone et al. 2012; Martin et al., 2014; Petrick and Wagner, 2014; Flues and Lutz, 2015).

2. We propose a simple **shift-share IV strategy** to account for endogeneity in the effect of energy prices on plant performance.

3. In practice:
   (a) We first assess the effects of recent **policy changes** on energy prices⇒ bottom line: difficult to evaluate new policies one-by-one.
   (b) We then evaluate the impact of **energy prices** on several measures of **plant performance**: energy demand, energy efficiency, CO2 emission, employment, workforce composition and labor productivity.

Outline of the Results

1. **Environmental Performance**: The (IV) own-elasticity of energy demand with respect to energy price is -0.52. The elasticity on CO2 is near -1 for all plants and -1.7 for ETS plants.
2. **Employment**: The (IV) cross-elasticity of employment with respect to energy price is -0.23, larger than -0.15 of previous studies reflecting a bias in OLS.

   Employment effects are skill-biased, significantly larger in trade-exposed sectors and in multi-plant firms (although driven by within firm labor relocation).
3. **Competitiveness**: Using only firms with all plants sampled, we find that a 10% increase in energy price decreases TFP and VA per worker by around 8%.

DATA AND BASIC FACTS

Description of data

Unbalanced panel of **plants** for **1997-2010**

- **EACEI** (Enquête Annuelle sur le Consommations d'Energie dans l'Industrie)
  - **Survey** on **consumption** and **expenditure** for **energy** products (by **source**: electricity, oil, coal, gas, steam, other)
  - **Unit** of analysis ⇒ **plant** (SIRET)
  - **Stratified sample** of medium-small **manufacturing** plants (10-250 employees) and population of big manufacturing plants (250+ employees)
- **DADS** (Déclaration Annuelle des Données Sociales)
  - Information on **employment** ⇒ number of **employees** and **workforce composition** by **occupation** (PCS)
  - **Unit** of analysis ⇒ **plants** (SIRET)
  - Information for the **population** of **active plants**
- **FARE/FICUS** (Fichier Approché des Résultats d'Esane)
  - **Balance sheets** for the **population** of French **companies**
  - **Unit** of analysis ⇒ **company** (SIREN)

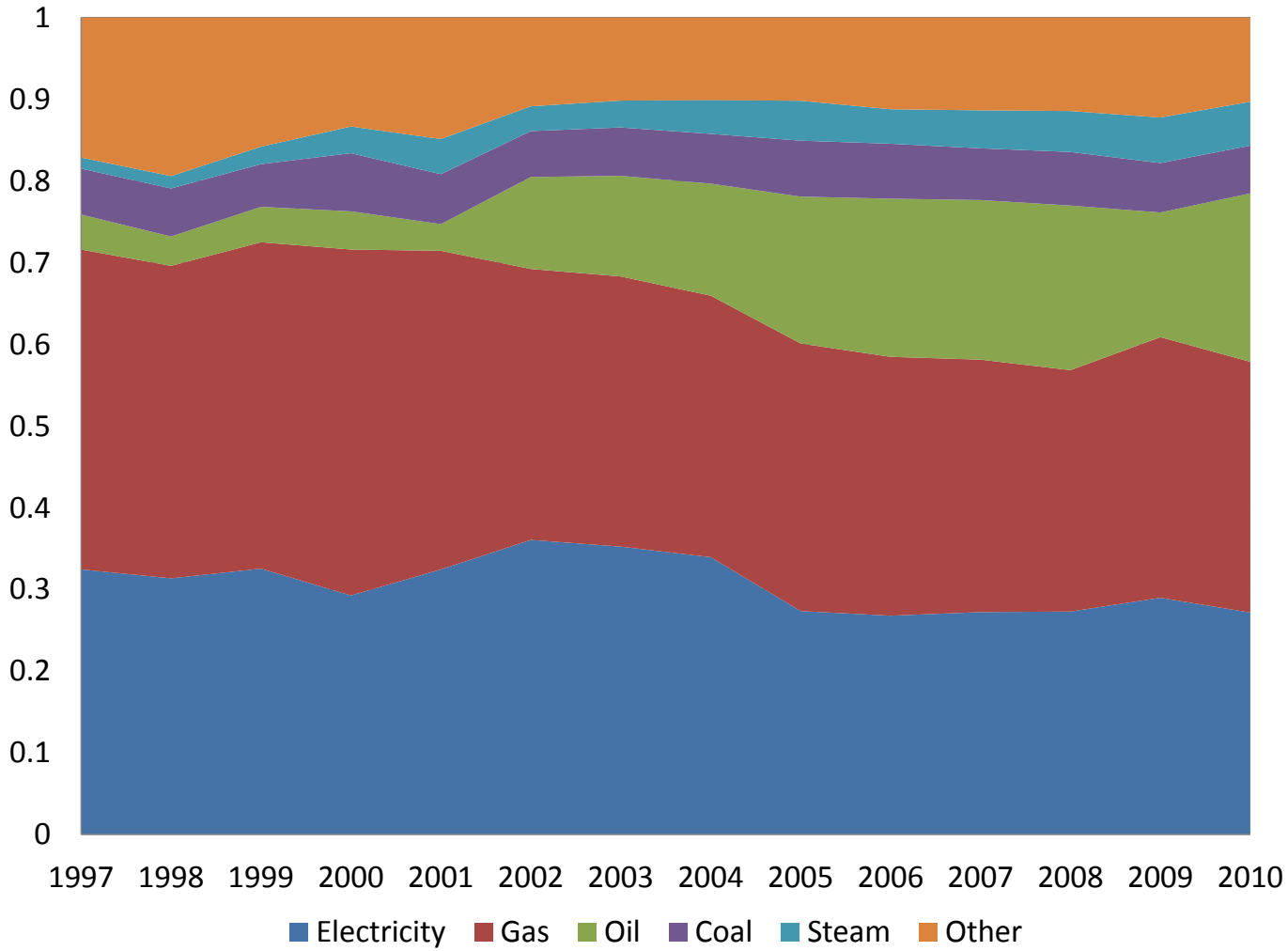
Energy prices?

- As in Davis et al (2013, REStat), we cannot measure **marginal electricity prices** (e.g. price in peak or off-peak hours).
- **No** specific **information** on the detailed **structure** of energy **tariff** schedule
- What we call **energy price** is, actually, the average **unit value price**, i.e. expenditures divided by quantity consumed (in kWh).

SOME FACTS

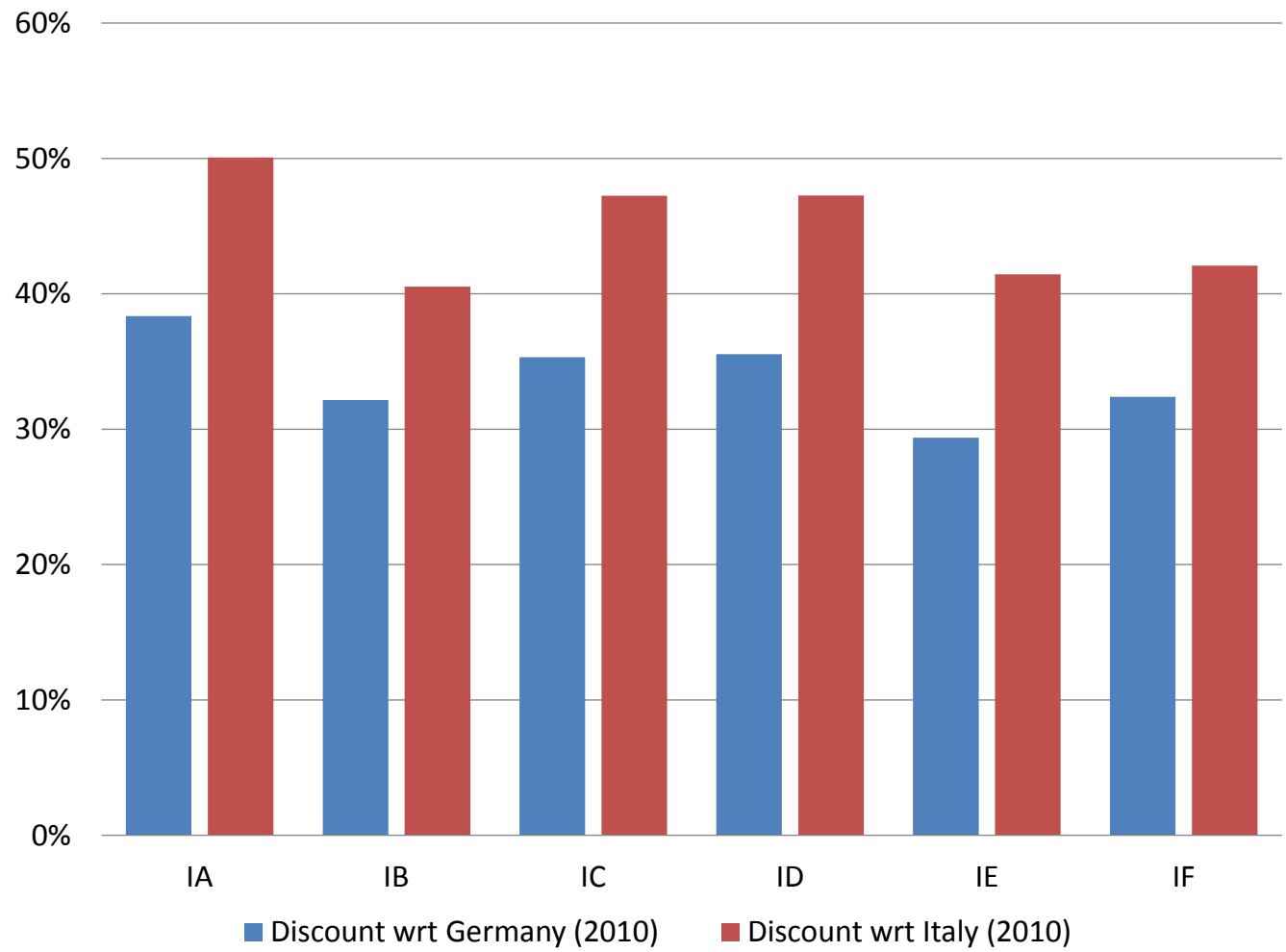
Stable energy mix

Figure: Energy mix of French plants (weighted by energy consumption)



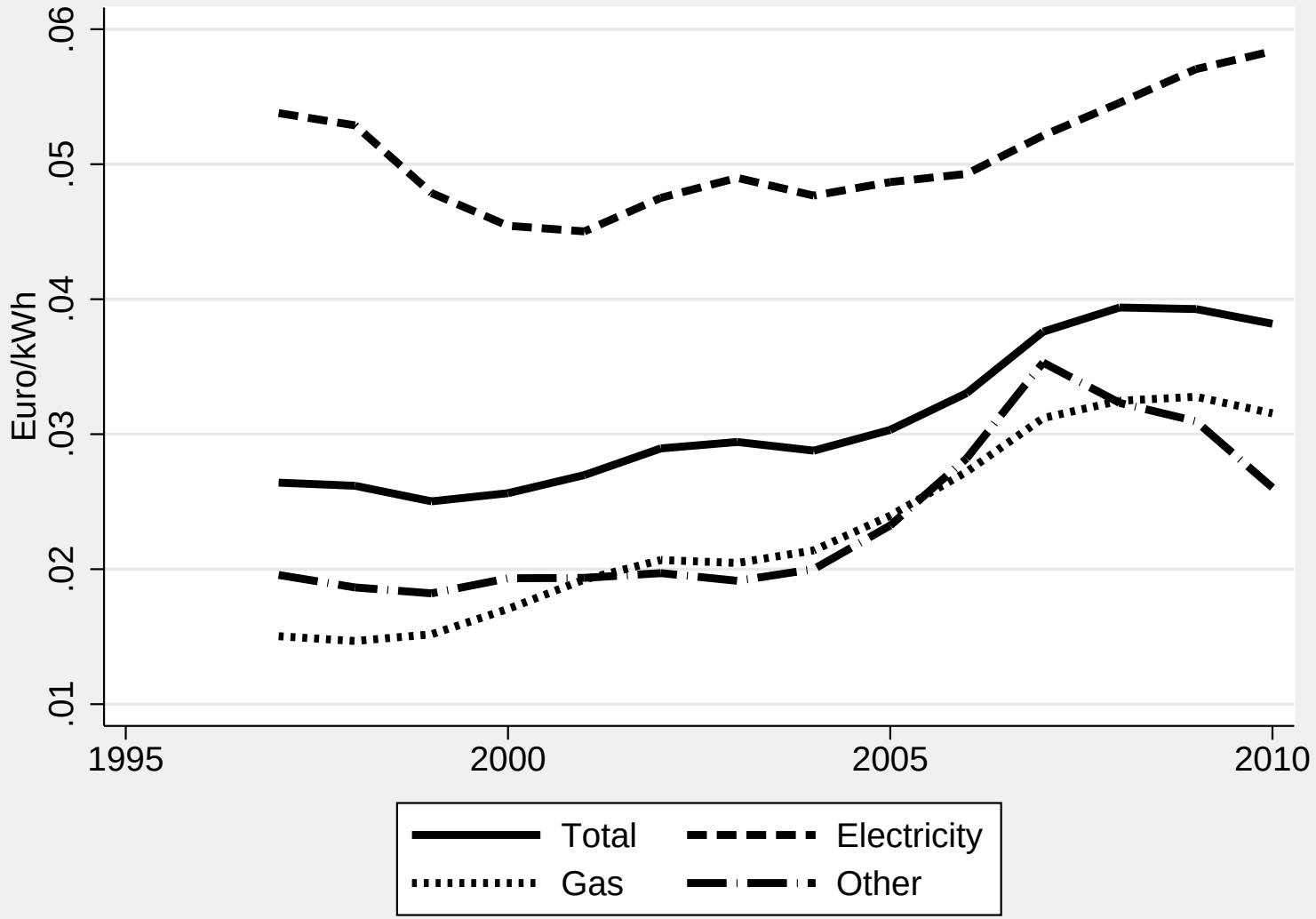
Low electricity prices

Figure: Discount in electricity price in France with respect to Italy and Germany by consumption band - IA: small consumers; IF: big consumers



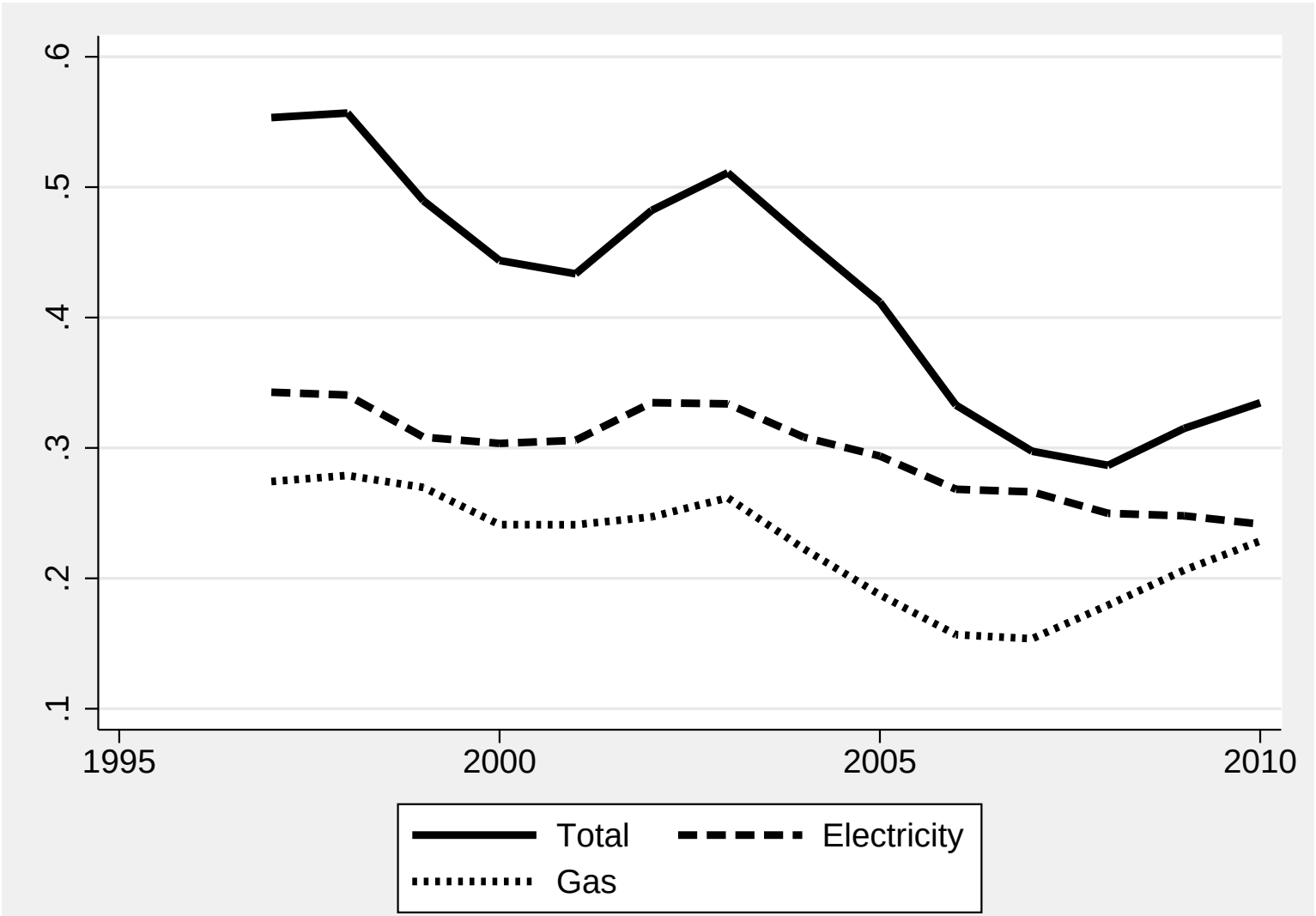
...but growing

Figure: Energy price trends (€/kWh)



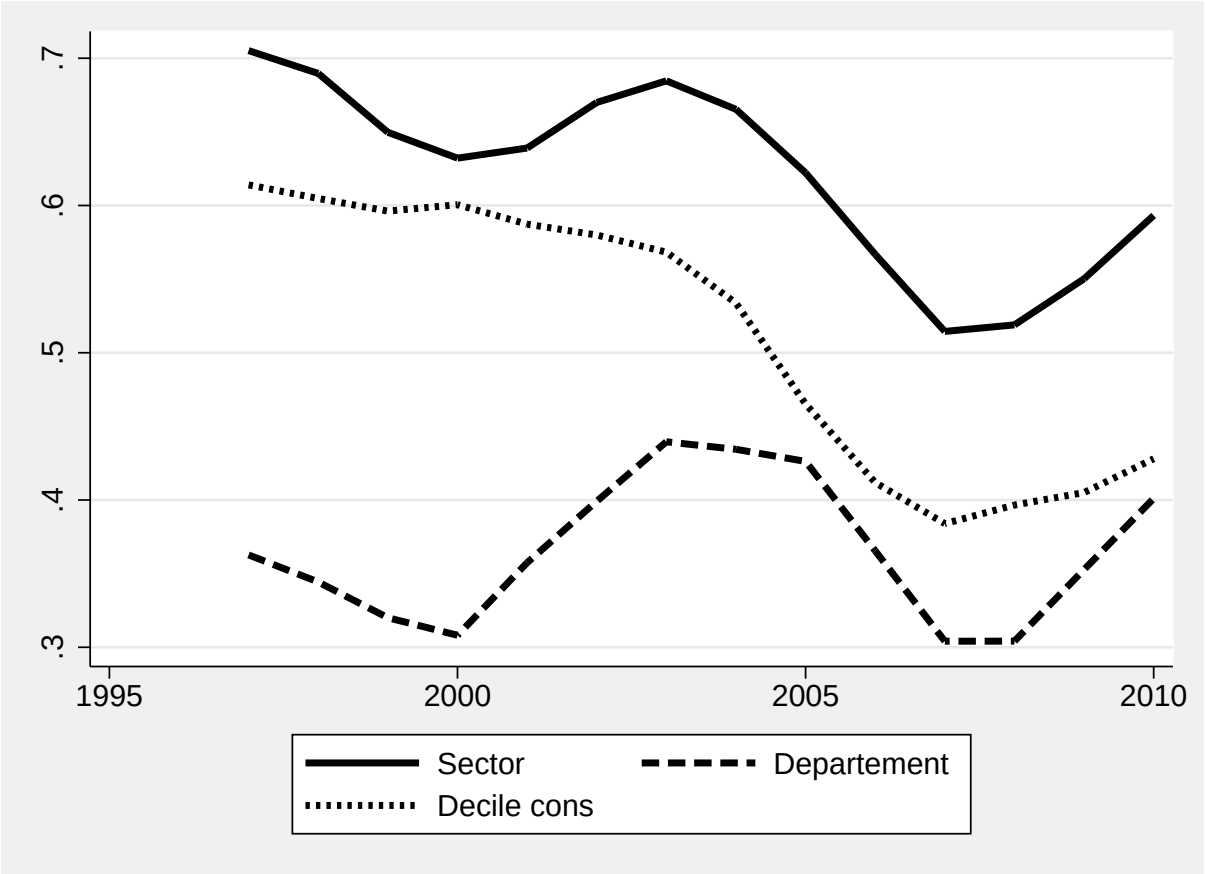
Heterogeneity in energy prices

Figure: SD of log energy prices



Reduction in quantity-discounts (Davis et al. 2014)

Figure: Share of explained SD - Total energy prices



Share energy cost here. More on discounts here.

POLICIES AND ENERGY PRICES

The French case

1. **Large share** of electricity is generated by **nuclear** power plants
   - **Messmer Plan** (after the oil crisis of 1973)
   - Now about **80-90 percent of electricity** is produced with nuclear power
   - **Baseload** source that cannot deal with **peaks** ⇒ France both **exports** and **imports** electricity
2. **Electricity and gas markets** dominated by **one player** (EDF and GDF, respectively)
   - **State-owned** companies (and well-managed)
   - Guarantee for **low prices**
   - Explicit aim of **reducing** geographical **heterogeneity** in **prices**
3. **Ambitious**, **Unilateral** policy plan (**the Energy Transition Law**):
   - **Carbon price floor** of 30€/tCO2 (ETS price around 6€/tCO2).
   - **Carbon tax**: 56€/tCO2 in 2020, 100€/tCO2 in 2030.
   - Expected effect on energy prices of around 8-10%

Regulatory changes in France over the 2000s

- Introduction of a **tax** on **electricity** (**CSPE**) in **2003** (more details in the following slides)
- Following **EU directives** and **deregulations** (from early 2000s):
  - Creation of an **independent transmission** system **operator** for **electricity**
  - **Opening** the **grid** to **non-discriminatory** third party access (**electricity**)
  - **Unbundling** and **opening** to third party access to underground **storage** of **natural gas**
- The **EU-ETS** induced an **increase** in overall **fossil fuel prices** (for **plants** covered by the **scheme**) and a generalized **increase** in **electricity prices**

Summary of relevant policies

- Contribution au Service Public de l'Électricité (CSPE)
- Product Market Regulation for Electricity and Gas (PMR)
- EU Emission Trading Scheme (ETS)

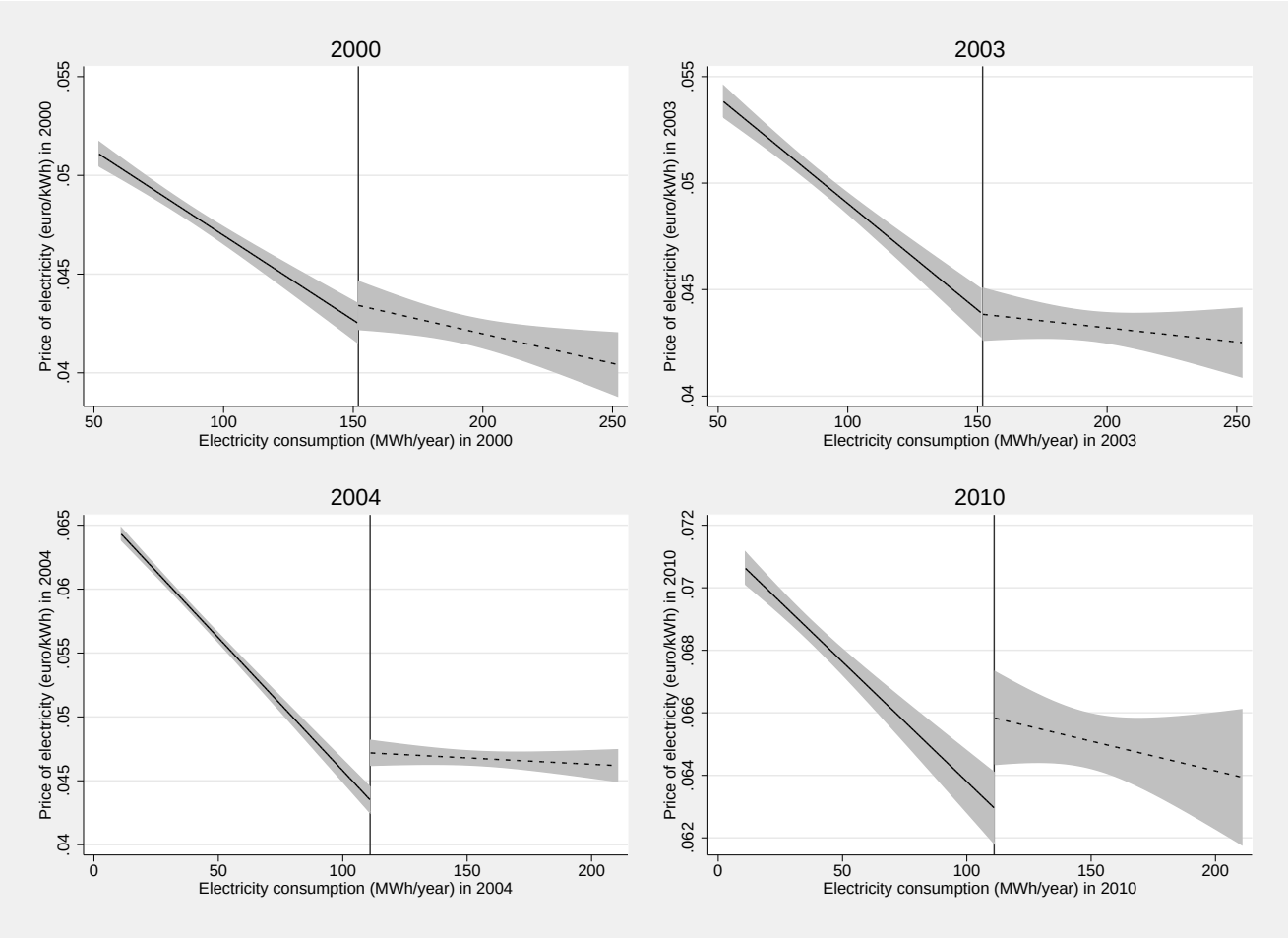
The CSPE tax

- The **CSPE** (Contribution au Service Public de l'Électricité) is a tax on electricity aimed at **financing** the '**public-service**' component of the supply of electricity
- Set up in **2002** with a rate of **3€/MWh** (3.3 in 2003, 4.5 from 2004, 9 in 2011, 10.5 in 2012, 13.5 in 2013, 16.5 in 2014, 19.5 in 2015 and 22.5 in 2016)
- **Tax revenue** is use to:
  - Cover the **obligatory purchase** by EDF of electricity produced with **co-generation** and **renewable** energy
  - Contribute to the **stabilization** of **prices** across different **regions** (especially islands and DOM/TOM)
  - Provide **discounts** for **poor** households on electricity purchase

Exemptions from CSPE

- **Big consumers** of electricity are (**partly**) **exempted** from the tax ⇒ to reduce the risk of reducing the **international competitiveness** of energy-intensive industries
  - From 2003 onwards, **ceiling** of 500,000€/year of overall **tax cost** for each plant (beyond that amount each additional kWh is not taxed) ⇒ the ceiling grew in time (to accommodate the increase in the tax rate) ⇒ about 1/5 of total electricity consumption is exempted
  - Up to 240GWh of **self-production** is exempted from the tax
  - Ceiling set to 0.5 percent of **company-level value added** for companies that consume more than 7GWh/year
- **Average tax per kWh** for **very big plants** is close to **zero**
- However, we do not observe **a clear discontinuity** in the effects of the tax on energy prices and factor demand.
- **EDF** is **quasi-monopolist** ⇒ changes in **net** electricity **prices** (i.e. reduction in quantity-discounts) offset or more than offset the **tax exemptions**.

Did the ceiling create a discontinuity in tax-inclusive electricity prices?



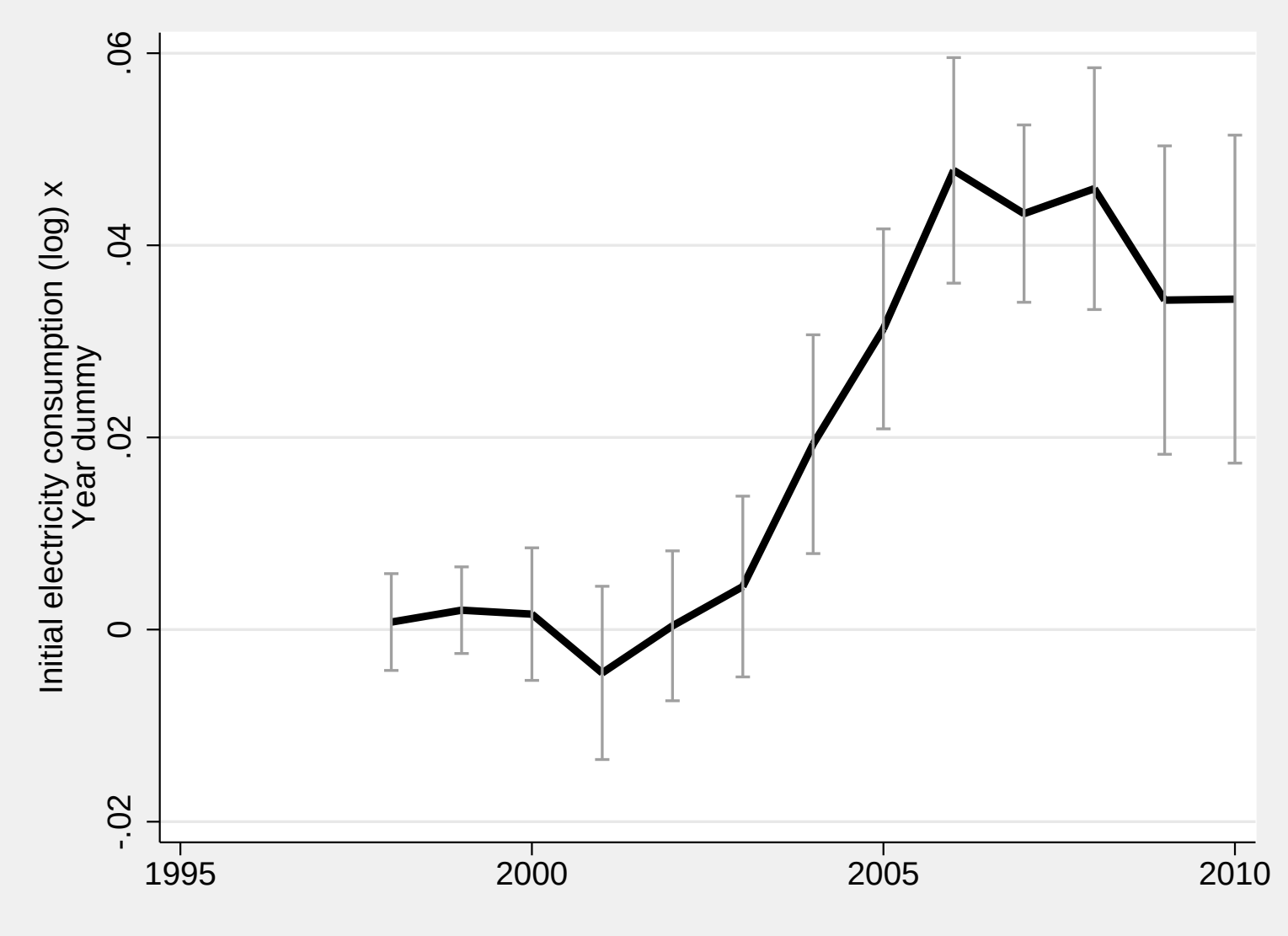
Discontinuity energy demand here. Discontinuity labor demand here.

Does the CSPE changed the structure of electricity prices within the plant?

- After **2002** there has been a **reduction** in the **elasticity** of prices to quantity
- **Hypothesis** $\Rightarrow$ the changes in **regulation** and taxes **reduced** the **price discounts** for **big consumers** of electricity wrt small ones
- To **evaluate** and **quantify** this effect we estimate the following equation:

$$log(Electr\_price_{it}) = \sum_t \beta^t log(Electr\_cons_{i0}) + \gamma_t^{Sector} + \eta_t^{Region} + \alpha_i + \varepsilon_{it}$$

Figure: Reductions in quantity discount on electricity price with respect to 1997



Product Market Regulation and EU-ETS

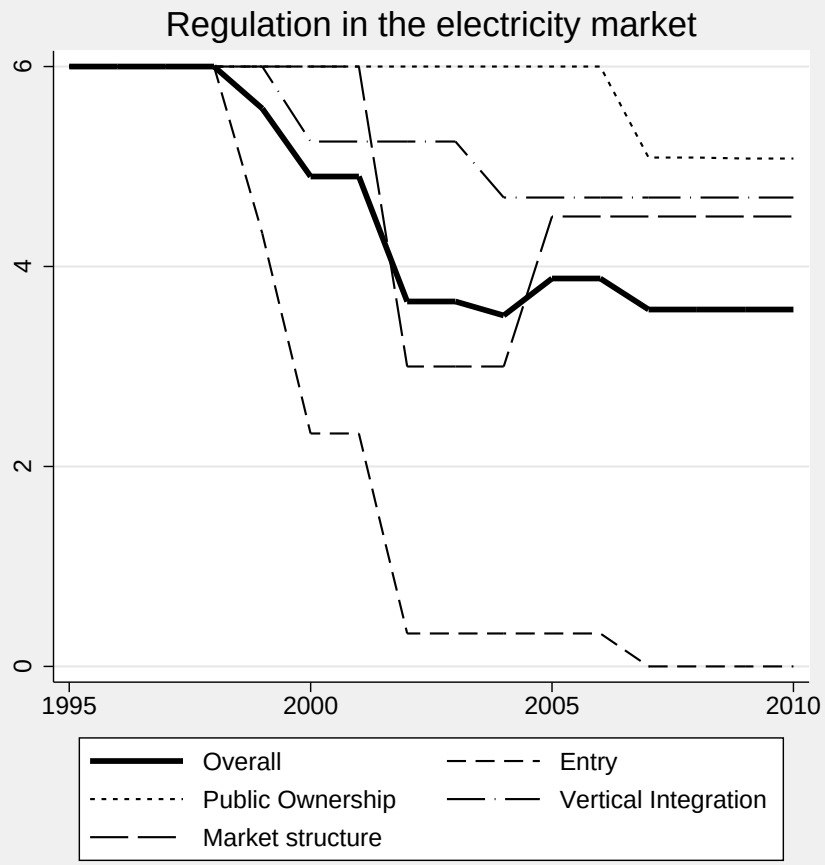
PMR

- **Decreases** in **PMR** are expected to **reduce** energy **prices** for plants buying a larger share of energy in the regulated markets.
- Lower price will induce a **change in the energy mix** towards gas and electricity.

ETS

- Impact of **EU-ETS** on overall **electricity** prices $\Rightarrow$ **not easy** to quantify in our framework.
- The **price** of dirty fuel, like carbon, **inclusive** of **price of allowances** for EU-ETS plants is higher than for non-ETS plants $\Rightarrow$ **move** from 'optimal' **fuel mix** to **less carbon intensive** fuel mix (more expensive).

Figure: Regulation index (6=fully regulated; 0=unregulated - source: OECD)



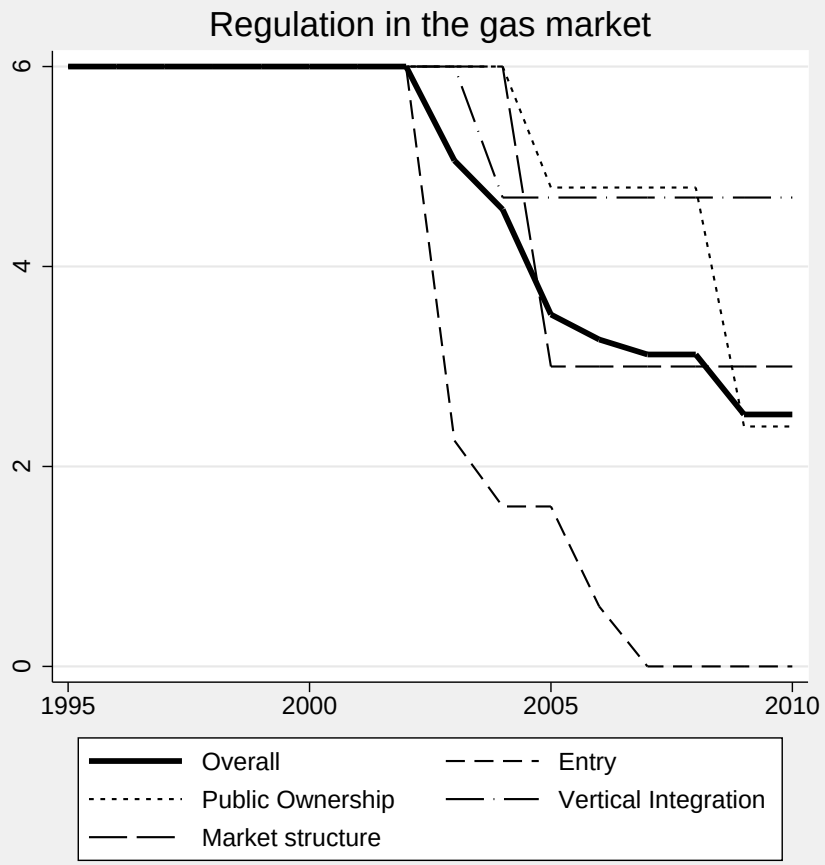
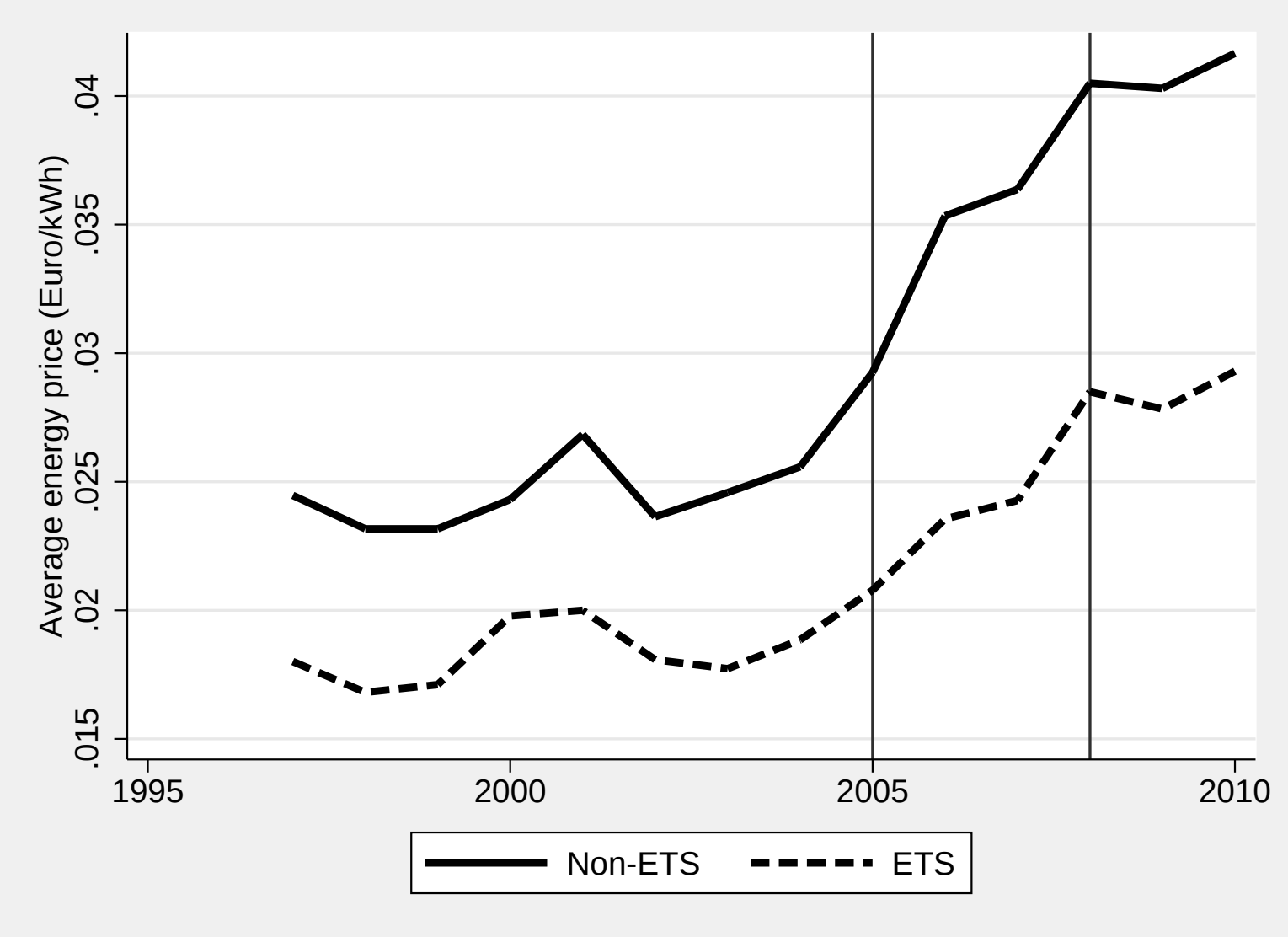


Figure: Average energy prices for ETS and non-ETS plants (weighted by energy consumption)



All policies together

Plant-specific measures of **policy change**:

- Plant-specific exposure to **Product Market Reforms** (PMR) for electricity and gas;
- Dummy for plants subjected to the **EU-ETS**;
- Average (plant-specific) **CSPE** per MWh of electricity.

Dep var: log(energy price)	(1)	(2)	(3)	(4)
PMR (1: fully regulated; 0: unregulated)	0.0704**			0.0647*
	(0.0359)			(0.0371)
Firm-specific CSPE (euro/MWh)		-0.0118**		-0.0106**
		(0.00475)		(0.00508)
ETS x D(2001-2004)			-0.00129	-0.00381
			(0.0270)	(0.0267)
ETS x D(2005-2007)			-0.00484	-0.0154
			(0.0438)	(0.0449)
ETS x D(2008-2010)			0.0463	0.0350
			(0.0440)	(0.0450)
N	105523	105523	105523	105523

Fixed effect model weighted by average energy consumption of the plant. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional control variables: year-sector (2-digit NACE rev 2) and year-region (NUTS2) dummies. Sample: plants that are observed in EACEI for at least three years.

Summary

- **Counter-intuitive** effect of the **CSPE** ⇒ No discontinuity, rents appropriation by EDF.
- **Counter-intuitive** effect also of **PMR** ⇒ price increase.
- **Substantial changes** in the structure of energy prices ⇒ **reductions in quantity-discounts** likely affect energy intensive companies.
- Overall, **energy prices** are the best **sufficient statistics** to evaluate effects of future climate policies.

ENERGY PRICES AND PERFORMANCE

Energy prices and plant performance

- How do **energy prices** influence the **performance** of French plants?
  $\Rightarrow$ several policy instruments ultimately **influence energy prices**.
- We evaluate the **relationship** between **plant-specific energy prices** and the **performance** (both **economic** and **environmental**) of French plants.

Estimating equation

- We **estimate** the following equation:

$$log(Outcome_{it}) = \beta log(Ener\_price_{it}) + X'_{it}\gamma + \alpha_i + \varepsilon_{it}$$

where:

- $Ener\_price_{it}$ is the **ratio** between total **expenditure** on energy and total **energy consumption** (in kWh) of plant i in year t
- β is the estimated **elasticity** of the outcome variable to energy prices
- X'_{it} is a series a **control** variables:
  - **Industry**-year dummies (NACE 2-digit rev 2)
  - **Region**-year dummies (NUTS2)
  - Year dummies specific for **ETS** plants (to account for the EU-ETS in a flexible way)
- α_i is the plant **fixed effect**

Details on estimating sample in here.

Endogeneity concerns

- **Unobserved** negative demand **shocks** reduce output and the **demand** of inputs (both labour and energy)
  - **Contracts** for **energy** supply (especially electricity and gas) **commit** the buyer to buy a **certain amount** of energy for a **certain price before** the **shock** is **observed**
  - **Unexpected reduction** in **demand** and **energy** consumption **raises** the **average price** of energy paid by plants
  - Unobserved shocks are **positively correlated** with energy **prices** and **negatively** correlated with **energy demand**, **employment** and **output** $\Rightarrow$ β_{OLS} should be **upwardly biased**
- Plants with **different energy mix** (i.e. **technology**) are exposed to **exogenous changes** in energy prices **differently**
  - Plants **respond** to **heterogeneous changes** in energy prices across sources by **changing** the energy **mix** (i.e. reducing the relative weight of sources that became more expensive)
  - Changes in energy mix is **jointly determined** (e.g technological choices) with energy intensity, labour demand and output $\Rightarrow$ source of **endogeneity**

Instrumental variable

- We build a shift-share **IV** that **only** keeps **exogenous variations** in energy **prices** and **accounts** for **both sources** of **endogeneity**

$$\begin{aligned} IV_{it} &= log(P\_electr_t \times Sh\_electr_{i,0} + P\_gas_t \times Sh\_gas_{i,0} + P\_oil_t \times Sh\_oil_{i,0} + \\ &+ P\_coal_t \times Sh\_coal_{i,0} + P\_steam_t \times Sh\_steam_{i,0}) \end{aligned}$$

- **Exogenous regulation** (and CSPE) induced substantial **changes** in **prices**, especially so for **electricity**
- Prices for **other sources** respond more to **'global' prices** and depend less on the level of consumption than electricity
- We **shut down** possible **responses** of plants to changing energy prices in terms of **energy mix** by weighting exogenous prices with a **time-invariant** (initial) plant-specific energy mix

Table: Baseline results - energy and CO2

	log(energy cons)		log(energy cons / L)	
	FE	FE-IV	FE	FE-IV
log(energy price)	-1.156***	-0.523***	-1.188***	-0.729***
	(0.00916)	(0.0353)	(0.00750)	(0.0288)
F excl IV first stage		6757.2		6757.4
N	106004	106004	105969	105969
	log(CO2)		**log(CO2 / L)**	
	FE	FE-IV	FE	FE-IV
log(energy price)	-1.724***	-1.055***	-1.590***	-0.840***
	(0.0136)	(0.0570)	(0.0164)	(0.0684)
F excl IV first stage		4820		4651.3
N	91628	91628	88811	88811

Fixed effect model. Robust standard errors in parenthesis. * p< 0.1, ** p<0.05, *** p<0.01. Additional control variables: year-sector (2-digit NACE rev 2) and year-region (NUTS2) dummies. Excluded IV: log of national energy prices (by fuel) weighted with initial energy mix of the plant. Sample: plants that are observed in EACEI for at least three years.

Interaction energy cost share here.

Table: Baseline results - employment

	log(empl)		Share HS workers	
	FE	FE-IV	FE	FE-IV
log(energy price)	-0.122***	-0.230***	0.00269***	0.00725*
	(0.00810)	(0.0306)	(0.00104)	(0.00391)
F excl IV first stage		6455.5		6455.5
N	102519	102519	102519	102519
	Share LS white collar		**Share blue collar**	
	FE	FE-IV	FE	FE-IV
log(energy price)	0.00294**	-0.00147	-0.00668***	-0.0189*
	(0.00131)	(0.00496)	(0.00153)	(0.00577)
F excl IV first stage		6455.5		6455.5
N	102519	102519	102519	102519

Fixed effect model. Robust standard errors in parenthesis. * p< 0.1, ** p<0.05, *** p<0.01. Additional control variables: year-sector (2-digit NACE rev 2) and year-region (NUTS2) dummies. Excluded IV: log of national energy prices (by fuel) weighted with initial energy mix of the plant. Sample: plants that are observed in EACEI for at least three years.

Interaction energy cost share here.

Explaining the different bias for employment and energy

- For **energy demand**, the IV-elasticity is, as expected, **smaller** than the OLS-elasticity. The bias is **particularly large** because energy prices are measured as the ratio between expenditures and energy consumption.
- For **labor**, the IV-elasticity is **larger** than the OLS-elasticity. This result is less intuitive to explain.
- In our IV strategy, all firm-specific changes in **technology** and the **energy (and input) mix** enters in the error term. These changes should be positively correlated with both employment and energy prices, and thus **mitigate** the negative effect of energy prices on employment in OLS.

Table: Energy intensive vs non energy intensive sectors

Energy intensive sectors						
	log(energy cons)		**log(CO2)**		**log(empl)**	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-1.137***	-0.542***	-1.723***	-1.086***	-0.133***	-0.288***
	(0.0399)	(0.0481)	(0.0695)	(0.0804)	(0.0145)	(0.0388)
F excl IV first stage		3254.7		2346.8		3137.9
N	55099	55099	47615	47615	53332	53332
Non energy intensive sectors						
	log(energy cons)		**log(CO2)**		**log(empl)**	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-1.181***	-0.466***	-1.727***	-0.989***	-0.109***	-0.125*
	(0.0296)	(0.0722)	(0.0454)	(0.116)	(0.0190)	(0.0645)
F excl IV first stage		1952.2		1278.0		1835.1
N	50905	50905	44013	44013	49187	49187

Fixed effect model. Robust standard errors in parenthesis. * p< 0.1, ** p<0.05, *** p<0.01. Additional control variables: year-sector (2-digit NACE rev 2) and year-region (NUTS2) dummies. Excluded IV: log of national energy prices (by fuel) weighted with initial energy mix of the plant. Sample: plants that are observed in EACEI for at least three years.

Table: ETS vs non ETS plants

ETS plants						
	log(energy cons)		**log(CO2)**		**log(empl)**	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-1.107***	-0.783***	-2.133***	-1.764***	-0.0797	0.0767
	(0.142)	(0.217)	(0.333)	(0.459)	(0.0594)	(0.213)
F excl IV first stage		96.19		97.41		95.81
N	3411	3411	3381	3381	3385	3385
Non ETS plants						
	log(energy cons)		**log(CO2)**		**log(empl)**	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-1.157***	-0.513***	-1.710***	-1.025***	-0.123***	-0.235***
	(0.0271)	(0.0408)	(0.0460)	(0.0658)	(0.0117)	(0.0341)
F excl IV first stage		5122.2		3562.4		4890.3
N	102593	102593	88247	88247	99134	99134

Fixed effect model. Robust standard errors in parenthesis. * p< 0.1, ** p<0.05, *** p<0.01. Additional control variables: year-sector (2-digit NACE rev 2) and year-region (NUTS2) dummies. Excluded IV: log of national energy prices (by fuel) weighted with initial energy mix of the plant. Sample: plants that are observed in EACEI for at least three years.

Table: Trade intensive sectors vs non trade intensive sectors

Trade intensive sectors

	log(energy cons)		**log(CO2)**		**log(empl)**	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-1.216***	-0.753***	-1.686***	-1.107***	-0.139***	-0.257***
	(0.0446)	(0.0680)	(0.0708)	(0.109)	(0.0190)	(0.0600)
F excl IV first stage		1787.9		1179.4		1708.1
N	42225	42225	37330	37330	40819	40819

Non trade intensive sectors

	log(energy cons)		**log(CO2)**		**log(empl)**	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-1.123***	-0.408***	-1.766***	-1.097***	-0.103***	-0.164***
	(0.0336)	(0.0540)	(0.0607)	(0.0915)	(0.0144)	(0.0417)
F excl IV first stage		2993.4		2102.2		2862.7
N	63779	63779	54298	54298	61700	61700

Fixed effect model. Robust standard errors in parenthesis. * p< 0.1, ** p<0.05, *** p<0.01. Additional control variables: year-sector (2-digit NACE rev 2) and year-region (NUTS2) dummies. Excluded IV: log of national energy prices (by fuel) weighted with initial energy mix of the plant. Sample: plants that are observed in EACEI for at least three years.

Table: Single plant firms vs multi plant firms

	Single plant firms					
	log(energy cons)		**log(CO2)**		**log(empl)**	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-1.193***	-0.366***	-1.787***	-0.919***	-0.113***	-0.185***
	(0.0327)	(0.0627)	(0.0582)	(0.102)	(0.0144)	(0.0435)
F excl IV first stage		2383.2		1631.4		2249.3
N	54108	54108	45396	45396	52424	52424
	Multi plant firms					
	log(energy cons)		**log(CO2)**		**log(empl)**	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-1.139***	-0.714***	-1.676***	-1.157***	-0.120***	-0.220***
	(0.0448)	(0.0556)	(0.0736)	(0.0929)	(0.0180)	(0.0538)
F excl IV first stage		2191.3		1561.5		2107.2
N	49038	49038	43917	43917	47467	47467

Fixed effect model. Robust standard errors in parenthesis. * p< 0.1, ** p<0.05, *** p<0.01. Additional control variables: year-sector (2-digit NACE rev 2) and year-region (NUTS2) dummies. Excluded IV: log of national energy prices (by fuel) weighted with initial energy mix of the plant. Sample: plants that are observed in EACEI for at least three years.

To what extent the difference btw multi and single plant depend on within-firm relocation?

- We run regressions only on multi-plant firms (with all plants included in EACEI)
- We condition on firm-year fixed effects (γ_{jt}) $\Rightarrow$ $log(Ener\_price_{i \in j,t})$ can be interpreted as the difference of energy prices between plant i and its company j.
- Dependent variable $\Rightarrow$ share of labour, energy and CO2 in plant i with respect to the total in firm j.

$$log(Outcome_{i \in j,t}) = \beta log(Ener\_price_{i \in j,t}) + \gamma_{jt} + \alpha_i + \varepsilon_{it}$$

Table: Within-firm relocation

	Share of firm employment		Share of firm energy cons		Share of firm CO2 emissions	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-0.0582**	-0.140*	-0.342***	-0.283***	-0.588	-0.380***
	(0.0225)	(0.0778)	(0.0370)	(0.0833)	(0.0540)	(0.108)
F excl IV first stage		40.43		63.24		62.76
N	4162	4162	4177	4177	4066	4066

Fixed effect model. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional control variables: firm-year dummies. Excluded IV: log of national energy prices (by fuel) weighted with initial energy mix of the plant. Sample: plants in multi-plant firms for which all plants are observed in EACEI; plants that are observed in EACEI for at least three years.

From plant-level to firm-level analysis

- We aggregate up energy-related and labour-related information at the firm level for those firms with all plants included in the EACEI survey (i.e. all single-plant firms, and multi-plant firms with all plants included in the survey).
- We use firm-level data to retrieve information on balance sheets and income statements (FICUS-FARE).
- Additional measures $\Rightarrow$ productivity (labour productivity and TFP$\Rightarrow$ direct measures of efficiency), investment, capital.

Table: Firm-level performance - energy and CO2

	log(energy cons)		**log(energy cons / L)**		**log(energy cons / turn)**	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-1.178***	-0.427***	-1.059***	-0.219***	-1.030***	-0.248***
	(0.0328)	(0.0585)	(0.0337)	(0.0659)	(0.0335)	(0.0641)
F excl IV first stage		2837.0		2776.3		2800.8
N	55582	55582	54582	54582	54865	54865
	log(CO2)		**log(CO2 / L)**		**log(CO2 / turn)**	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-1.805***	-1.081***	-1.696***	-0.884***	-1.668***	-0.972***
	(0.0586)	(0.0961)	(0.0584)	(0.105)	(0.0579)	(0.102)
F excl IV first stage		1881.8		1841.4		1858.2
N	47236	47236	46447	46447	46662	46662

Fixed effect model. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional control variables: firm-year dummies. Excluded IV: log of national energy prices (by fuel) weighted with initial energy mix of the plant. Sample: plants in multi-plant firms for which all plants are observed in EACEI; plants that are observed in EACEI for at least three years.

Table: Firm-level performance - employment and economic performance

	log(empl)		log(VA / empl)		log(turn / empl)	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-0.112***	-0.189***	-0.0448***	-0.0709*	-0.0214*	0.0153
	(0.0133)	(0.0371)	(0.0138)	(0.0406)	(0.0130)	(0.0366)
F excl IV first stage		2776.3		2733.0		2747.0
N	54582	54582	53699	53699	54080	54080
	log(TFP)		**log(invest / empl)**		**log(capital stock / empl)**	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-0.0480***	-0.0792**	0.0227	-0.0349	-0.0283	-0.0608
	(0.0128)	(0.0374)	(0.0492)	(0.174)	(0.0180)	(0.0551)
F excl IV first stage		2647.1		1325.0		2669.5
N	52742	52742	33323	33323	53212	53212
	Share HS workers		**Share LS white collar**		**Share blue collar**	
	FE	FE-IV	FE	FE-IV	FE	FE-IV
log(energy price)	-0.00669	0.00375	-0.0235	-0.0513	-0.0457	-0.259
	(0.00727)	(0.0394)	(0.0219)	(0.154)	(0.0382)	(0.198)
F excl IV first stage		2776.3		2776.3		2776.3
N	54582	54582	54582	54582	54582	54582

Firm-level estimates. Fixed effect model. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional control variables: year-sector (2-digit NACE rev 2) and year-region (NUTS2) dummies. Excluded IV: log of national energy prices (by fuel) weighted with initial energy mix of the plant. Sample: firms for which all plants are included in EACEI and that are observed in EACEI for at least three years.

Summary and Extensions

1. Our study **confirms** previous results on the **effects** of environmental policies: **improve** environmental performance and energy efficiency at the **cost** of a small negative effect on employment and competitiveness.
2. We highlight **heterogeneous responses** by skills (low/high), sector (tradable/non-tradable) and firm characteristics (multi/single plants $\Rightarrow$ mitigate effects for multi-plants).
3. Our analysis of the **drivers** of energy price changes highlights potential problems of **single policy** evaluation.
4. Our approach is suitable to **simulate firm-specific** responses to current and future policy: french carbon tax (56€/tCO2 in 2020; 100€/ton in 2030) and fuel-specific taxes.
5. Extensions: firm exit (no results so far), aggregate effects using sample weights (issue of representativeness for the estimation sample), role of technical change (control for green patents), tracking detailed changes in skill composition (use matched employer-employee data).

THANK YOU FOR YOUR ATTENTION

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Table: Energy costs / wages

Sector	Energy expenditure / wages (average)
Manufacture of basic metals	0.3814
Manufacture of chemicals and chemical products	0.3782
Manufacture of other non-metallic mineral products	0.3675
Manufacture of wood and of products of wood and cork	0.3381
Manufacture of textiles	0.3234
Manufacture of paper and paper products	0.2841
Manufacture of rubber and plastic products	0.2381
Total	0.2169
Manufacture of fabricated metal products	0.2068
Manufacture of furniture	0.2050
Manufacture of coke and refined petroleum products	0.1970
Manufacture of motor vehicles, trailers and semi-trailers	0.1638
Repair and installation of machinery and equipment	0.1557
Manufacture of basic pharmaceutical products	0.1442
Manufacture of machinery and equipment n.e.c.	0.1436
Manufacture of electrical equipment	0.1354
Manufacture of computer, electronic and optical products	0.1267
Other manufacturing	0.1123
Manufacture of other transport equipment	0.1014
Manufacture of leather and related products	0.0857
Manufacture of wearing apparel	0.0805

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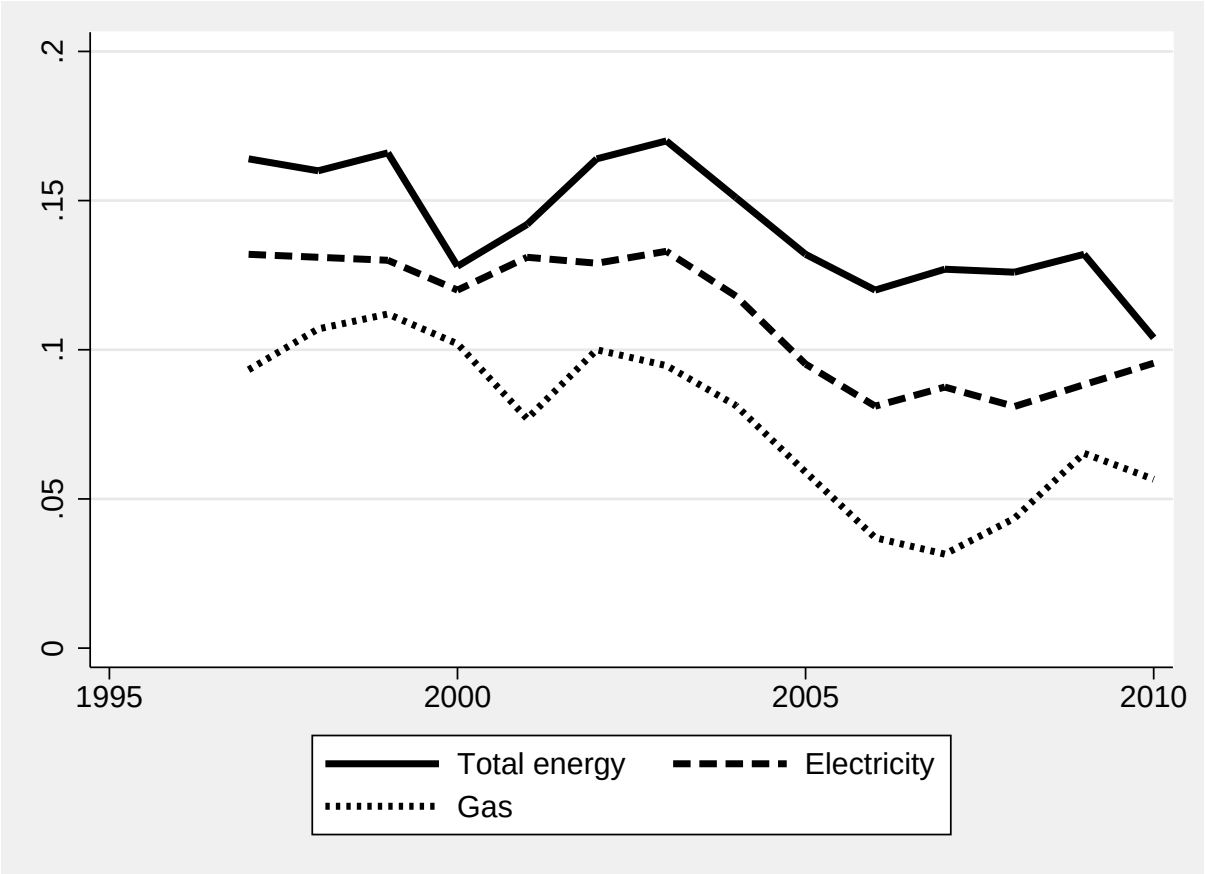
More on quantity discounts

Figure: Cross-sectional elasticity of energy prices wrt to energy consumption (region and industry dummies included, weighted by energy purchase)



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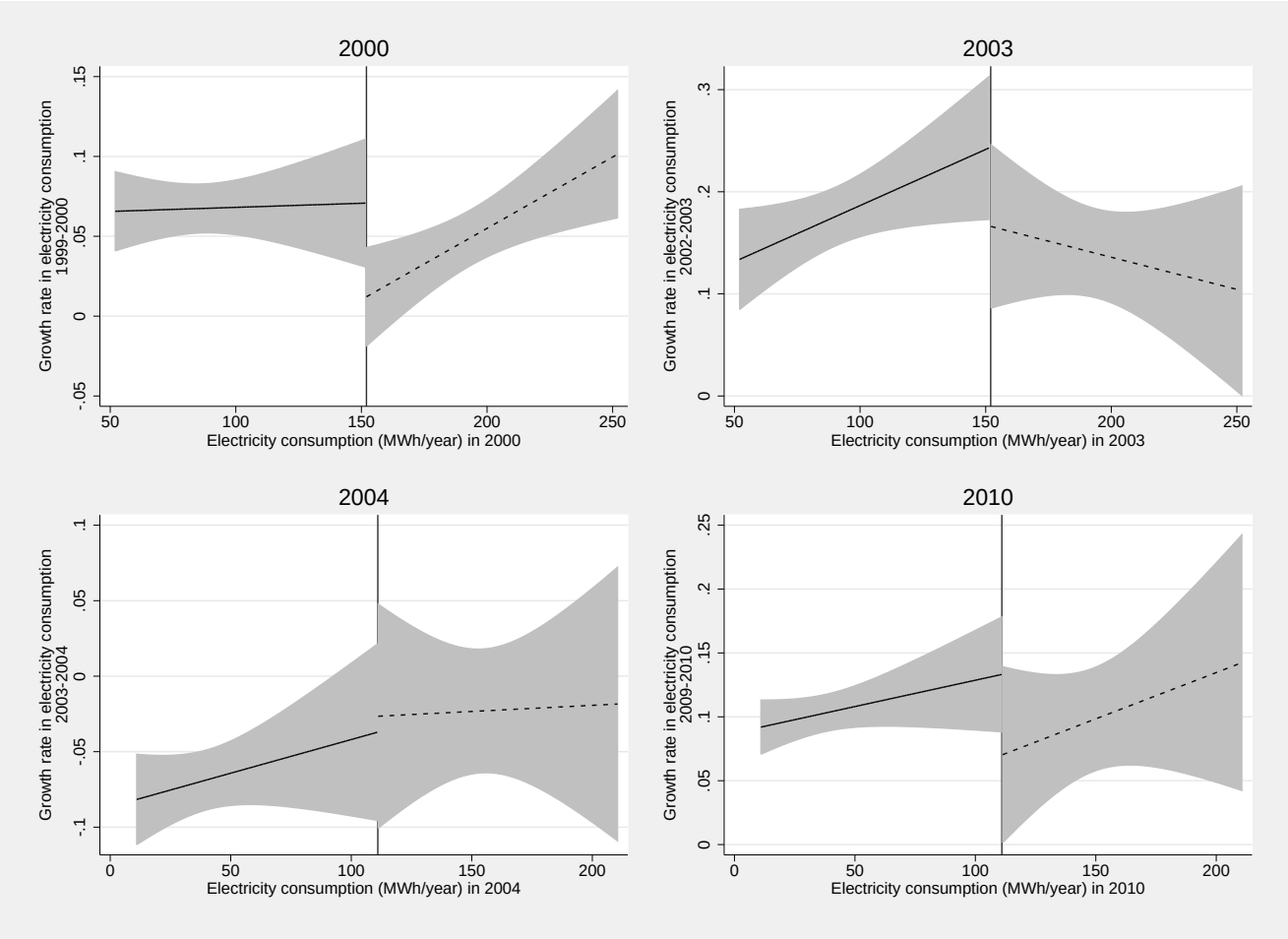
Did the ceiling create a discontinuity in the growth of electricity consumption?



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Did the ceiling create a discontinuity in the growth of employment?

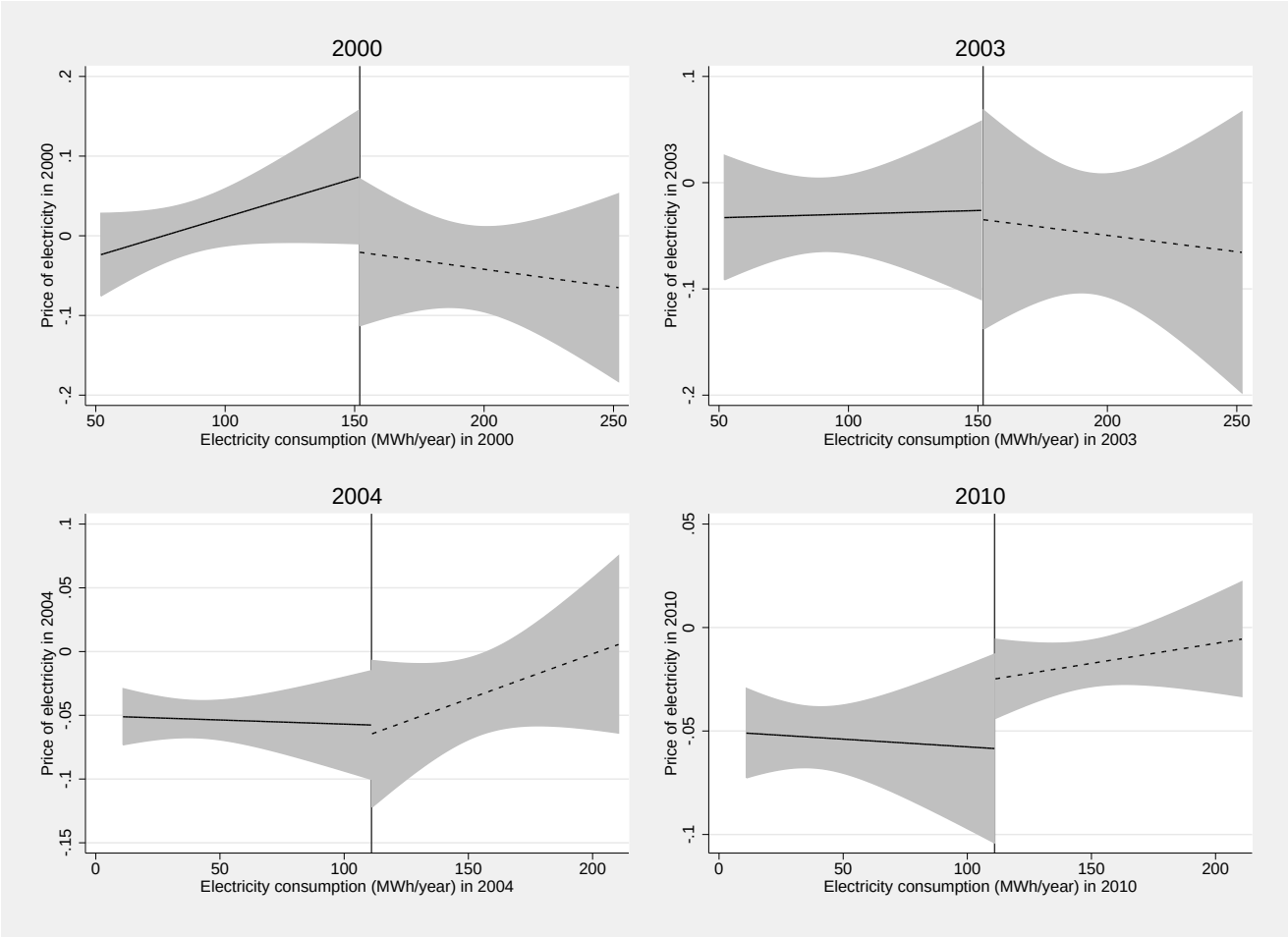

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Table: Interaction between energy price and initial ratio between energy cost and wages - energy and CO2

	log(energy cons)		log(energy cons / L)	
	FE	FE-IV	FE	FE-IV
log(energy price)	-1.104***	-0.397***	-1.151***	-0.660***
	(0.00978)	(0.0375)	(0.00802)	(0.0305)
log(energy price) x Initial energy cost share of wages	-0.192***	-0.286***	-0.134***	-0.162***
	(0.0145)	(0.0218)	(0.0119)	(0.0179)
F excl IV first stage		3197.1		3196.9
N	105178	105178	105144	105144
	log(CO2)		log(CO2 / L)	
	FE	FE-IV	FE	FE-IV
log(energy price)	-1.691***	-0.956***	-1.553***	-0.717***
	(0.0146)	(0.0609)	(0.0175)	(0.0730)
log(energy price) x Initial energy cost share of wages	-0.114***	-0.189***	-0.132***	-0.258***
	(0.0201)	(0.0291)	(0.0240)	(0.0345)
F excl IV first stage		2248.5		2181.5
N	90969	90969	88302	88302

Fixed effect model. Robust standard errors in parenthesis. * p< 0.1, ** p<0.05, *** p<0.01. Additional control variables: year-sector (2-digit NACE rev 2) and year-region (NUTS2) dummies. Excluded IV: log of national energy prices (by fuel) weighted with initial energy mix of the plant. Sample: plants that are observed in EACEI for at least three years.

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Table: Interaction between energy price and initial ratio between energy cost and wages - employment

	log(empl)		Share HS workers	
	FE	FE-IV	FE	FE-IV
log(energy price)	-0.129***	-0.260***	0.00372***	0.0124***
	(0.00868)	(0.0325)	(0.00111)	(0.00414)
log(energy price) x Initial energy cost share of wages	0.0258**	0.0769***	-0.00384**	-0.0121***
	(0.0127)	(0.0186)	(0.00162)	(0.00237)
F excl IV first stage		3073.9		3073.9
N	101903	101903	101903	101903
	Share LS white collar		Share blue collar	
	FE	FE-IV	FE	FE-IV
log(energy price)	0.00396***	-0.00213	-0.00865***	-0.0159***
	(0.00140)	(0.00525)	(0.00163)	(0.00611)
log(energy price) x Initial energy cost share of wages	-0.00294	-0.000778	0.00651***	0.0141***
	(0.00206)	(0.00300)	(0.00239)	(0.00349)
F excl IV first stage		3073.9		3073.9
N	101903	101903	101903	101903

Fixed effect model. Robust standard errors in parenthesis. * p< 0.1, ** p<0.05, *** p<0.01. Additional control variables: year-sector (2-digit NACE rev 2) and year-region (NUTS2) dummies. Excluded IV: log of national energy prices (by fuel) weighted with initial energy mix of the plant. Sample: plants that are observed in EACEI for at least three years.

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Figure: Share of explained SD - Electricity prices

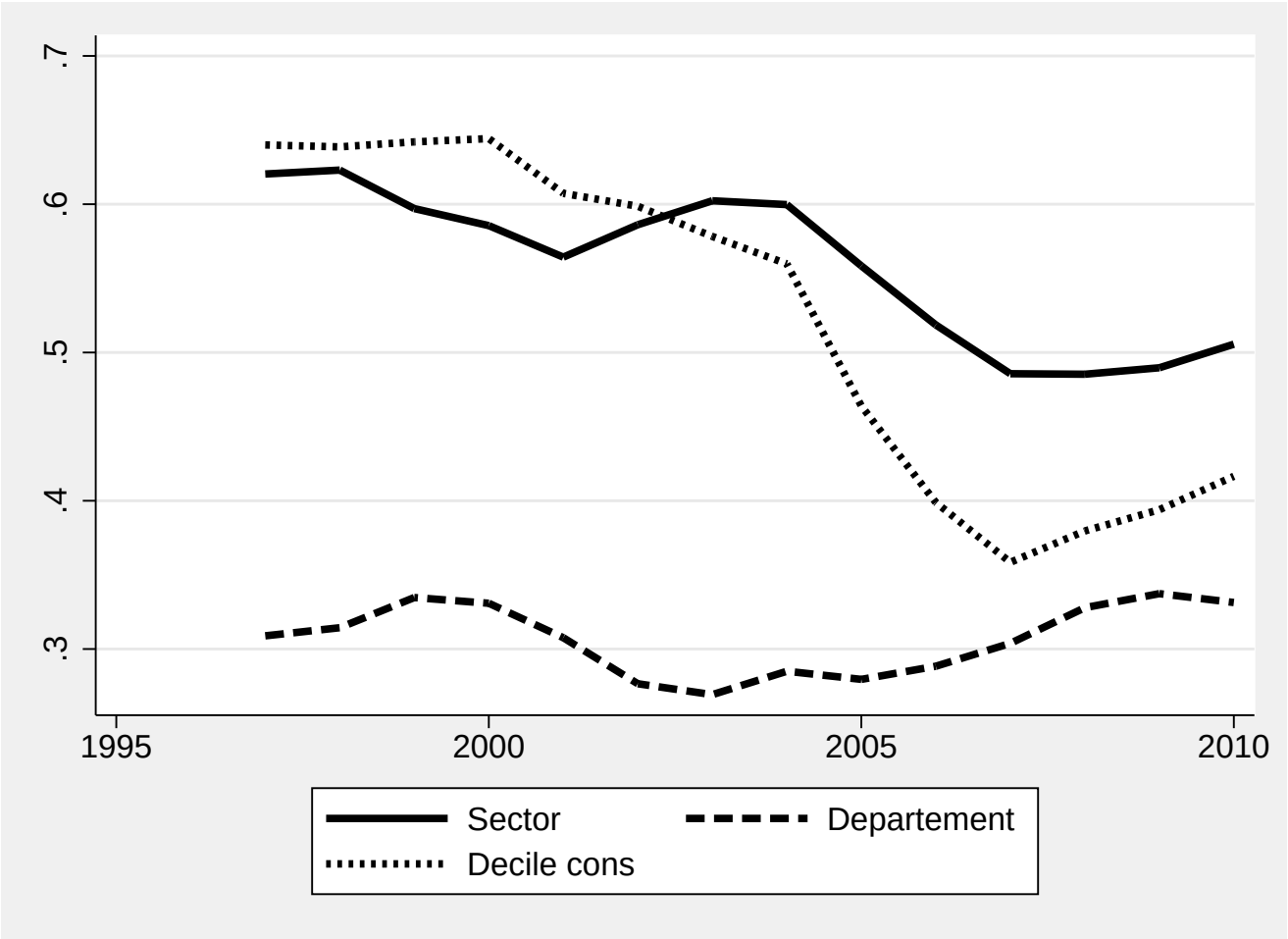
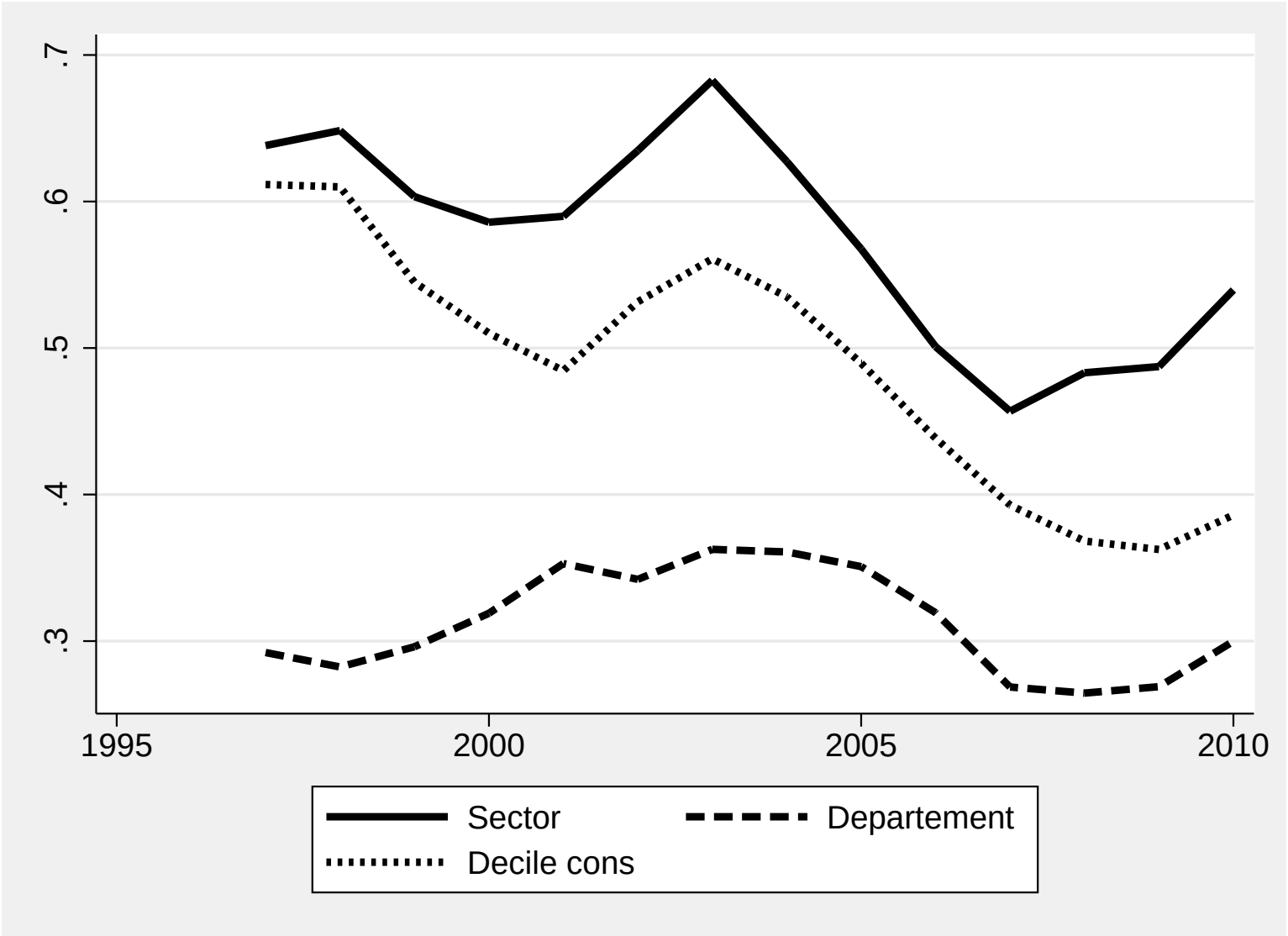


Figure: Share of explained SD - Gas prices



Details about the estimating sample

- **Unbalanced panel** of plants for **1997-2010**
- **Particularly** 'unbalanced' for **small** plants
- Only keep plants that are observed **at least 3 times** over the period 1997-2010 (results are **not sensitive** to different choices)

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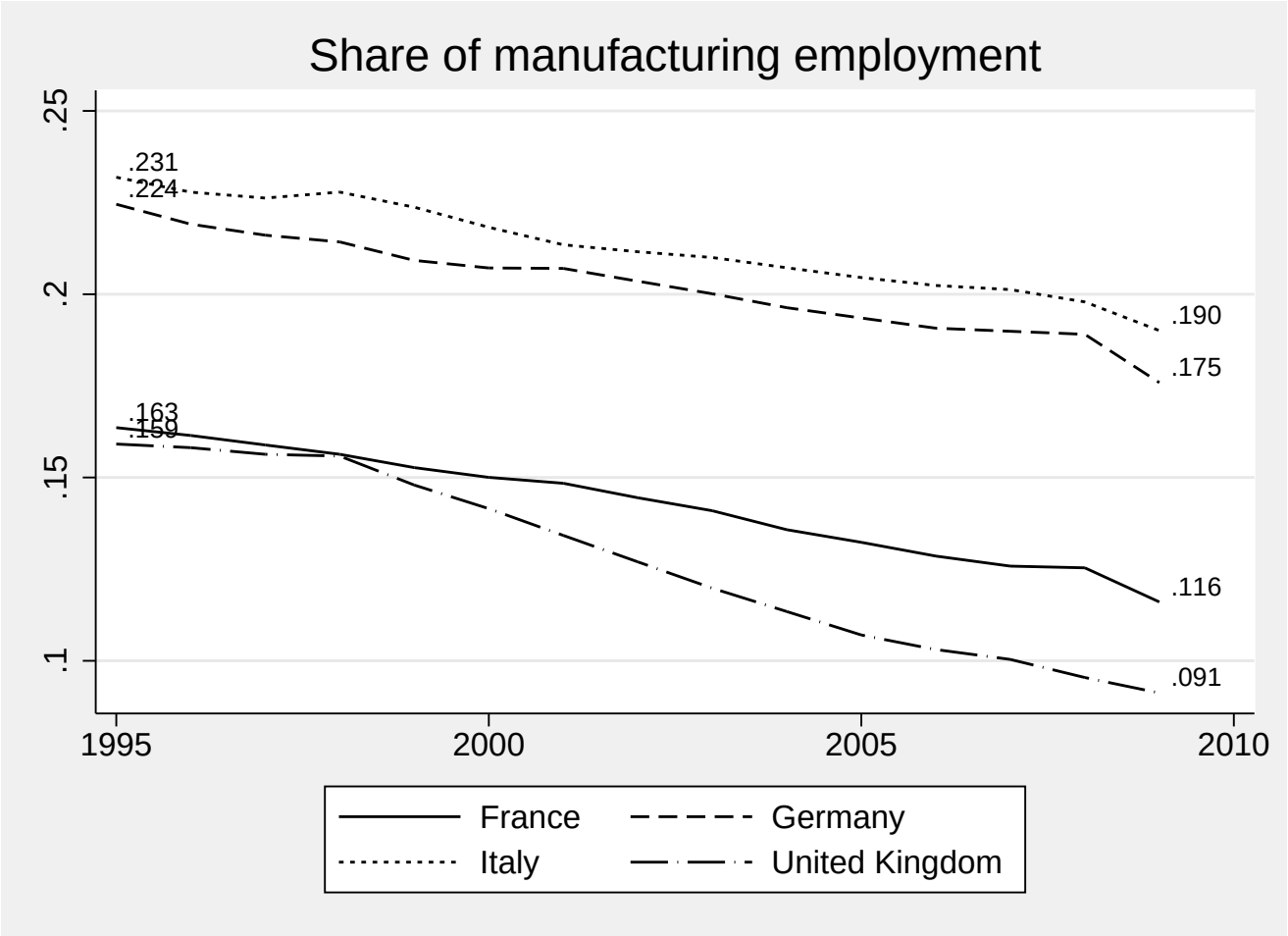
Climate policy vs EU competitiveness?

Figure: Share of employees in manufacturing sectors (source: WIOD)



PCS code (2-digit)	PCS code (1-digit)	Description (in French)
High-skill occupations		
21	20	Chefs d'entreprises artisanales
22	20	Chefs d'entreprises industrielles ou commerciales de moins de 10 salariés
23	20	Chefs d'entreprises industrielles ou commerciales de 10 salariés et plus
31	30	Professionnels de la santé et avocats
33	30	Cadres de la Fonction Publique
34	30	Professeurs, professions scientifiques
35	30	Professions de l'information, des arts et des spectacles
37	30	Cadres administratifs et commerciaux d'entreprises
38	30	Ingénieurs et cadres techniques d'entreprises
Medium-skill (white collars) occupations		
42	40	Instituteurs et assimilés
43	40	Professions intermédiaires de la santé et du travail social
44	40	Clergé, religieux
45	40	Professions intermédiaires administratives de la Fonction Publique
46	40	Professions intermédiaires administratives et commerciales des entreprises
47	40	Techniciens
48	40	Contremaîtres, agents de maîtrise
52	50	Employés civils et agents de service de la Fonction Publique
53	50	Agents de surveillance
54	50	Employés administratifs d'entreprises
55	50	Employés de commerce
56	50	Personnels des services directs aux particuliers
Low-skill (blue collars) occupations		
62	60	Ouvriers qualifiés de type industriel
63	60	Ouvriers qualifiés de type artisanal
64	60	Chauffeurs
65	60	Ouvriers qualifiés de la manutention, du magasinage et du transport
67	60	Ouvriers non qualifiés de type industriel
68	60	Ouvriers non qualifiés de type artisanal
69	60	Ouvriers agricoles