# The causal impact of climate change policy on Business

by Ralf Martin

based on work with Ulrich Wagner (Carlos III) and Laure de Preux (CEP)

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# Background

The challenge:  80% reduction by 2050

But which policies will deliver this?

Economists: Strong price signal is key

[.. .]Setting a price for carbon [..] is politically difficult, and may not in practice be sufficient, or quick enough [.. to create the conditions for environmental innovation] (CEMEP)

"[The] Head of Environmental Affairs at the CBI, told UK Environment News that the proposed climate change levy poses a serious threat to British competitiveness."

So what does climate change policy do to firms?

# Strategy in this study

- Look at past policies
  - UK Climate Change Levy
  - First firm level evaluation
  - Good for causal identification

# Focus

- Effect on energy consumption?
- Effect on employment?
- Can price instruments trigger an innovation response?

# Summary of Results

The CCL has

- significantly reduced energy consumption and thereby GHG emissions
- not had a negative effect on employment or productivity
- had a positive effect on innovation (patenting)

## Structure

- The CCL
- Identification Strategy
- Data
- Regressions results
- Discussion & Conclusion

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# The CCL

- Tax on energy consumption for business
- **Introduced in 2001**

Table 1: Taxation of energy and implicit carbon by fuel type

| fuel type | tax rate $[\frac{\text{pence}}{\text{kWh}}]$ | fuel price | implicit carbon tax $[\frac{£}{\text{tC}}]$ |
|---|---|---|---|
| electricity | 0.43 | 4.25 | 31 |
| coal | 0.15 | 2.46 | 16 |
| gas | 0.15 | 0.91 | 30 |
| LPG | 0.07 | 0.85 | 22 |

On Average: 15% tax rate

£20 per tonne of carbon

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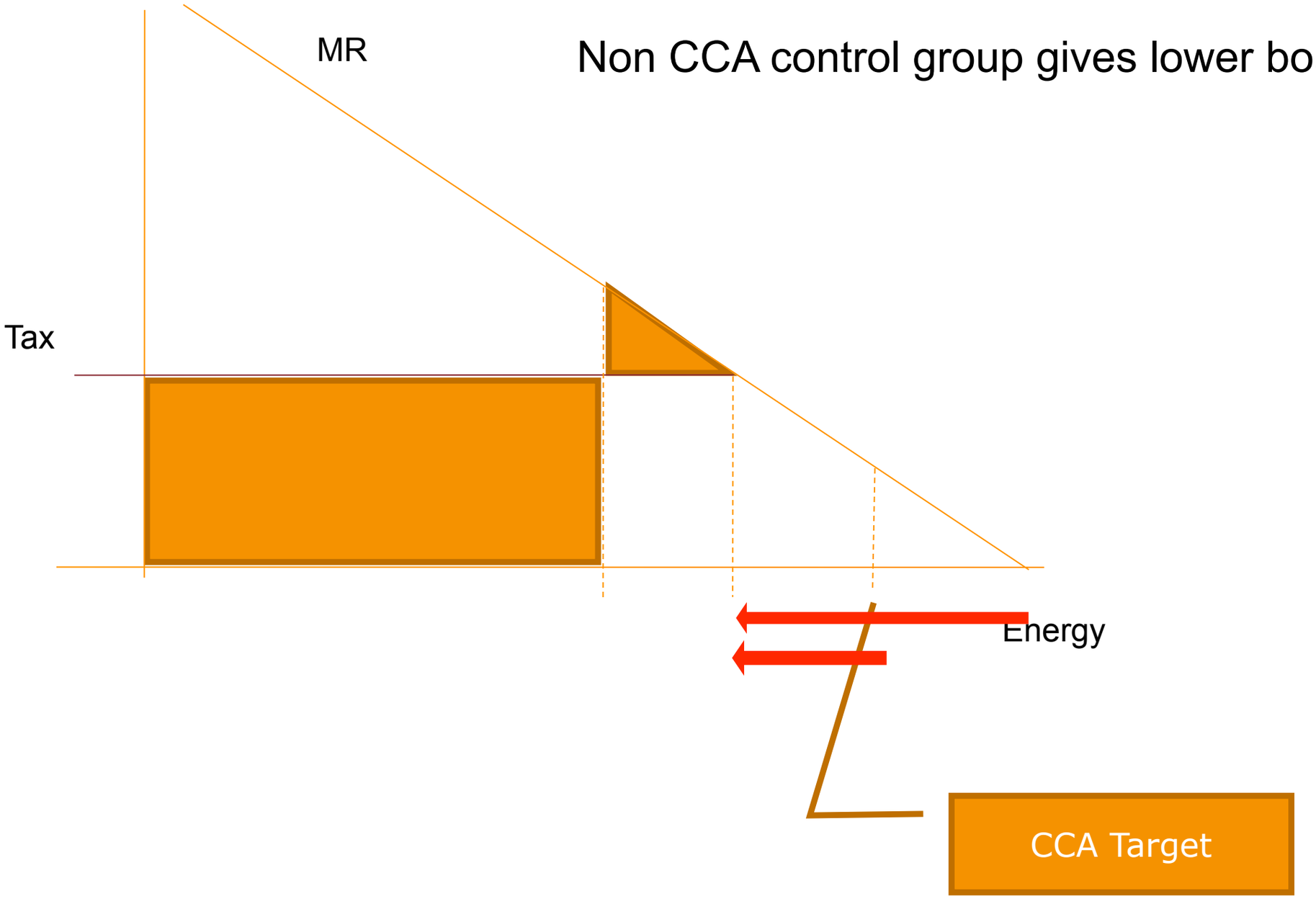
# Identification of CCL effect

- Some firms were exempt from CCL.
- Climate Change Agreements (CCA): 80% CCL reduction in exchange for compliance with energy (efficiency) target set by government
- About 6000 CCAs

# Climate Change Agreements (CCAs)

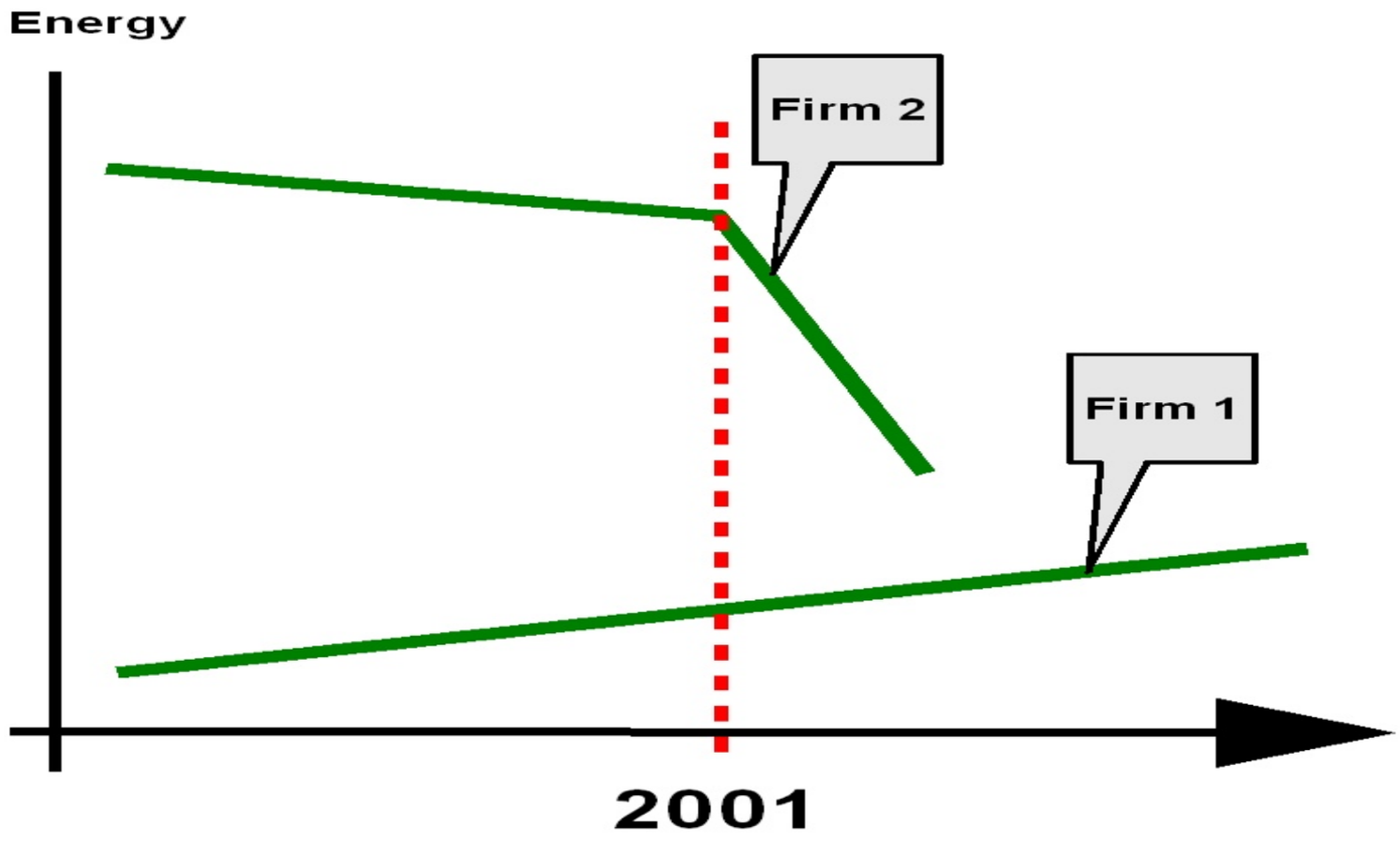
## Issue 1 – CCA Targets




Non CCA control group gives lower bound

# Climate Change Agreements (CCAs)

## Issue 2 – Selection into CCA Targets




$$\Delta y_{it} = \alpha \Delta CCA_{it} + x'_{it}\beta + \xi_t + \eta_i + \varepsilon_{it}.$$

Rather than CCA, look at IPPC firms

Assumption: Post 2001 shocks to IPPC firms don't determine IPPC coverage

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# Data

**Production data and energy expenditure**

Annual Respondents Database (ARD) from ONS
≈10.000 firms for 1999-2004

**Energy consumption data** (kWh, tonnes etc.)

Quarterly Fuels Inquiry (ARD) from ONS
≈1.000 firms for 1997-2004

**CCA participation data**; ≈5.000 agreements

Online from DEFRA & HMRC Webpages

**PPC coverage**

via European Pollution and Emissions Register (EPER)
Online available

**Patent data:**

European Patent Office (EPO) database
≈60,000 patents in 10,000 UK firms

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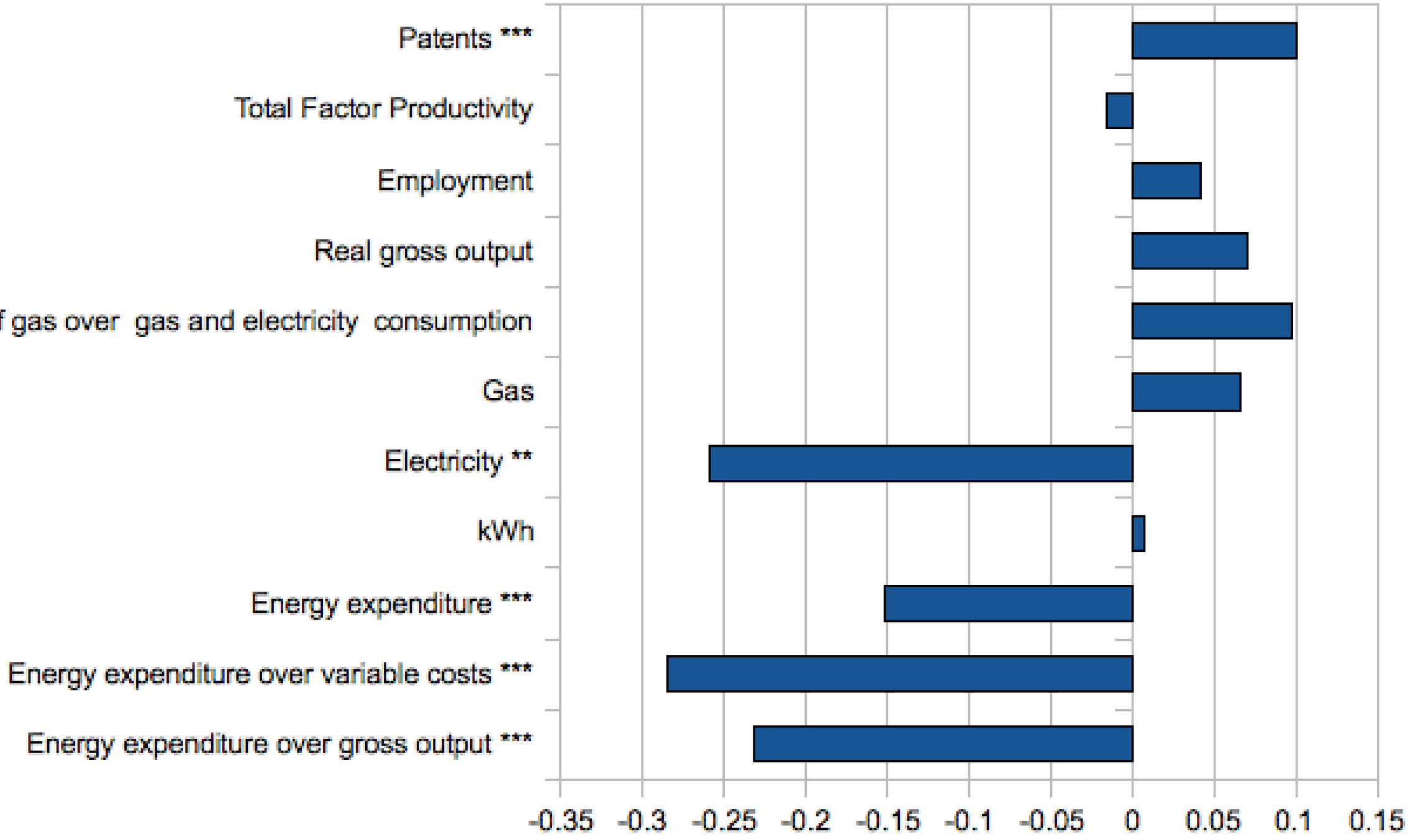
# Descriptive Stats for 2000

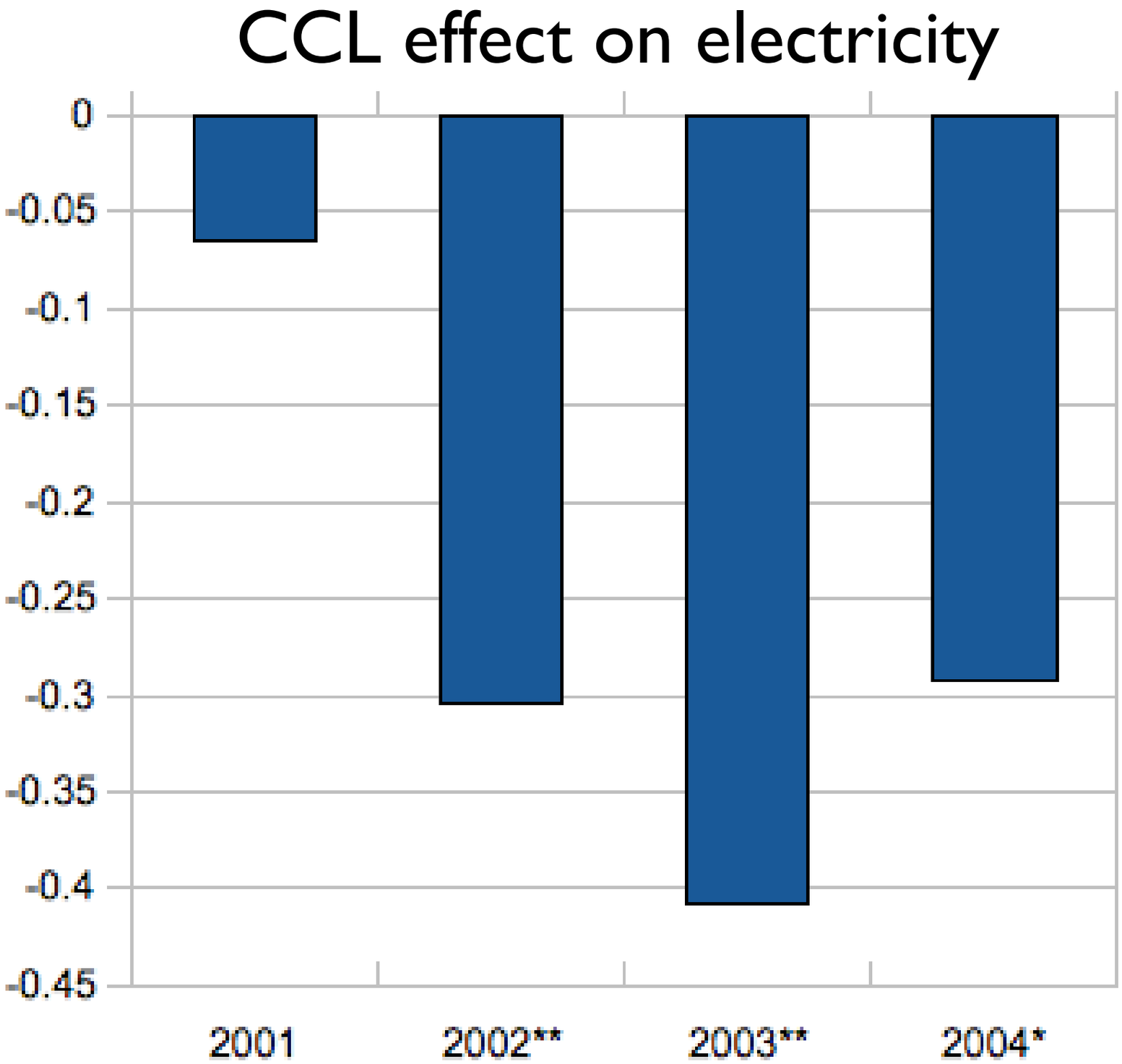
| **Data set** | | **ARD** | |
|---|---|---|---|
| **Variables** | **CCA=0** | **CCA=1** | **diff test** |
| **Age** | 13.55 | 17.53 | *** |
| **Employment** (L) | 151.49 | 536.44 | *** |
| **Gross Output** (GO) | 19.08 | 86.08 | *** |
| **Energy Expenditures** (EE) | 0.22 | 1.95 | *** |
| **Variable Costs** (Vcost) | 15.99 | 75.14 | *** |
| **Capital Stock** (K) | 9.64 | 58.17 | *** |
| **Number of Plants** | 8,282 | 1,050 | |

# Graphical Summary of regression results




Values indicate **CCL** effect

# Results: Time profile



# Aggregate CCL impact

$\Lambda(el)$=-0.258 x 0.65=-16.8%

Impact on "Treated"

Share of "Treated" in electricity consumption

Implied energy price elasticity: 1.7

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# Summary

- CCL covered firms reduce energy consumption by significantly more
- CCL firms patent significantly more
- CCL firms do not perform worse r in terms of employment or productivity
- Climate Change Levy gives covered firms incentive to reduce energy consumption and innovate.
- CCL had no negative effect on employment

# Implications

- Moderate unilateral energy/carbon taxes can have a strong effect on energy usage and emissions without harming the economy
- What's the point if nobody else does it? Innovations!
- Highlights difficulty for governments of negotiating targets with industry
- Should we have taxes/carbon prices now in the recession? Use revenue to cut wage taxes.
- For the UK: scrap CCAs there is no negative employment effect

# Future work

- Examine things by sector
- Variations in target stringency
- Similar work for EUETS

# Thank u

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# Extra Slides

# Regression results: Energy

| DepVar | ExpVar | OLS | Reduced Form (OLS) | IV | Fixed Effects | Reduced Form (FE) | Fixed Effects IV | Obs./ Plants |
|---|---|---|---|---|---|---|---|---|
| **Energy exp. over gross output** | CCA/EPER | 0.026** | 0.086*** | 0.220*** | 0.025 | 0.111*** | 0.231*** | 14,336 |
| Δln(EE/GO) | | (0.013) | (0.028) | (0.072) | (0.019) | (0.040) | (0.084) | 4,209 |
| **Energy exp. over variable costs** | CCA/EPER | 0.026** | 0.104*** | 0.266*** | 0.015 | 0.137*** | 0.285*** | 14,336 |
| Δln(EE/VCost) | | (0.012) | (0.026) | (0.069) | (0.018) | (0.037) | (0.080) | 4,209 |
| **Energy exp.** | CCA/EPER | 0.019 | 0.033 | 0.085 | 0.036** | 0.075** | 0.156** | 14,336 |
| Δln(EE) | | (0.012) | (0.024) | (0.061) | (0.017) | (0.029) | (0.061) | 4,209 |
| **Total kWh** | CCA/EPER | 0.068** | -0.000 | -0.001 | 0.079** | -0.004 | -0.007 | 4,452 |
| Δln(kWh) | | (0.027) | (0.049) | (0.115) | (0.035) | (0.068) | (0.135) | 928 |
| **Electricity** | CCA/EPER | 0.026 | 0.085* | 0.206* | 0.028 | 0.128** | 0.258** | 4,452 |
| Δln(El) | | (0.021) | (0.046) | (0.118) | (0.024) | (0.058) | (0.127) | 926 |
| **Gas** | CCA/EPER | 0.016 | 0.014 | 0.036 | 0.012 | -0.035 | -0.066 | 3,602 |
| Δln(Gas) | | (0.037) | (0.052) | (0.127) | (0.047) | (0.080) | (0.151) | 764 |
| **Share of gas over gas & elec. cons.** | CCA/EPER | 0.018** | -0.044 | -0.107 | 0.022** | -0.048 | -0.097 | 4,435 |
| Δ(Gas/(Gas+El)) | | (0.008) | (0.031) | (0.078) | (0.009) | (0.039) | (0.084) | 926 |

# Other robustness tests

- Common support
- Singletons
- Should do: exit, for different types of industries/kinds of firms

# First stage regressions

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| **Dep.Variable** | | | | | **CCA par** |
| **Sample** | | | **ARD sample** | | |
| **Time period** | **2001** | **2001** | **2000-2004** | **2000-2004** | **2001** |
| **Method** | **OLS** | **Probit** | **OLS** | **FE** | **Probit** |
| **EPER** | 0.411*** | 0.383*** | 0.391*** | 0.480*** | |
| | (0.030) | (0.044) | (0.033) | (0.040) | |
| **lnGO(t-1)** | | | | | -0.014*** |
| | | | | | (0.004) |
| **lnK(t-1)** | | | | | 0.016*** |
| | | | | | (0.003) |
| **lnEE(t-1)** | | | | | 0.020*** |
| | | | | | (0.003) |
| **lnL(t-1)** | | | | | 0.011*** |
| | | | | | (0.003) |
| **age controls** | yes | yes | yes | yes | yes |
| **sector controls** | yes | yes | yes | no | yes |
| **region X year controls** | yes | yes | yes | yes | yes |
| **plant fixed effects** | no | no | no | yes | no |
| **obs** | 9175 | 8506 | 17040 | 17040 | 8456 |

Notes: Probit results report the marginal effects on the probability of being in a CCA. Standard error

# Regression results for patents

| | Model | (1) Logit | (2) Poisson | (3) Clogit | (4) FE Poisson | (5) FE | Observation |
|---|---|---|---|---|---|---|---|
| **Patent type** | **Policy Variable** | **I(Patent)** | **Patent Count** | **I(Patent)** | **Patent Count** | **Share in total Patents** | **firms** |
| **All patents** | CCA | 0.069*** | 1.382*** | -0.109*** | -0.510** | | 134320 |
| | | (0.017) | (0.295) | (0.035) | (0.243) | | 8395 |
| | EPER | 0.055*** | 1.326*** | -0.161*** | -0.585*** | | |
| | | (0.021) | (0.376) | (0.048) | (0.186) | | |
| **CCR Patents All** | CCA | 0.024 | 0.506** | -0.135 | -0.531 | -0.004 | 8832 |
| | | (0.024) | (0.228) | (0.087) | (0.388) | (0.009) | 552 |
| | EPER | 0.033 | 0.474 | -0.140* | -0.432 | 0.032 | |
| | | (0.029) | (0.317) | (0.082) | (0.359) | (0.021) | |
| **CCR Patents Popp** | CCA | 0.021 | 0.491* | -0.138 | -0.513 | -0.009 | 8576 |
| | | (0.024) | (0.269) | (0.088) | (0.371) | (0.008) | 536 |
| | EPER | 0.026 | 0.436 | -0.172** | -0.528** | 0.016 | |
| | | (0.029) | (0.304) | (0.076) | (0.221) | (0.015) | |
| **Non Popp Patents** | CCA | 0.070*** | 1.375*** | -0.106*** | -0.510** | 0.021 | 134224 |
| | | (0.017) | (0.236) | (0.035) | (0.220) | (0.019) | 8389 |
| | EPER | 0.056*** | 1.328*** | -0.167*** | -0.586** | -0.012 | |
| | | (0.022) | (0.375) | (0.048) | (0.277) | (0.025) | |

# Time profile for patent impact

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| **Model** | **Logit** | **Poisson** | **Clogit** | **FE Poisson** |
| **Policy Variable** | **I(Patent)** | **Patents** | **I(Patent)** | **Patents** |
| EPERX1998 | 0.194*** | 1.915*** | 0.076 | -0.022 |
| | (0.040) | (0.259) | (0.048) | (0.159) |
| EPERX1999 | 0.145*** | 1.932*** | 0.010 | -0.005 |
| | (0.037) | (0.275) | (0.058) | (0.186) |
| EPERX2000 | 0.113*** | 1.756*** | -0.034 | -0.181 |
| | (0.035) | (0.314) | (0.059) | (0.235) |
| EPERX2001 | 0.083*** | 1.540*** | -0.086 | -0.397 |
| | (0.032) | (0.342) | (0.065) | (0.293) |
| EPERX2002 | 0.036 | 1.063*** | -0.207*** | -0.874** |
| | (0.029) | (0.384) | (0.072) | (0.350) |
| EPERX2003 | 0.052* | 1.471*** | -0.150** | -0.465 |
| | (0.029) | (0.421) | (0.073) | (0.307) |
| EPERX2004 | 0.056* | 1.180*** | -0.161** | -0.757** |
| | (0.031) | (0.367) | (0.077) | (0.361) |
| EPERX2005 | 0.049 | 1.241*** | -0.182** | -0.696** |
| | (0.031) | (0.352) | (0.083) | (0.312) |

# Econometric model

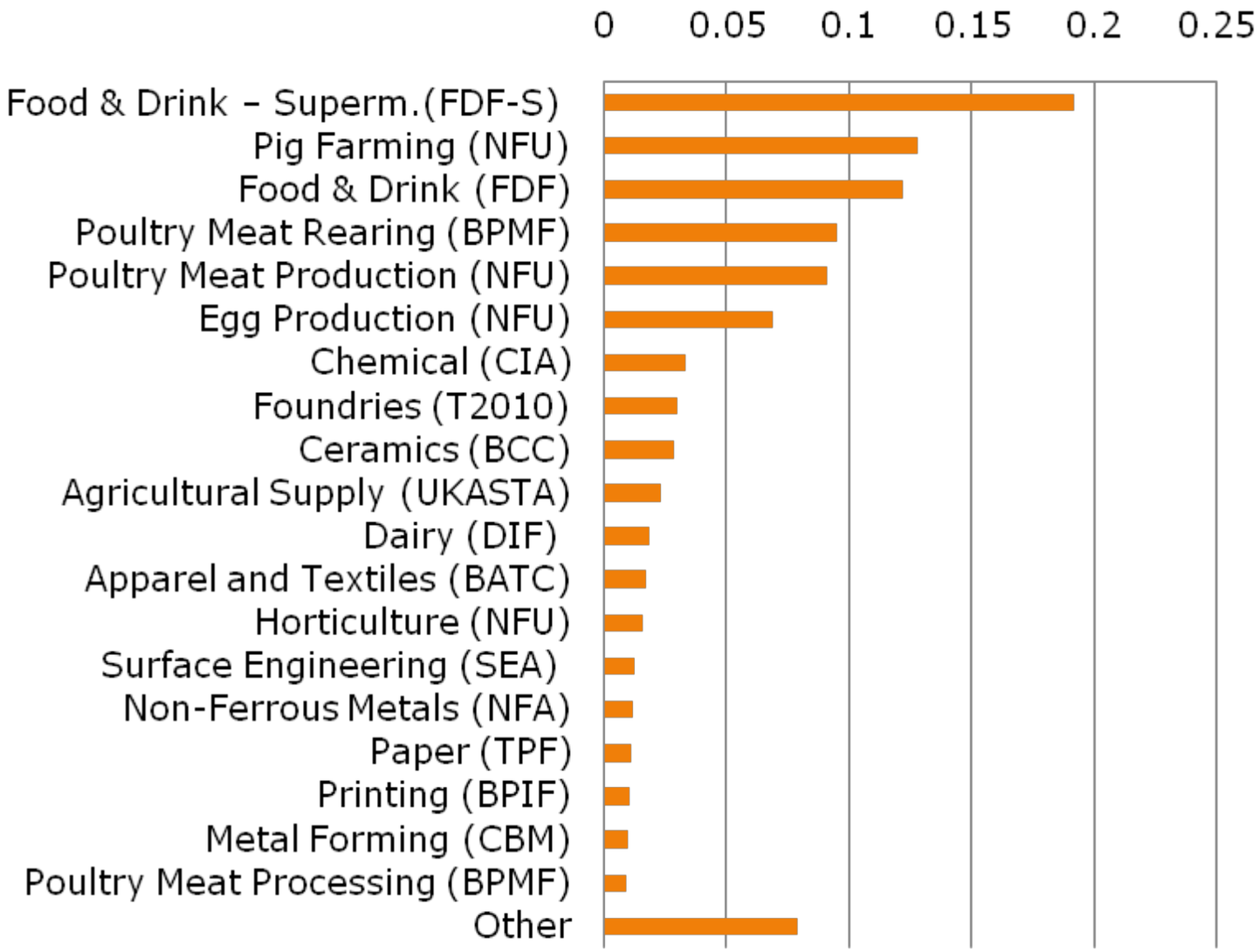
Basic equation: $$\Delta y_{it} = \alpha \Delta CCA_{it} + x'_{it}\beta + \xi_t + \eta_i + \varepsilon_{it}.$$

First stage IV: $$\Delta CCA_{it} = \tilde{\alpha} \Delta EPER_{it} + x'_{it}\tilde{\beta} + \tilde{\eta}_i + \tilde{\varepsilon}_{it}$$

Second stage IV: $$\Delta y_{it} = \alpha \Delta \widehat{CCA}_{it} + x'_{it}\beta + \eta_i + \varepsilon_{it}$$

Reduced form: $$\Delta y_{it} = \alpha \Delta EPER_{it} + x'_{it}\beta + \eta_i + \varepsilon_{it}$$

# CCAs across Umbrella Agreements




Total number of aggreements: 7904

# Data (cont.)

| Technology type | US Sub Class | IPC Sub Class | IPC Group | US Class |
|---|---|---|---|---|
| Heat Exchange | 165 | 4 - 5 | F23L | 15/02/09 |

Overall: 1100 CCR patents in 650 firms

# Data (cont.)

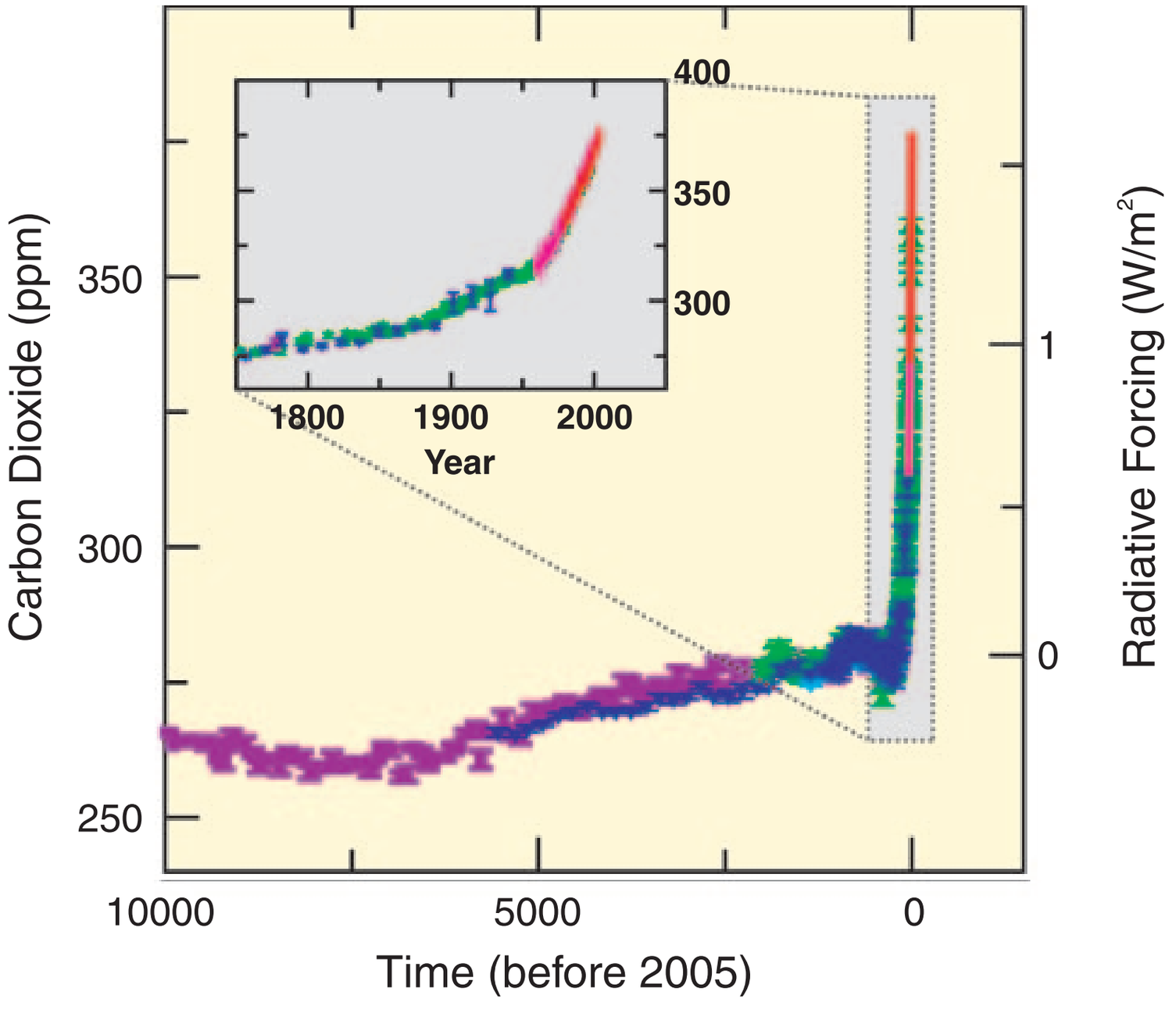
- **Patent data:**
  European Patent Office (EPO) database
  ≈60,000 patents in 10,000 UK firms

- **Climate Change related (CCR) patents:**
  - Abstract searches: “Energy efficiency”
  - Patent Classes; e.g.

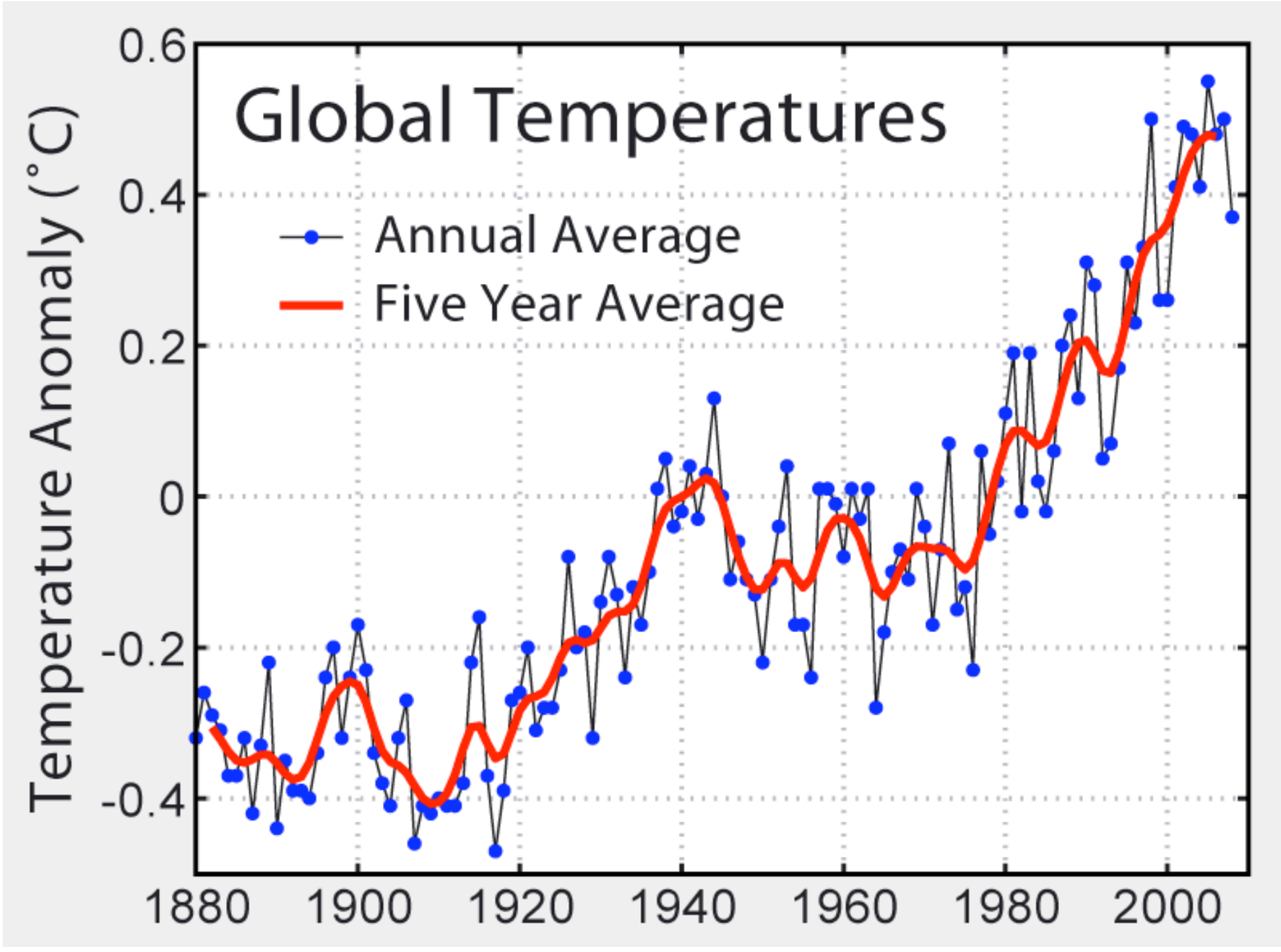
| Technology type | US Sub Class | IPC Sub Class | IPC Group | US Class |
|---|---|---|---|---|
| Heat Exchange | 165 | 4 - 5 | F23L | 15/02/09 |

Overall: 1100 CCR patents in 650 firms

# Historical CO2 concentration



# Temperature record



# Econometric Strategy for patent data

2 types of model

CCA Participation

Binary (clogit): $$\mathbf{Pr}\{\mathbb{I}(Patents_{it} > 0) = 1\} = f\left(\beta_D D_{it} + \mathrm{x}'_{\mathrm{it}}\beta_X + \alpha_i\right)$$

Count data (Poisson): $$\mathbb{E}\left[Patents_{it}\right] = \exp\left(\beta_D D_{it} + \mathbf{X_{it}}\beta_X\right)\exp(\alpha_i)$$

**Controlling for selection**

1. Fixed effects
2. Instrumenting CCA participation with CAA eligibility: Firms covered by PPC regulation (EPER)

# Descriptive stats: Patents

| Patents type | Sample | mean | firms | patents | p25 | p75 | p90 |
|---|---|---|---|---|---|---|---|
| All | non CCA | 5.92 | 9816 | 58111 | 1 | 3 | 7 |
| | CCA | 31.11 *** | 269 | 8368 | 1 | 10 | 45 |
| | non EPER | 5.37 | 9931 | 53288 | 1 | 3 | 7 |
| | EPER | 85.66 *** | 154 | 13191 | 1 | 9 | 73 |
| | *Totals* | | 10085 | 66479 | | | |
| CCR | non CCA | 1.72 | 612 | 1051 | 1 | 1 | 2 |
| | CCA | 3.54 ** | 41 | 145 | 1 | 4 | 8 |
| | non EPER | 1.56 | 623 | 972 | 1 | 1 | 2 |
| | EPER | 7.47 *** | 30 | 224 | 1 | 4 | 17 |
| | *Totals* | | 653 | 1196 | | | |

Notes: The table reports descriptive statistics on the total number of patent applications that are filed by the firms in our UK sample for the period 1980 to 2005. It distinguishes by patent type as well as by which environmental policy a firm holding the patent was subject to.

# Relation to previous studies

- Agnolucci et al: no CCL announcement effect in manufacturing, announcement effect in services.

  *We find manufacturing effect*

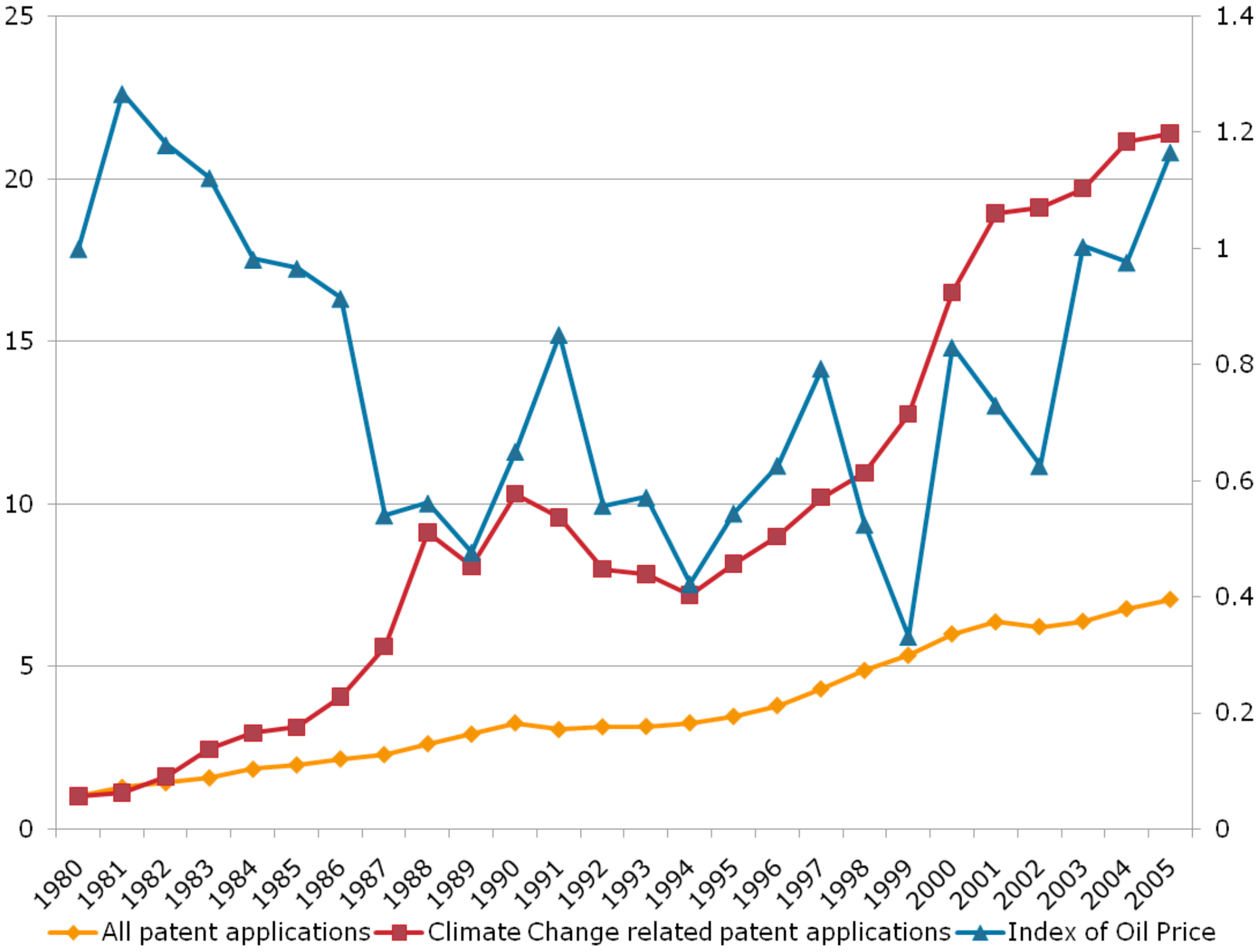
- Ekins & Etheridge, Barker et al.: yes, targets were easily achieved, but there was still a big CCA effect. (based on long run trends)

  *Maybe, but CCL effect was even stronger*

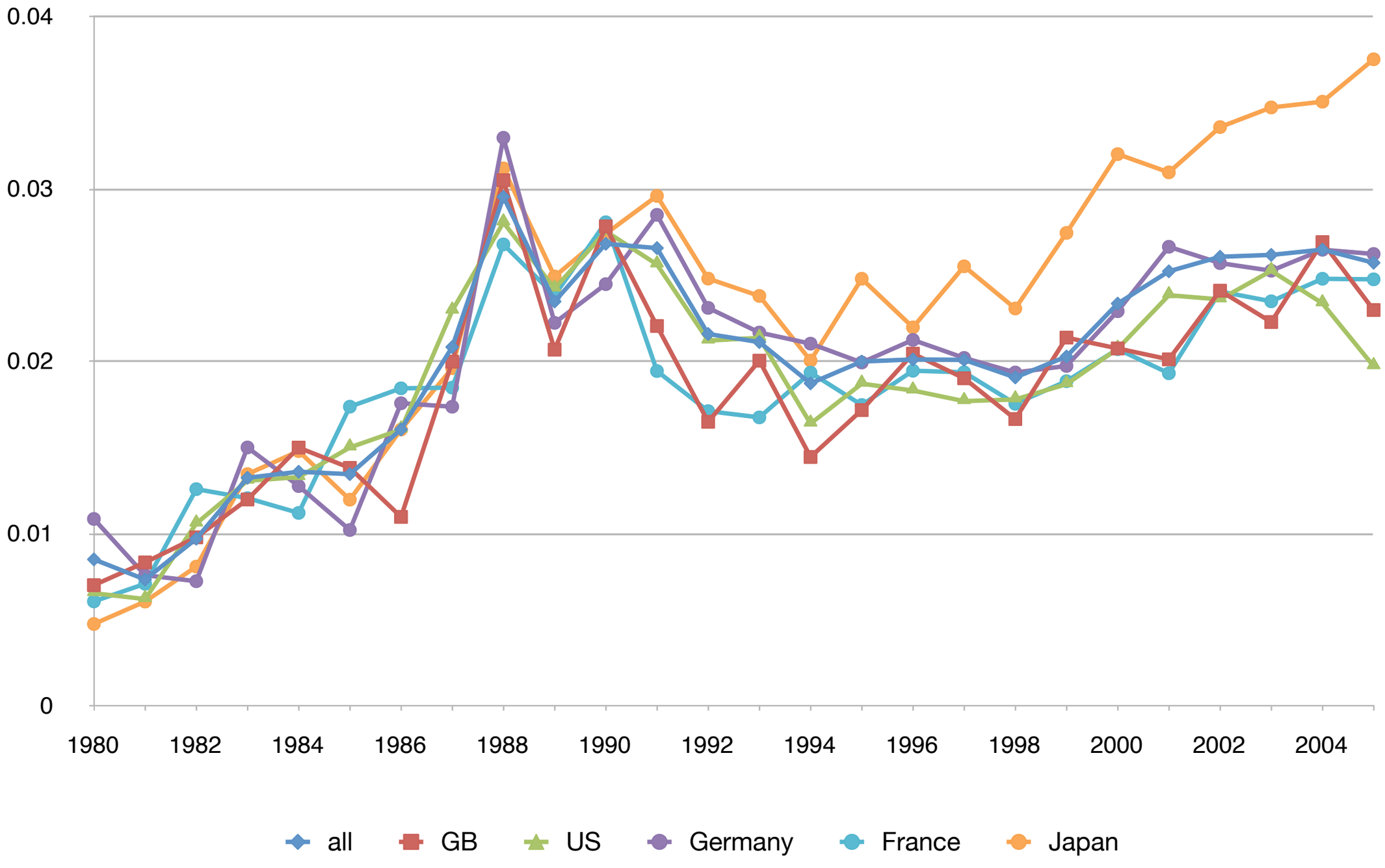
- Implied energy price elasticities are high compared to others: 1 to 2.5

  Roy et al.: 0.8-1.25

# EPO CCR Patents



# CCR Patent Share across countries



# Robustness: Placebo Regressions

- Restricting to pre 2001 sample
- Pretend CCL was introduced in 1995

| | | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|---|
| | Model | Logit | Poisson | Clogit | FE Poisson | Observations/ |
| Patent type | Policy Variable | I(Patent) | Patent Count | I(Patent) | Patent Count | firms |
| All patents | Placebo CCA | 0.129*** | 1.682*** | 0.019 | -0.045 | 61622 |
| | | (0.021) | (0.172) | (0.040) | (0.336) | 5602 |
| | Placebo EPER | 0.155*** | 1.746*** | 0.081 | 0.086 | |
| | | (0.030) | (0.319) | (0.052) | (0.184) | |

# Climate Change Agreements (CCAs)

## Issue 2 – Self Selection

- CCA participation voluntary
- Higher incentives for
  - Energy intensive firms
  - Firms that reduce energy consumption anyways
- To control:
  - Allow for fixed differences in levels and trends of firms
  - Instrument based on eligibility: Coverage by PPC.
  - Key assumption: Firms are not selecting into PPC because of post 2001 shock to outcome variables

- Michael Roberts, the CBI's director of business environment, said: "Many companies will find these costs hard to take when manufacturing is under so much pressure and there are fears of a slowdown in the global economy." (http://www.independent.co.uk/news/business/news/climate-change-levy-to-cost-business-pound100m-engineering-industry-claims-702144.html)