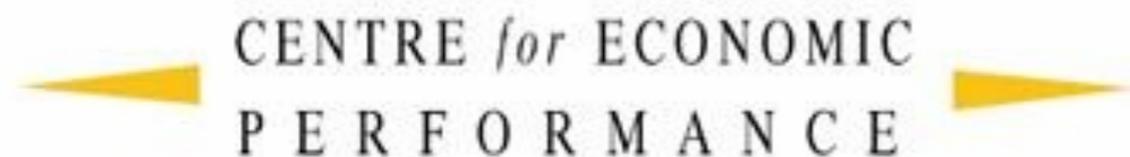


# The causal impact of climate change policy on Business

by Ralf Martin

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

Seminar at Breugel, 28 September 2009



Anglo-German Foundation  
Deutsch-Britische Stiftung



# Background

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The challenge: 80% GHG reduction by 2050

But which policies will deliver this?

Economists: Strong price signal is key

But does it work in practice and how much?

And what about competitiveness?

# Strategy in this study

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

# Summary of Results

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- had a positive effect on innovation (patenting)

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- 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 [ $\frac{\text{£}}{\text{tC}}$ ]
electricity	0.43	4.25	31
coal	0.15	2.46	16
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LPG	0.07	0.85	22

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**On Average:** 15% tax rate  
£20 per tonne of carbon

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- About 6000 CCAs

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2 issues

- Targets

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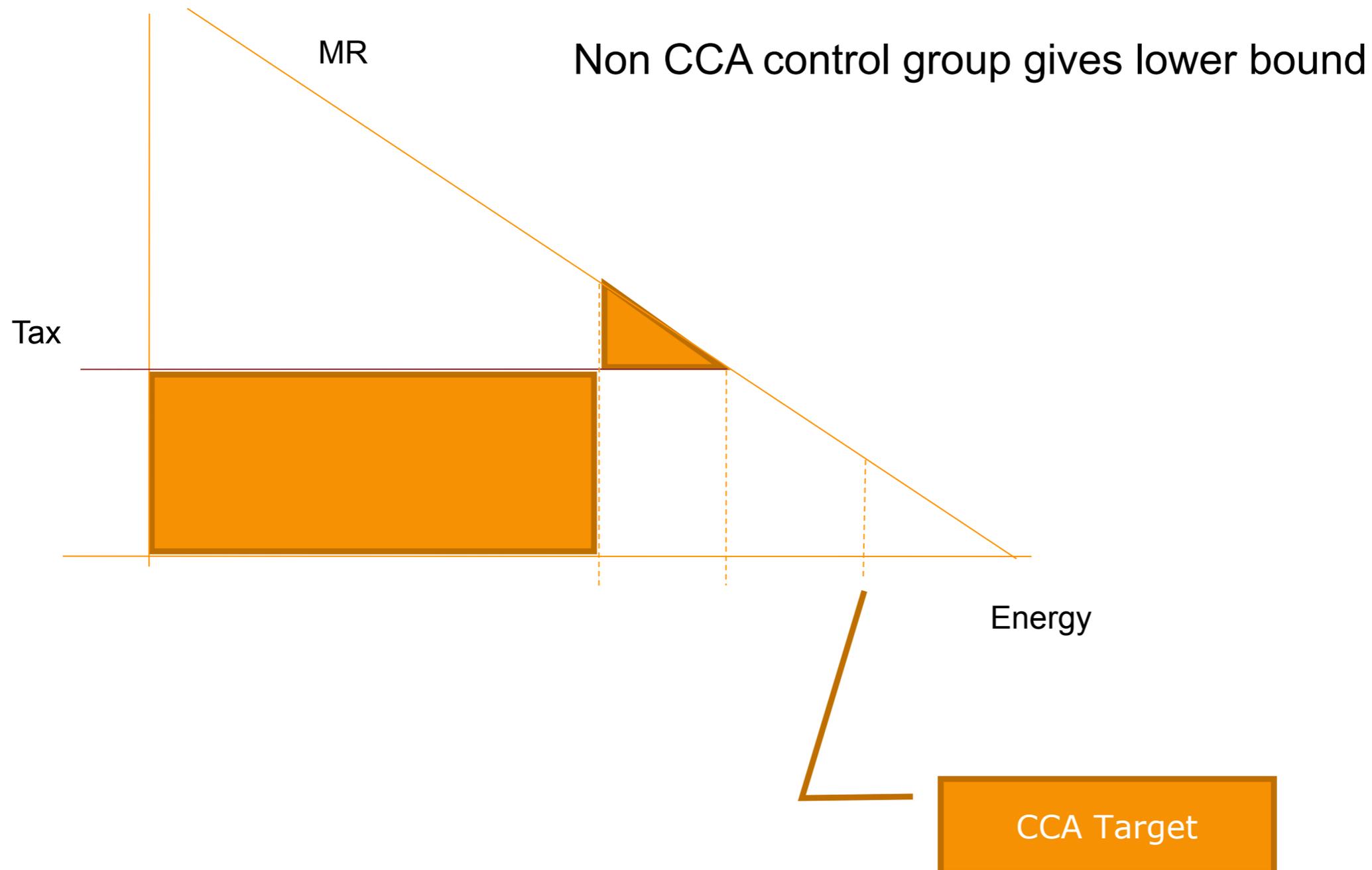
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2 issues

- Targets
- Selection

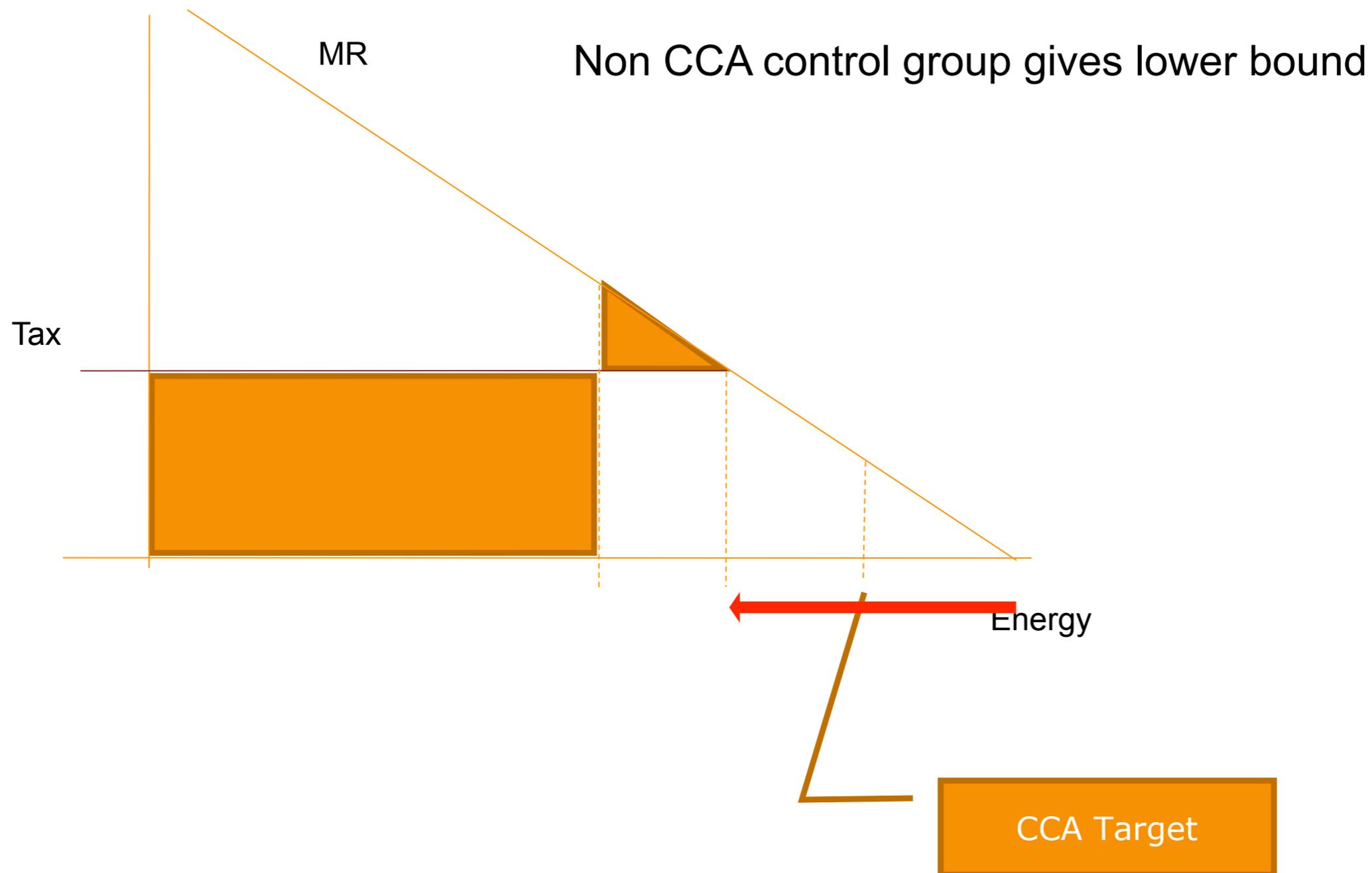
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## Issue 1 – CCA Targets



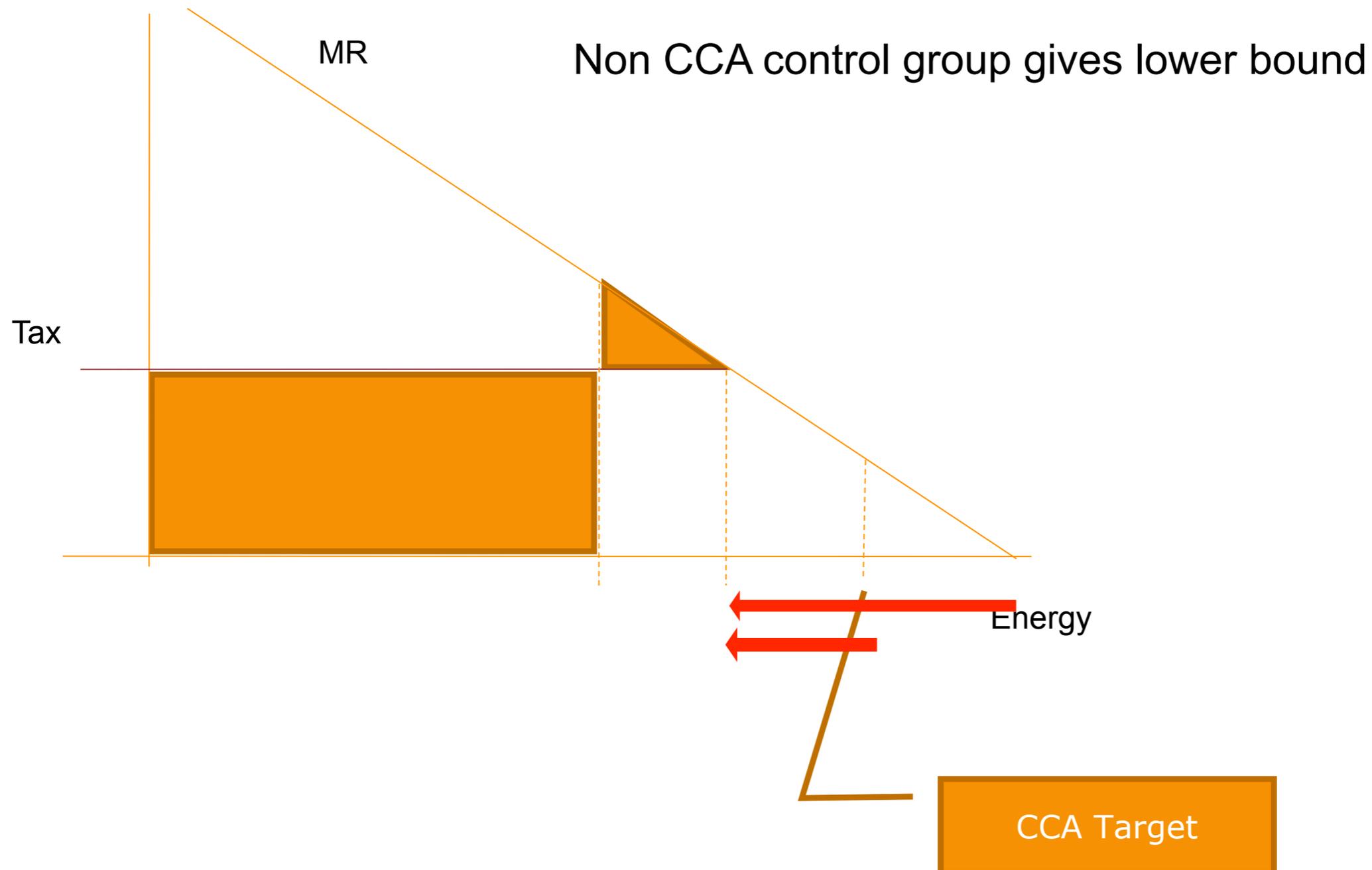
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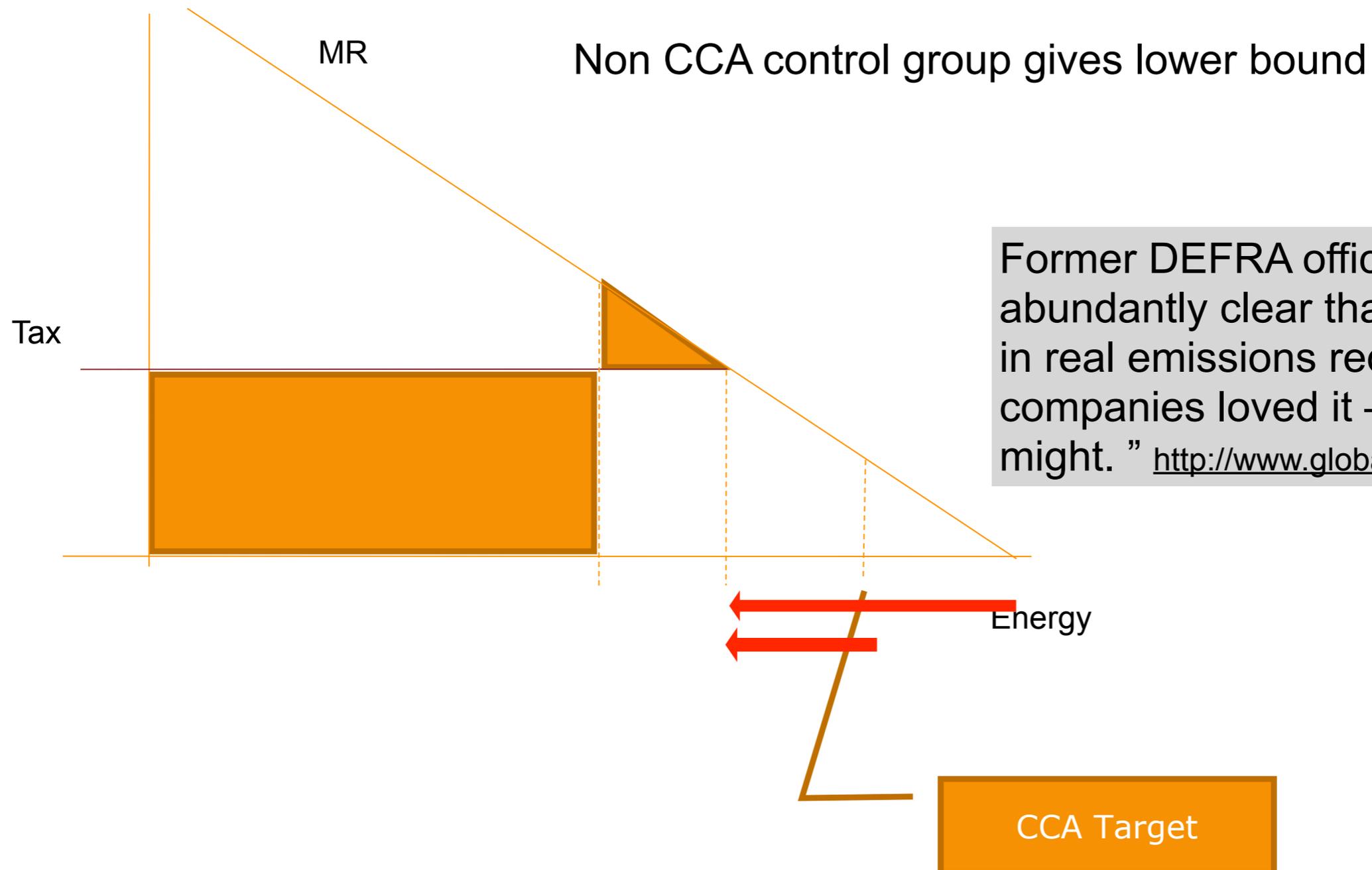
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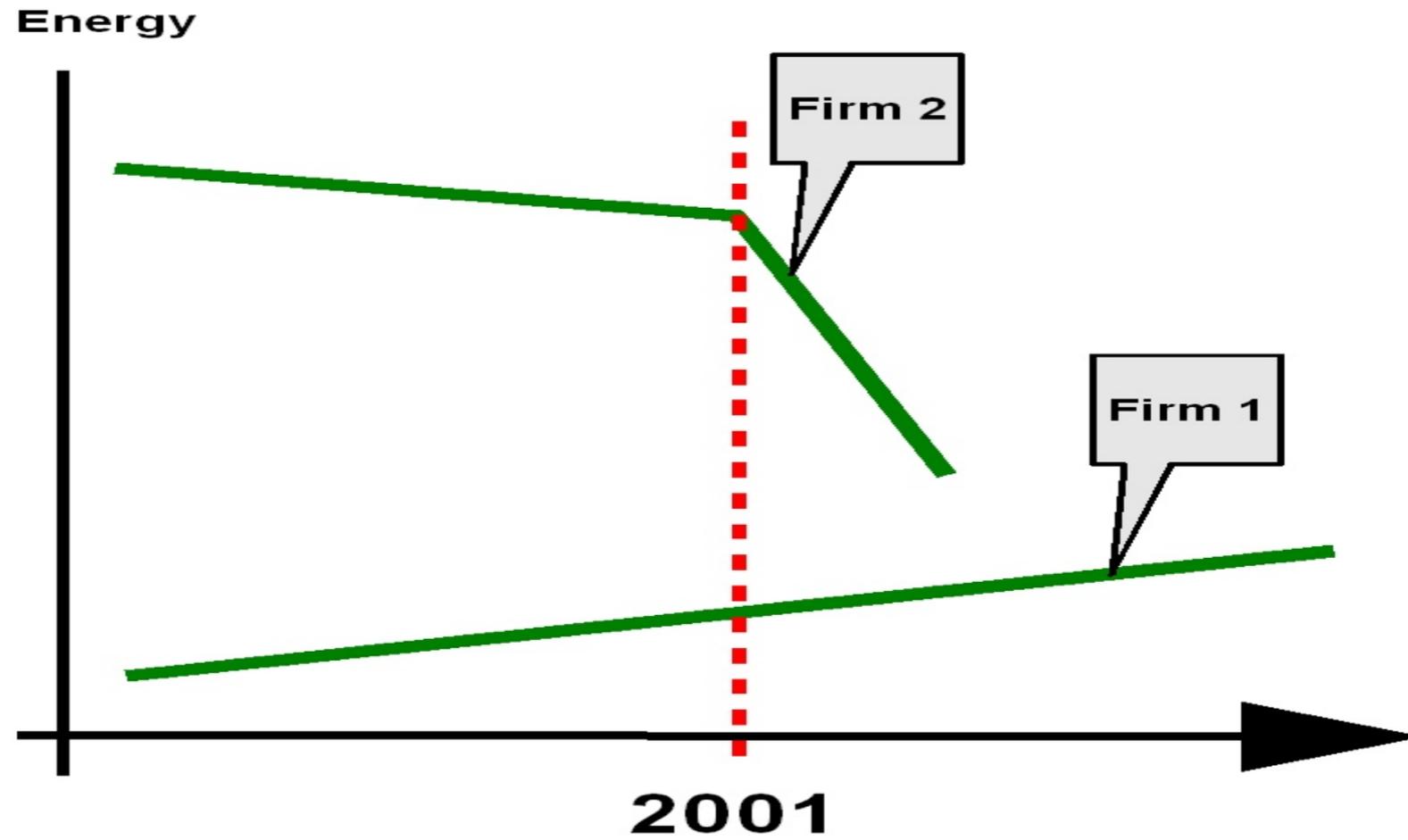
Former DEFRA official: “It was abundantly clear that it wouldn’t result in real emissions reductions. But companies loved it – as well they might.” <http://www.globaldashboard.org/>

# Climate Change Agreements (CCAs)

Issue 2 – Selection into CCA Targets

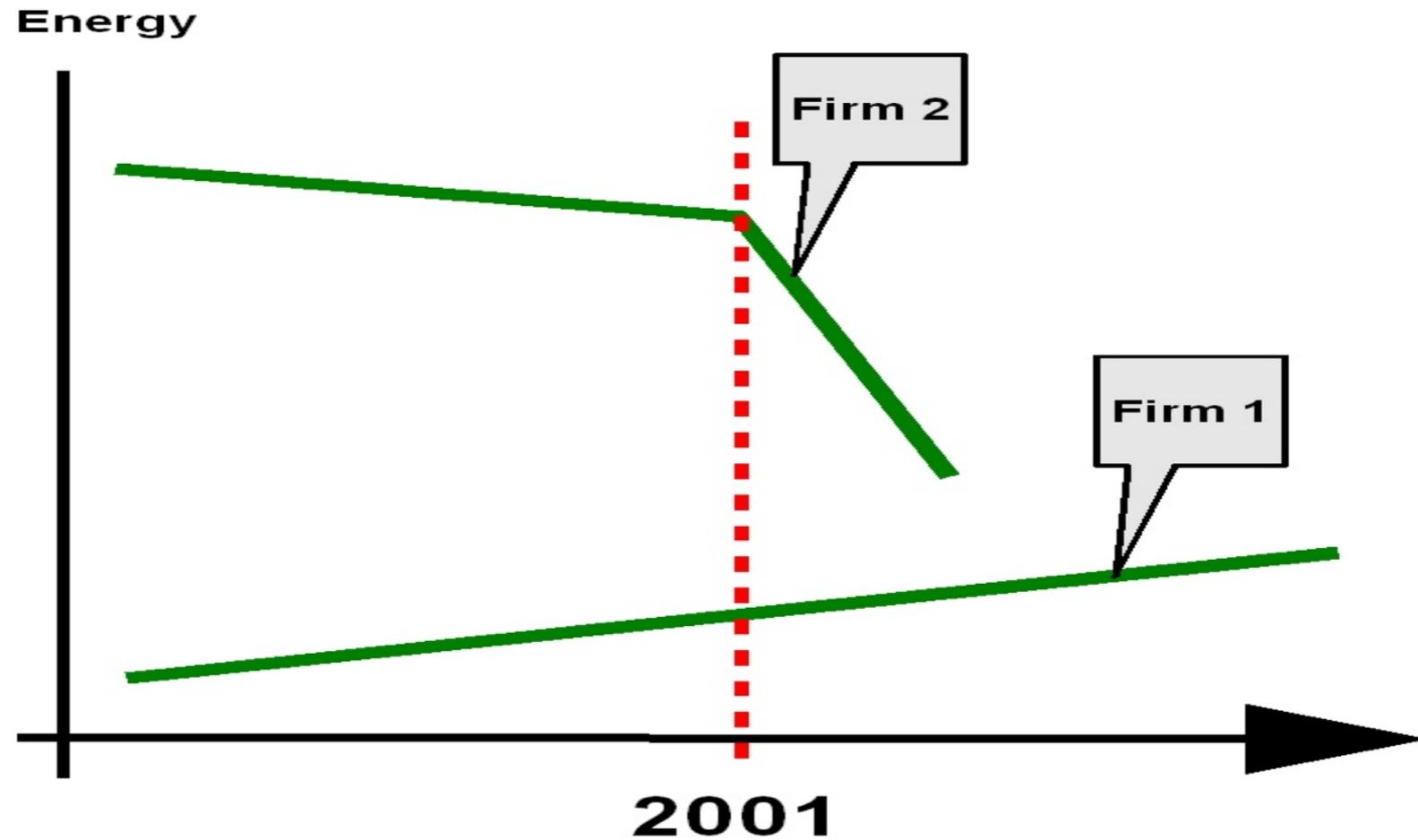
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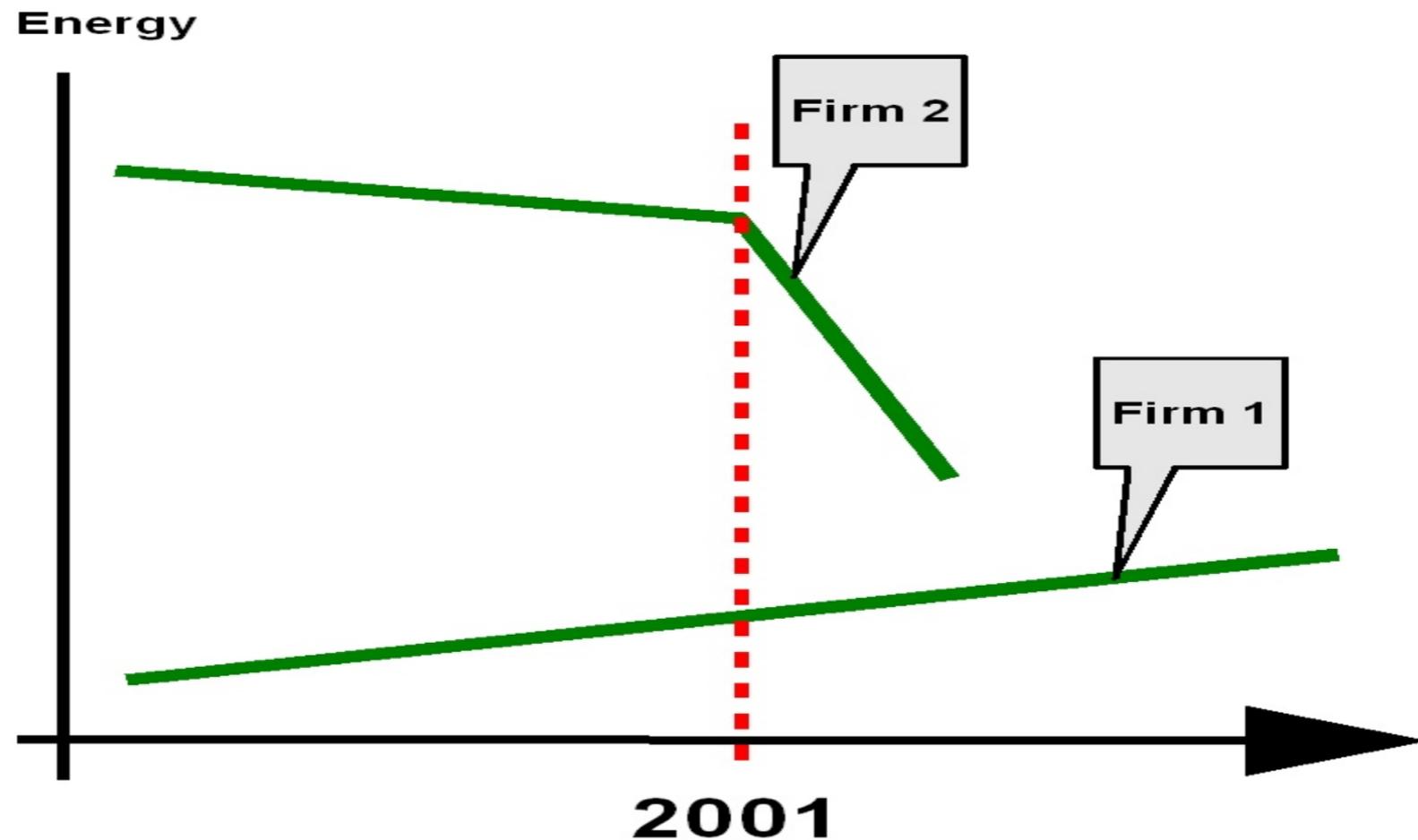
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Rather than CCA, look at IPPC firms

# Climate Change Agreements (CCAs)

## Issue 2 – Selection into CCA Targets



Rather than CCA, look at IPPC firms

Assumption: No systematic post 2000 shock for PPC firms other than CCA

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

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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

# Descriptive Stats for 2000

Variable	CCA=0	CCA=1	Significant?
Age	13.55	17.53	***
Employment	151.49	536.44	***
Energy Expenditure	0.22	1.95	***
Output	19.08	86.08	***
Plants	8282	1050	

Variable	EPER=0	EPER=1	Significant?
$\Delta \ln(\text{Employment})$	-0.021	-0.016	
$\Delta \ln(\text{Energy Expenditure})$	0.034	0.026	
$\Delta \ln(\text{Output})$	0.026	0.037	

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# Regression results: Energy

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

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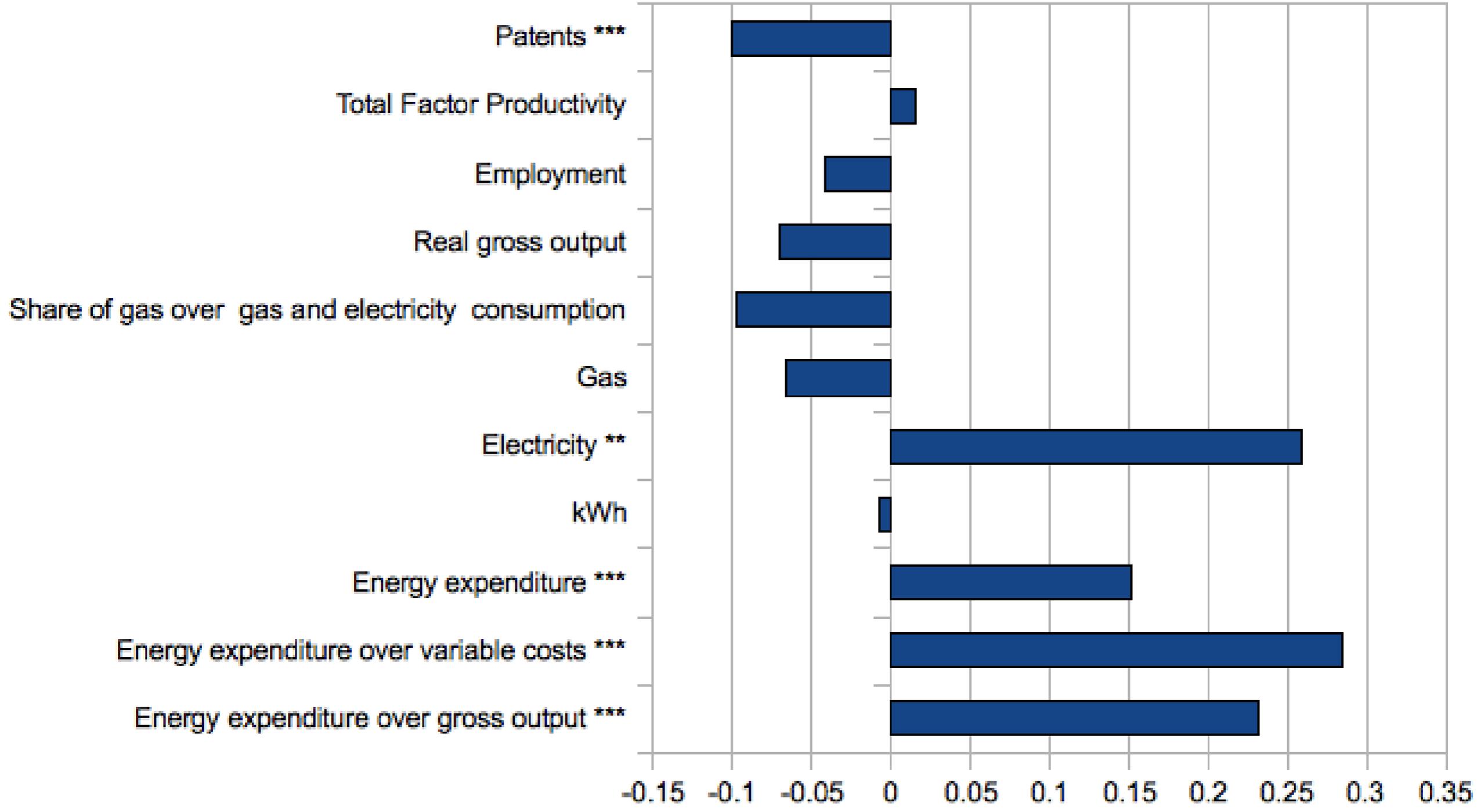
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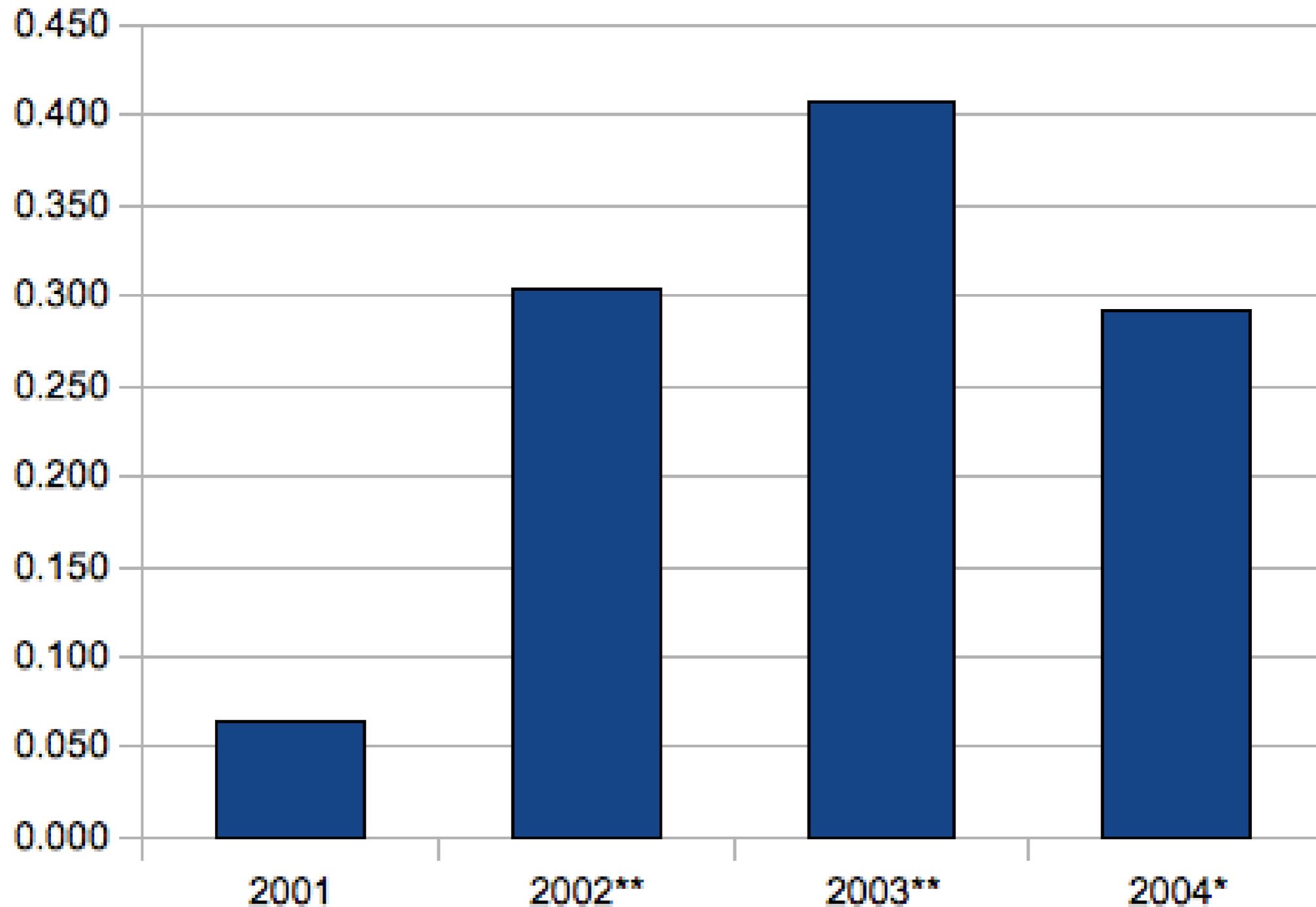
# Graphical Summary of regression results



Values indicate **CCA** effect

# Results: Time profile

## CCA effect on electricity



# Aggregate CCL impact

$$\Lambda(\text{el}) = -0.258 \times 0.65 = -16.8\%$$

Impact on “Treated”

Share of “Treated” in  
electricity consumption

Implied energy price elasticity: 1.7

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- CCL firms patent significantly more
- CCL firms do not perform worse 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

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# 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**

# First stage regressions

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

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

# Other robustness tests

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

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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
<b>All patents</b>	CCA	0.069*** (0.017)	1.382*** (0.295)	-0.109*** (0.035)	-0.510** (0.243)		134320
	EPER	0.055*** (0.021)	1.326*** (0.376)	-0.161*** (0.048)	-0.585*** (0.186)		8395
<b>CCR Patents All</b>	CCA	0.024 (0.024)	0.506** (0.228)	-0.135 (0.087)	-0.531 (0.388)	-0.004 (0.009)	8832
	EPER	0.033 (0.029)	0.474 (0.317)	-0.140* (0.082)	-0.432 (0.359)	0.032 (0.021)	552
<b>CCR Patents Popp</b>	CCA	0.021 (0.024)	0.491* (0.269)	-0.138 (0.088)	-0.513 (0.371)	-0.009 (0.008)	8576
	EPER	0.026 (0.029)	0.436 (0.304)	-0.172** (0.076)	-0.528** (0.221)	0.016 (0.015)	536
<b>Non Popp Patents</b>	CCA	0.070*** (0.017)	1.375*** (0.236)	-0.106*** (0.035)	-0.510** (0.220)	0.021 (0.019)	134224
	EPER	0.056*** (0.022)	1.328*** (0.375)	-0.167*** (0.048)	-0.586** (0.277)	-0.012 (0.025)	8389

# 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
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# Regression results for patents

	Model	(1) Logit	(2) Poisson	(3) Clogit	(4) FE Poisson	(5) FE Share in total Patents	Observation firms
<b>Patent type</b>	<b>Policy Variable</b>	<b>I(Patent)</b>	<b>Patent Count</b>	<b>I(Patent)</b>	<b>Patent Count</b>		
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# Time profile for patent impact

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

# Time profile for patent impact

<b>Model</b>	(1) <b>Logit</b>	(2) <b>Poisson</b>	(3) <b>Clogit</b>	(4) <b>FE Poisson</b>
<b>Policy Variable</b>	<b>I(Patent)</b>	<b>Patents</b>	<b>I(Patent)</b>	<b>Patents</b>
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<b>Model</b>	(1)	(2)	(3)	(4)
<b>Policy Variable</b>	<b>Logit</b>	<b>Poisson</b>	<b>Clogit</b>	<b>FE Poisson</b>
	<b>I(Patent)</b>	<b>Patents</b>	<b>I(Patent)</b>	<b>Patents</b>
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# Econometric model

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

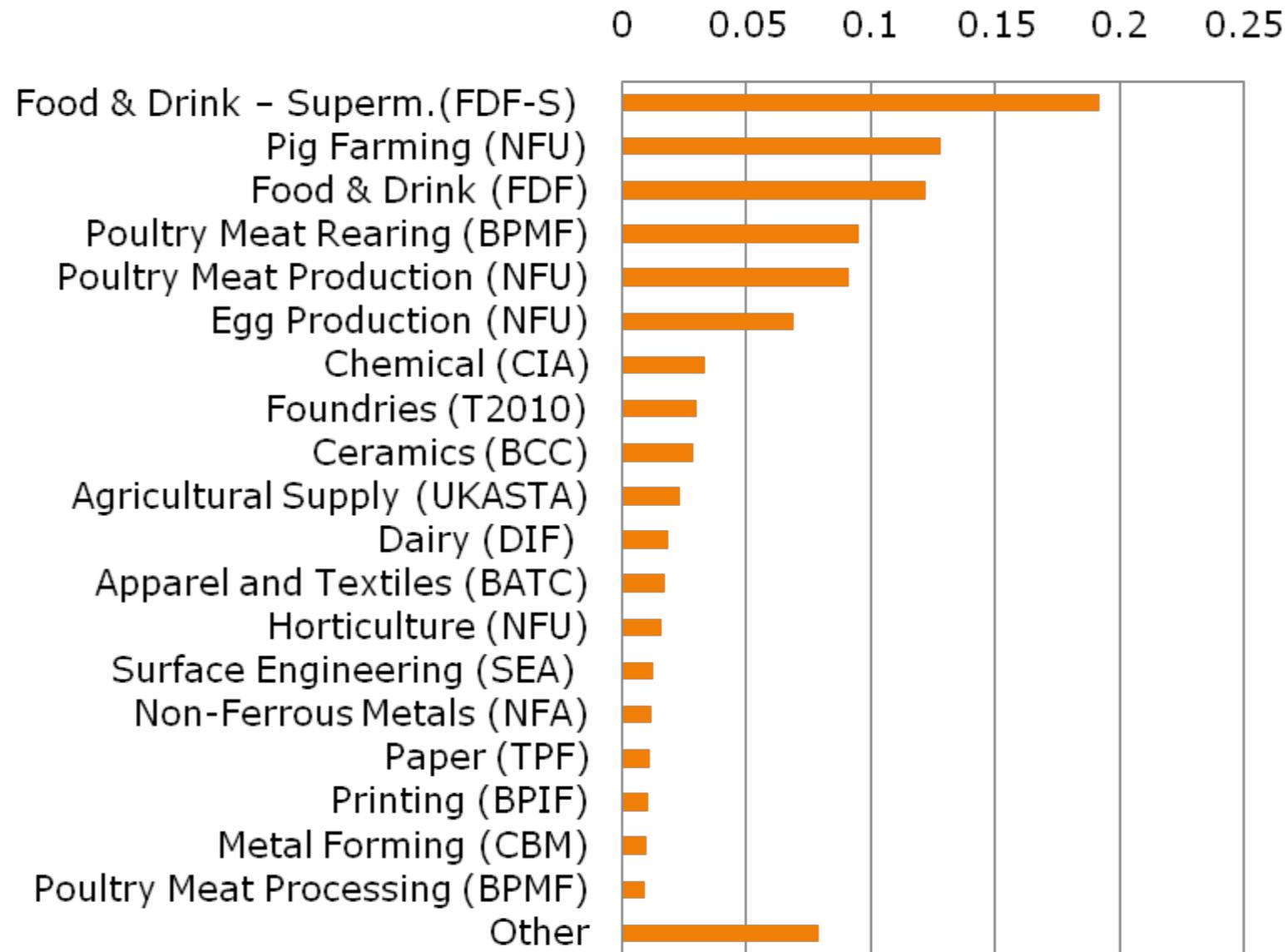
First stage IV: 
$$\Delta CCA_{it} = \tilde{\alpha} \Delta EPER_{it} + x'_{it} \tilde{\beta} + \tilde{\eta}_i + \tilde{\varepsilon}_{it}$$

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

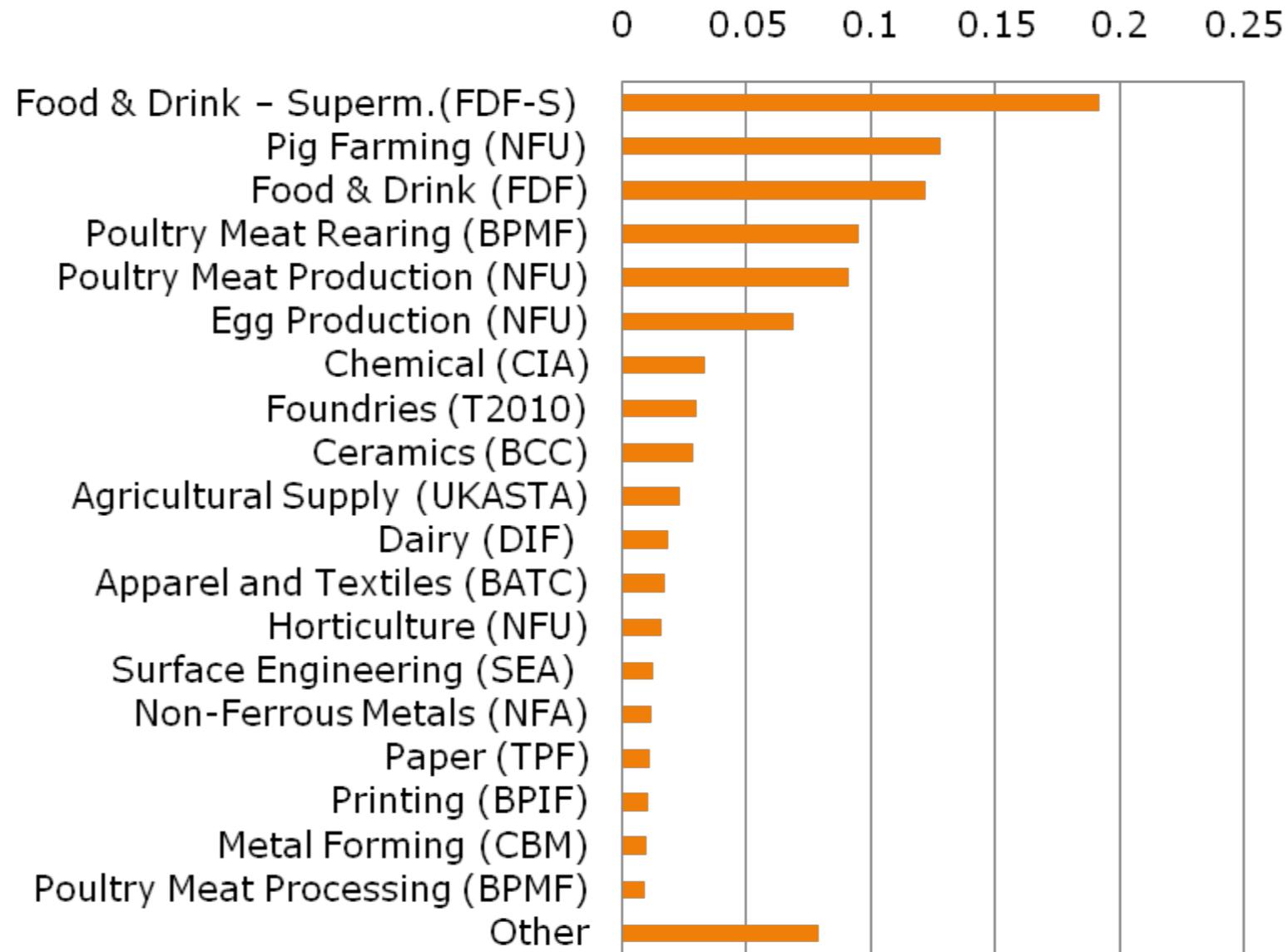
Reduced form: 
$$\Delta y_{it} = \alpha \Delta EPER_{it} + x'_{it} \beta + \eta_i + \varepsilon_{it}$$



# CCAs across Umbrella Agreements



# CCAs across Umbrella Agreements



Total number of agreements: 7904

# Data (cont.)

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

**Overall: 1100 CCR patents in 650 firms**

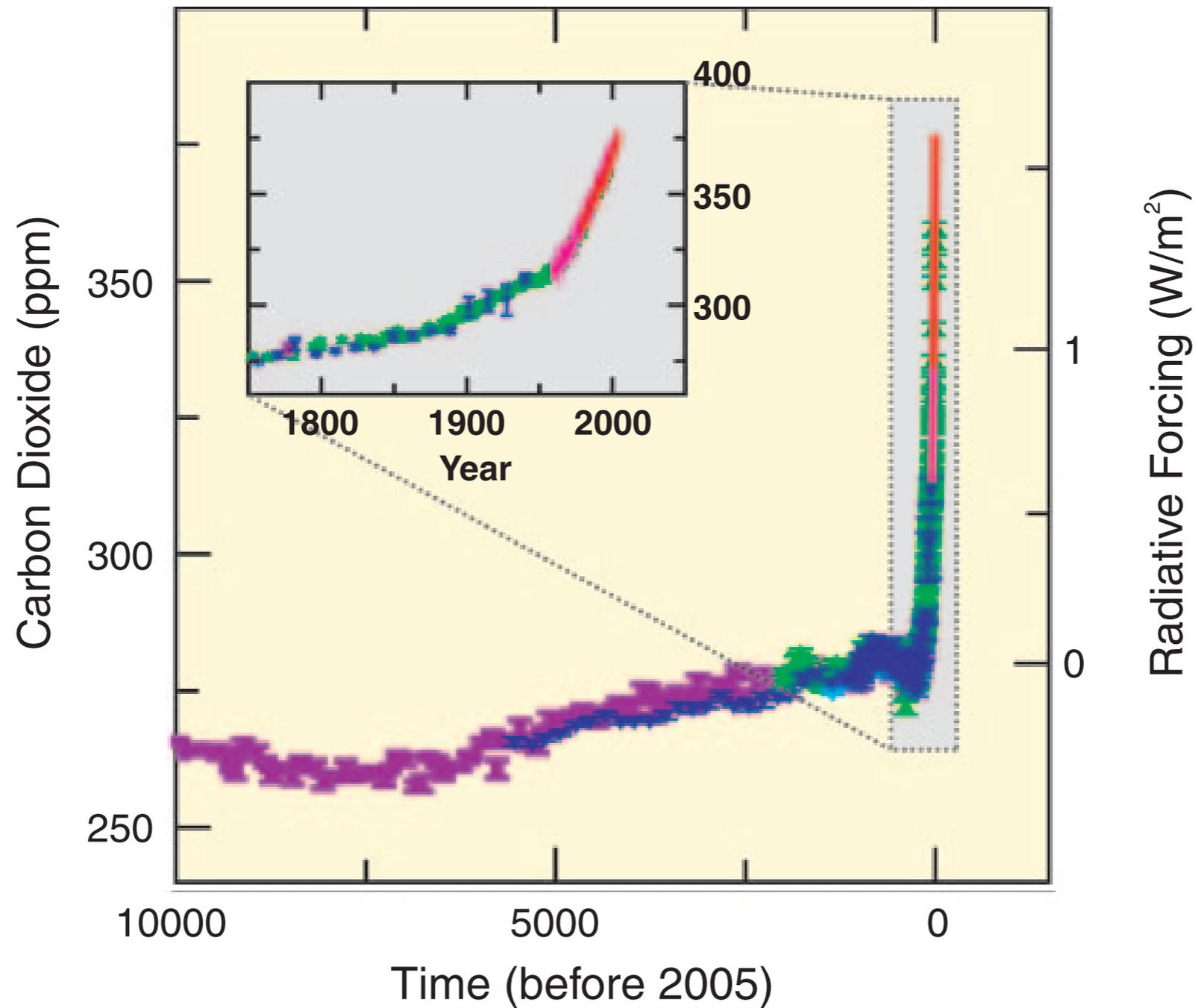
# Data (cont.)

- **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.

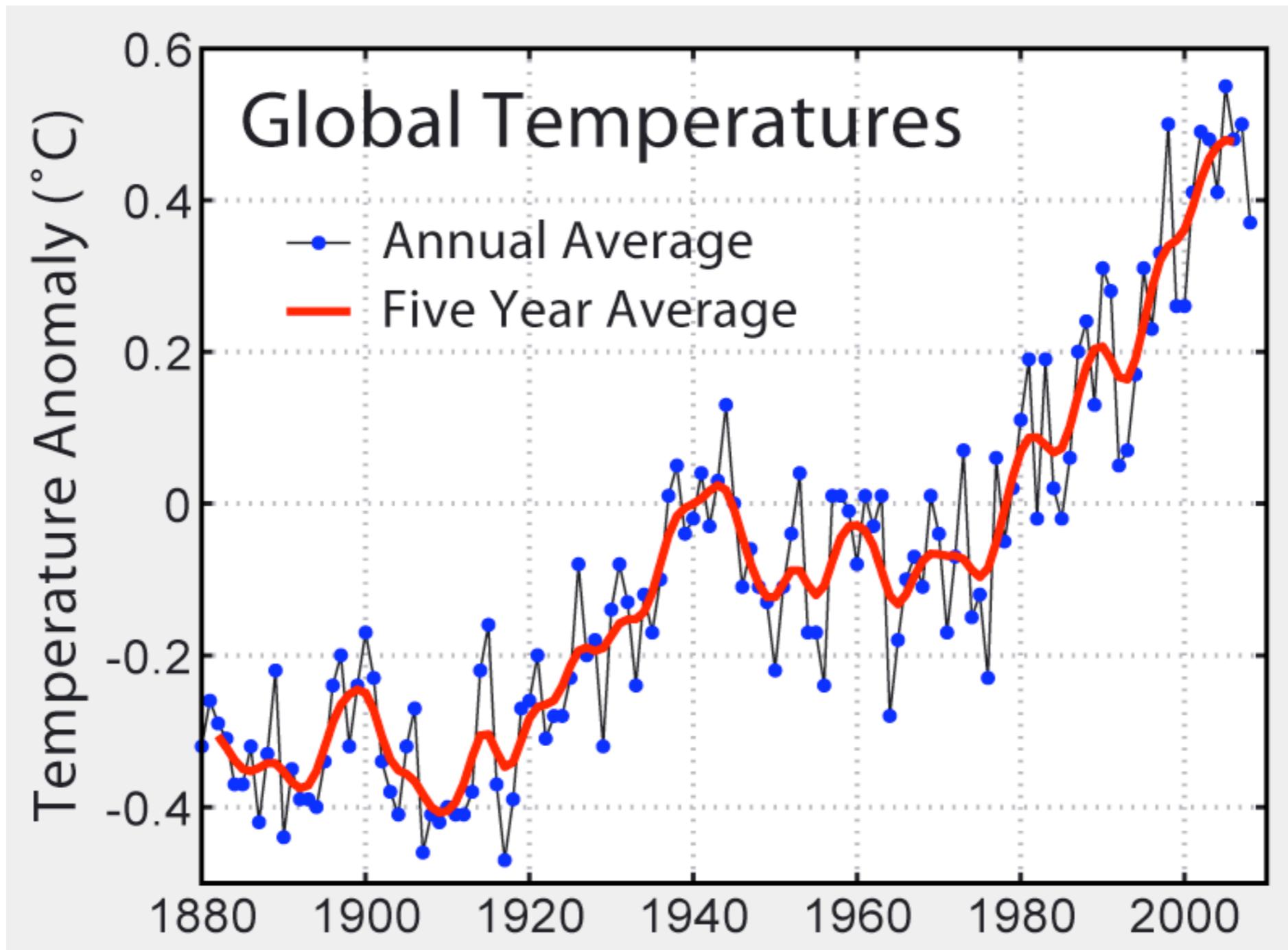
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# Historical CO<sub>2</sub> concentration



# Temperature record



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## 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
	<i>Totals</i>			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
	<i>Totals</i>			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*

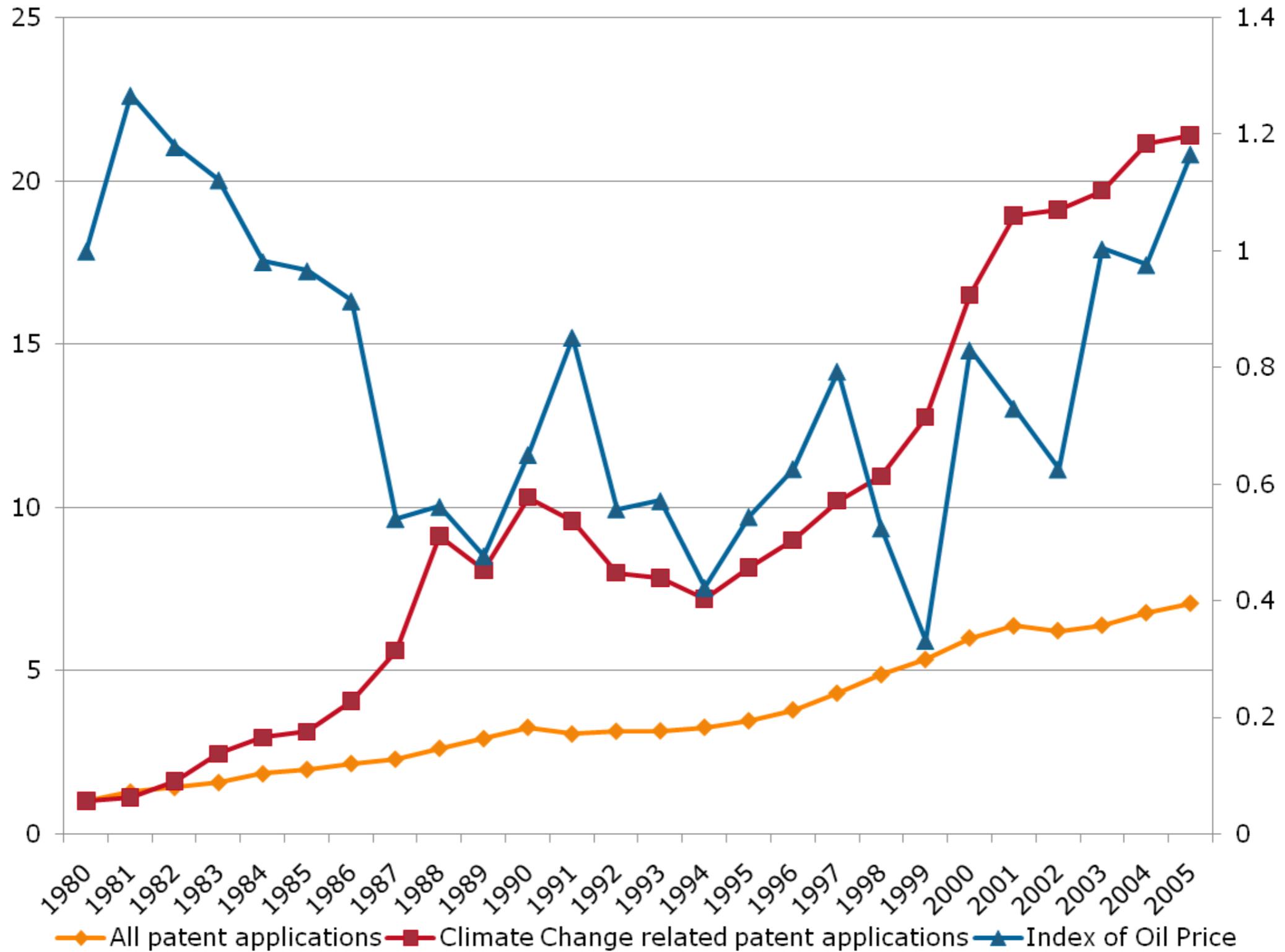
- Ekins & Etheridge, Barker et al.: yes, targets were easily achieved, but there was still a big CCA effect. (based on long run trends)

*Maybe, but CCL effect was even stronger*

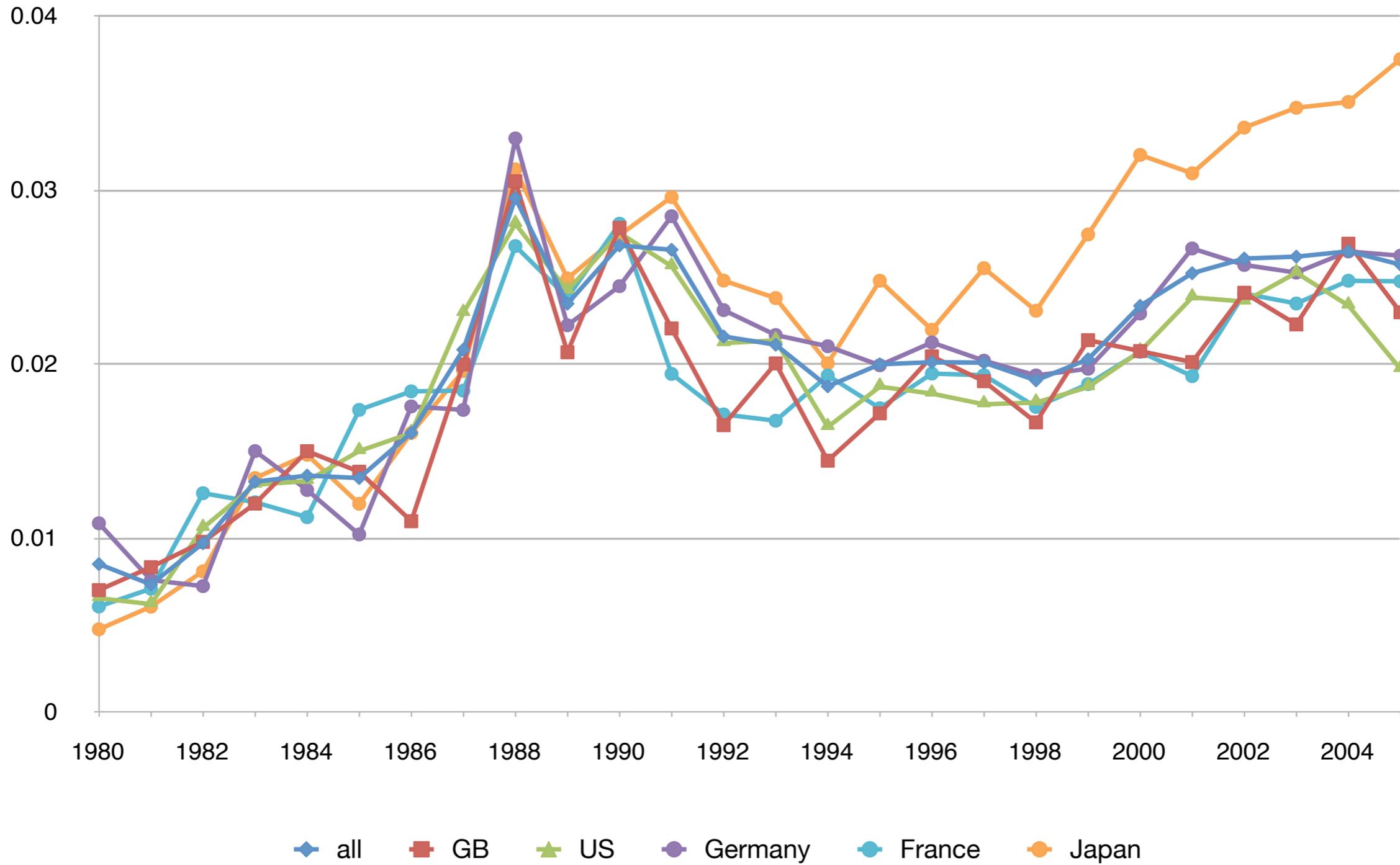
- Implied energy price elasticities are high compared to others: 1 to 2.5

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

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

# Climate Change Agreements (CCAs)

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  - 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>)