What have the Romans ~~has the EU ETS~~ ever done for us?

by Ralf Martin

BASED ON JOINT WORK WITH
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PRINZ

UKRI Economic and Social Research Council

LSE


NO ONE EXPECTS
THE SPANISH INQUISITION
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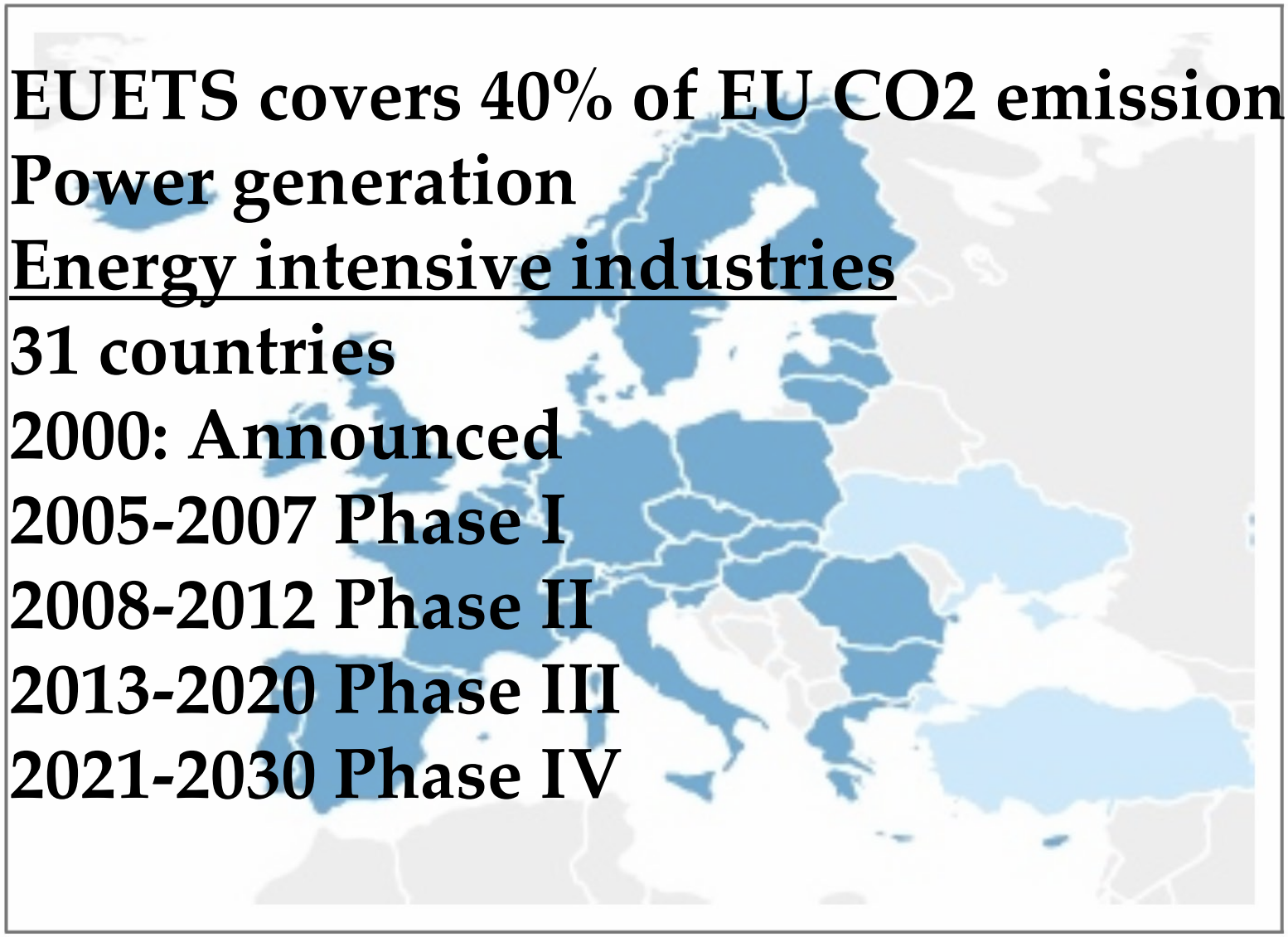
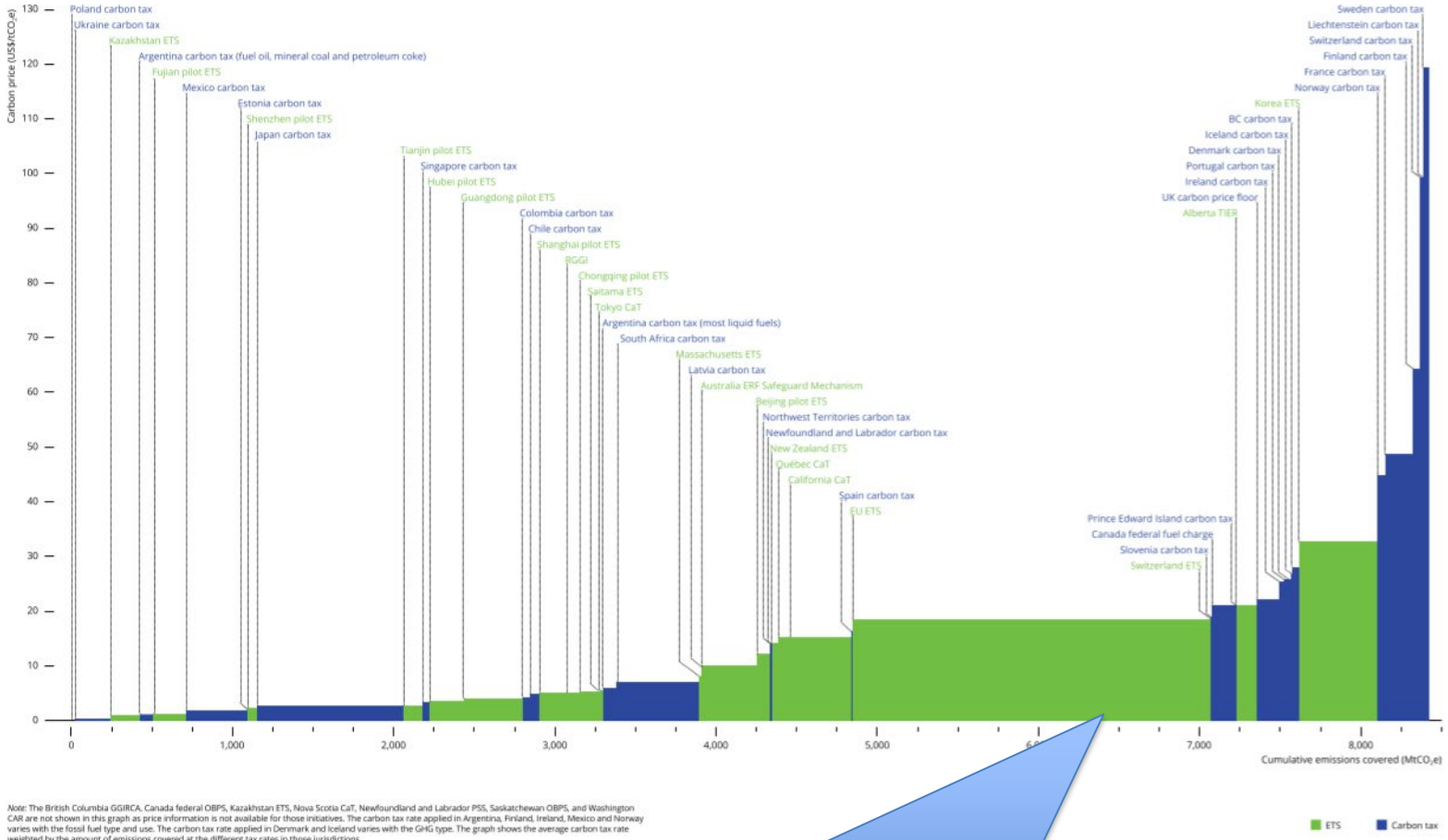
…apart from being the biggest carbon trading experiment to date?



- EUETS covers 40% of EU CO2 emissions
- Power generation
- Energy intensive industries
- 31 countries
- 2000: Announced
- 2005-2007 Phase I
- 2008-2012 Phase II
- 2013-2020 Phase III
- 2021-2030 Phase IV

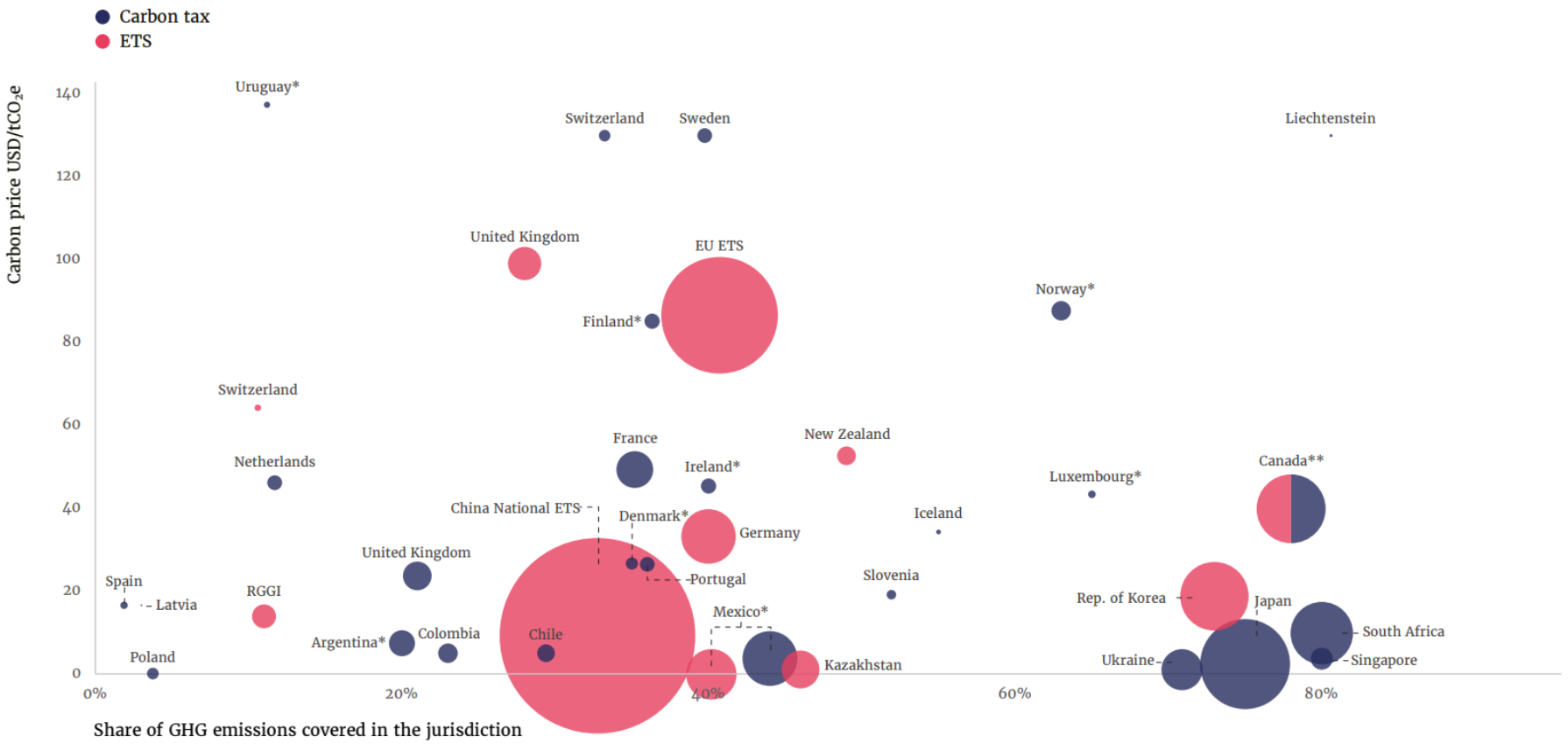
Carbon Pricing around the world



Note: The British Columbia GGIRCA, Canada federal OBPS, Kazakhstan ETS, Nova Scotia CaT, Newfoundland and Labrador PSS, Saskatchewan OBPS, and Washington CAR are not shown in this graph as price information is not available for those initiatives. The carbon tax rate applied in Argentina, Finland, Ireland, Mexico and Norway varies with the fossil fuel type and use. The carbon tax rate applied in Denmark and Iceland varies with the GHG type. The graph shows the average carbon tax rate weighted by the amount of emissions covered at the different tax rates in those jurisdictions.

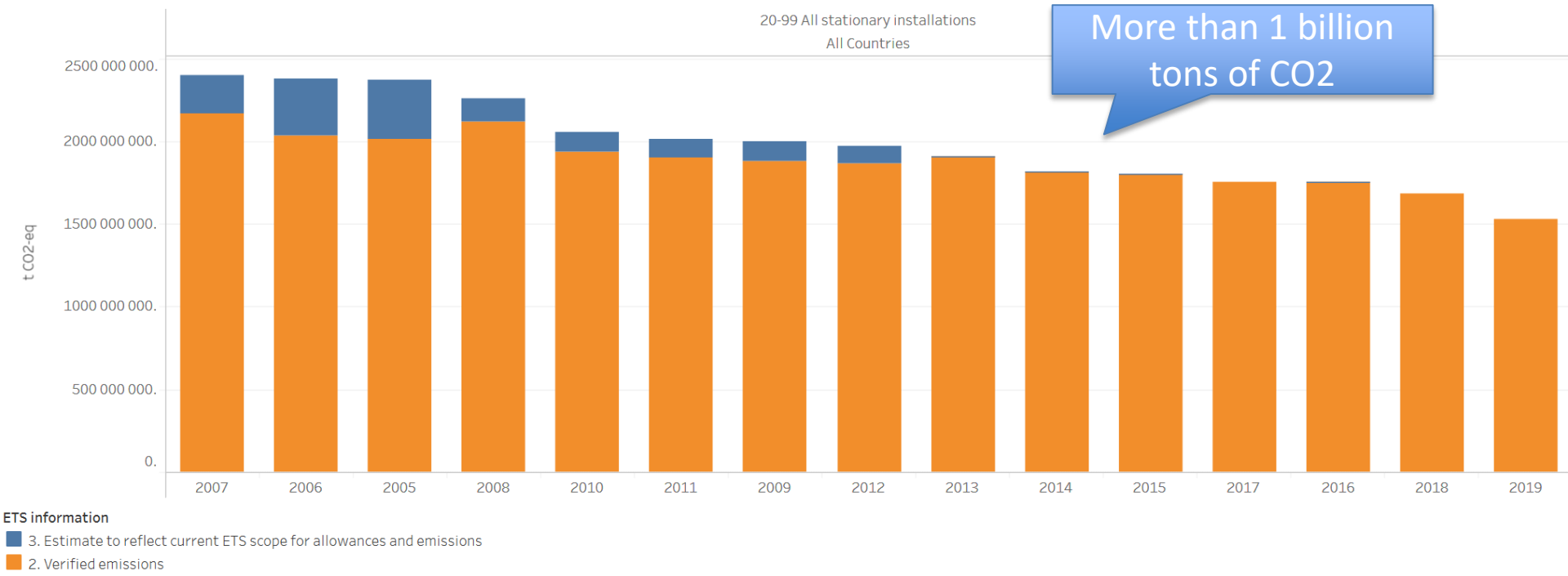
EU ETS is currently single biggest carbon pricing policy instrument (in terms of pricing revenue)
Source: [Worldbank]

Absolute emissions coverage, share of emissions covered, and prices for CPIs across jurisdictions



Source: [Worldbank]

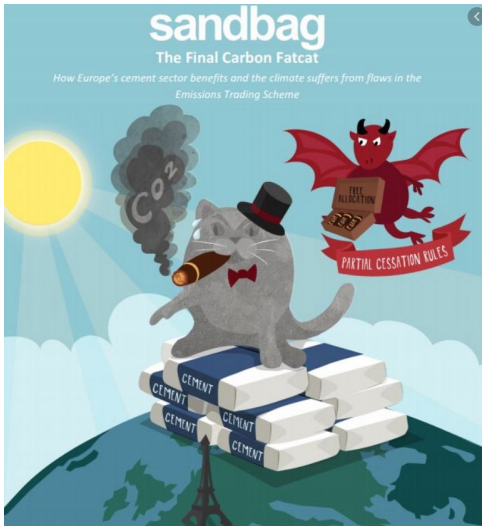
Verified emissions over time



Schroedinger's ETS?

- Accused of being a failure because it's not achieving enough
- Accused of being a failure because it causes loss of competitiveness and carbon leakage

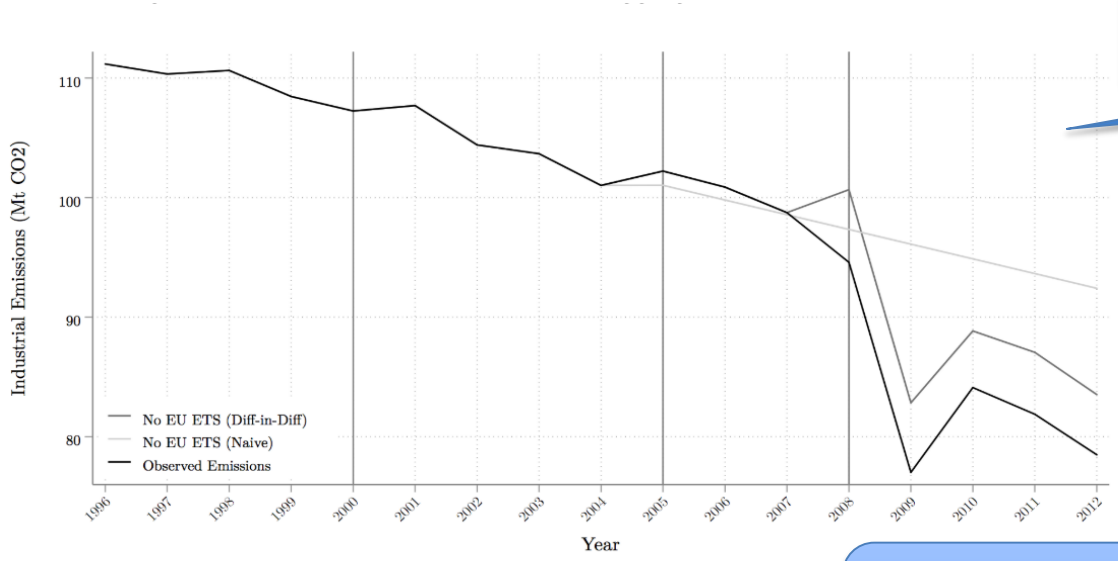
Are fat cats lazy?



- Accused of Rewarding Fat Cats?

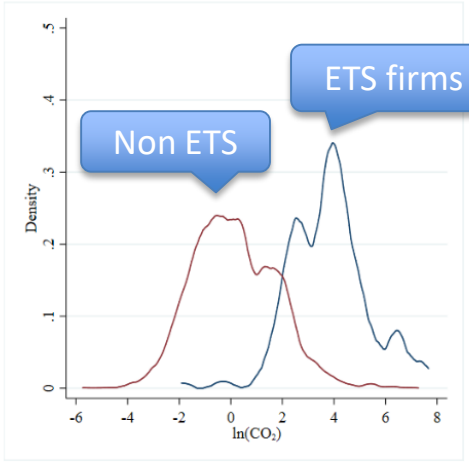
Carbon Price….

The causal impact of the EU ETS



Approach 1

Our Approach: Differences-in-Differences



(a) CO_2 (Unmatched)

Has the gap between ETS and non ETS firms changed?

Approach 2

Issues

Only source are confidential government business census data

- Data: Firm level data on emissions pre 2000 –

- Are there comparable non-ETS firms

Main check: pre-treatment parallel trends

- ETS firms reduce emissions by more: is that good for the climate?

Examine other outcomes: VA, K, Imports, L

(French) Data

Annual Survey of Industrial Energy Consumption (EACEI)

- Quantities and values of energy consumed by type, as well as their usages.
- Sample, universe in most energy intensive sectors

FICUS-FARE

- Firm-level accounting and performance data (universe)

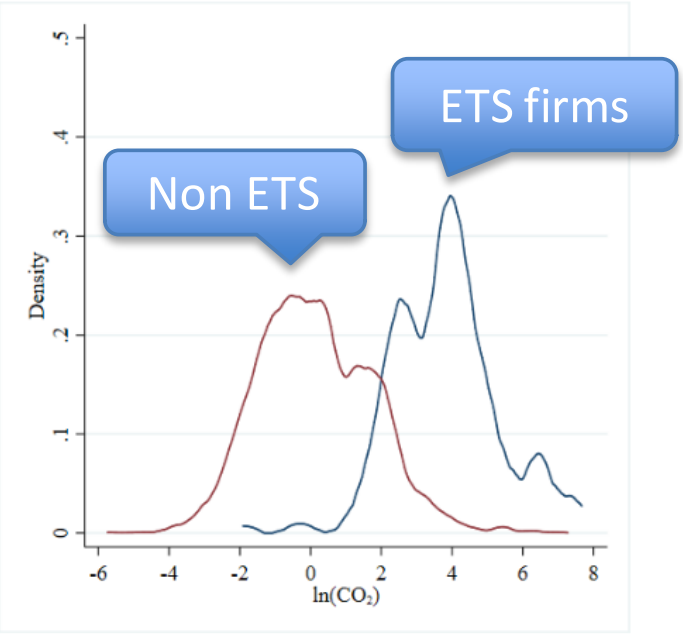
Customs Data (DGDDI)

- All firm level imports and exports

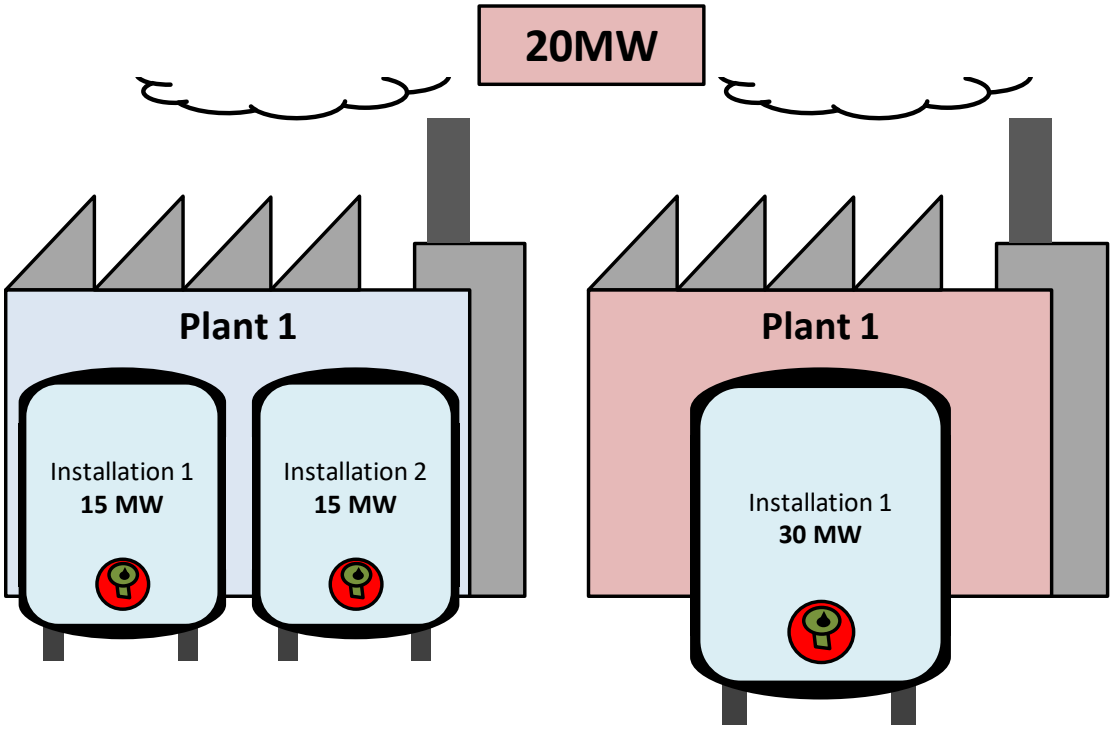
The European Union Transaction Log (EUTL)

- Free permits allocated
- Permits surrendered
- Identity of EU ETS regulated firms

ETS vs non ETS firms



(a) CO_2 (Unmatched)

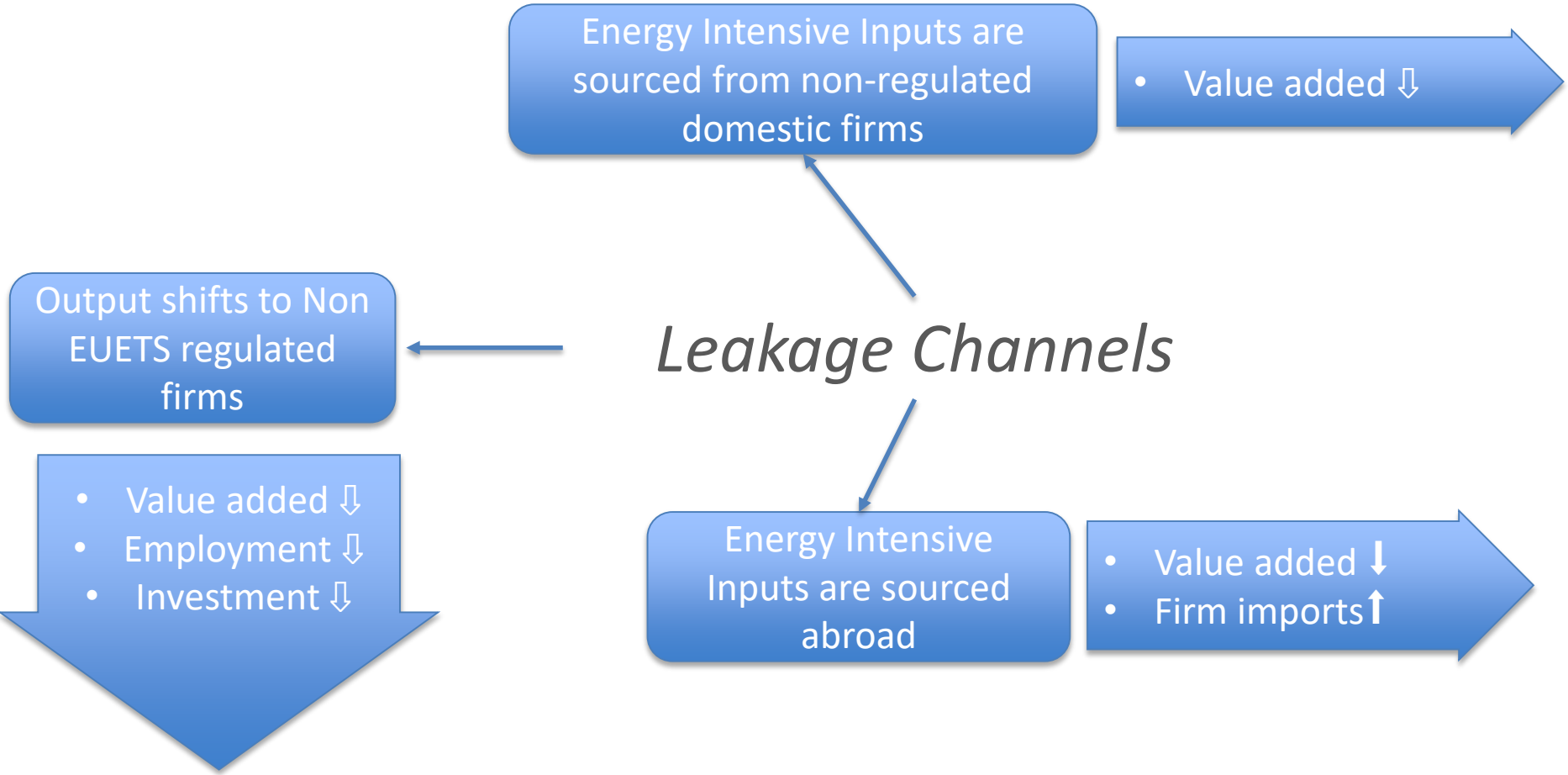


NOT REGULATED
NON-ETS

REGULATED
ETS

- Sector specific size thresholds at installation level
- ETS firms are bigger on average but there is a good overlap even in terms of carbon
- Robustness: matching
- **Crucially: pre-treatment trends are parallel**

ETS firms reduce emissions by more is that good for the climate?



Econometric Model

Period specific sector fixed effects

$$\Delta y_{j,s,t} = \sum_{\tau=1}^{4} \left[\mathbb{1}\left\{ t \in \Theta_\tau \right\} \cdot \beta_\tau \cdot \mathbb{1}\left\{ ETS_j \right\} + \lambda_{s,\tau} \right] + \varepsilon_{j,s,t} \qquad (1)$$

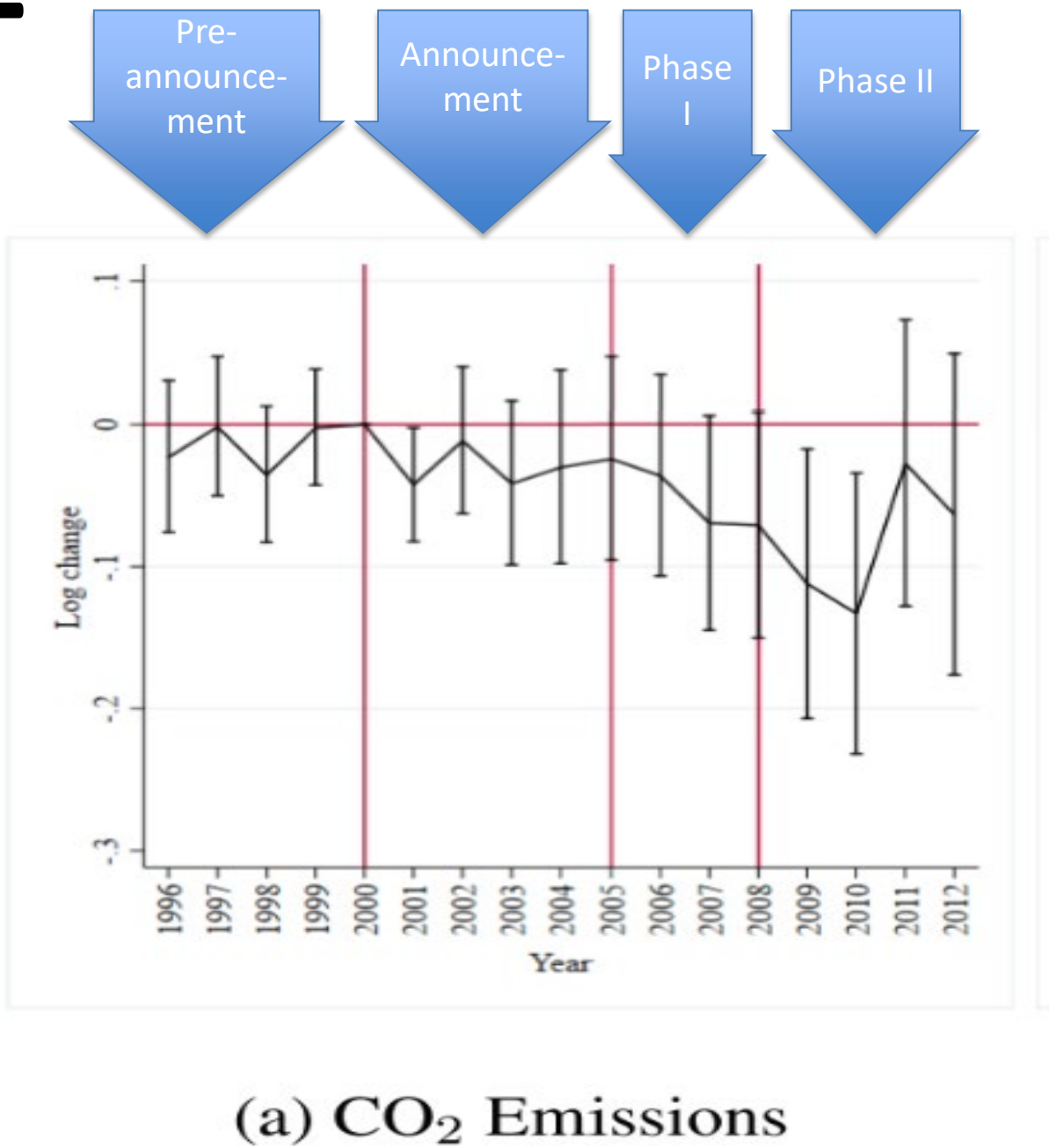
where

$$\begin{aligned}
\Theta_1 &= \{1996, \ldots, 1999\} \quad \text{(Pre-Announcement Period)}, \\
\Theta_2 &= \{2001, \ldots, 2004\} \quad \text{(Announcement Period)}, \\
\Theta_3 &= \{2005, \ldots, 2007\} \quad \text{(Trading Phase I)}, \\
\Theta_4 &= \{2008, \ldots, 2012\} \quad \text{(Trading Phase II)}.
\end{aligned}$$

Results – CO2

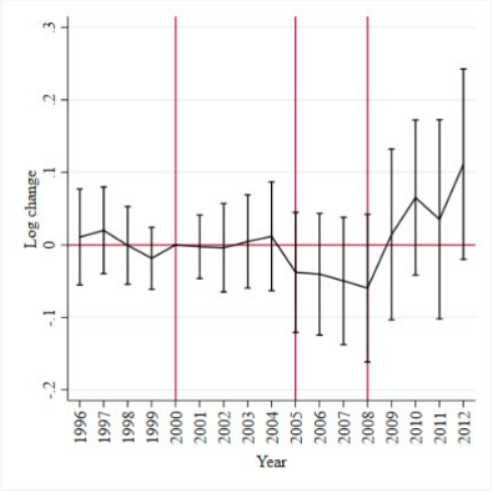
	(1) $\Delta \log(CO_2)$
Pre-Announcement	-0.019
	(0.020)
Announcement Period	-0.035
	(0.022)
Trading Phase I	-0.044
	(0.032)
Trading Phase II	-0.082**
	(0.041)
Mean in 2000	135.354
Observations	42,733
Total # of Firms	3,837
# of Regulated Firms	163
Adjusted R^2	0.028

CO2 declined 8.2% faster in EU ETS firms during Phase II

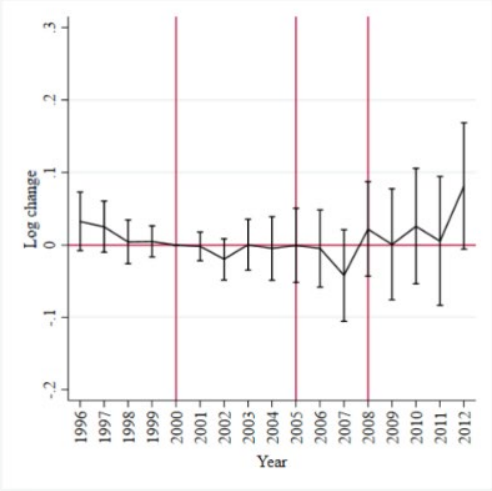


(a) CO_2 Emissions

Leakage?



(c) Value Added



(d) Employment

Table 1: The Effect of the EU ETS on the Environmental and Eco

	(1) $\Delta \log(CO_2)$	(2) $\Delta \log$(Value Added)	(3) $\Delta \log$(Emp)
Pre-Announcement	-0.019	0.015	0.025
	(0.020)	(0.023)	(0.016)
Announcement Period	-0.035	0.003	-0.009
	(0.022)	(0.024)	(0.014)
Trading Phase I	-0.044	-0.041	-0.015
	(0.032)	(0.036)	(0.025)
Trading Phase II	-0.082**	0.025	0.024
	(0.041)	(0.048)	(0.034)
Mean in 2000	135.354	91.934	1,213
Observations	42,733	42,733	42,733
Total # of Firms	3,837	3,837	3,837
# of Regulated Firms	163	163	163
Adjusted R^2	0.028	0.075	0.099

No significant effect on value added or employment. If anything a positive effect in Phase II

Leakage via Imports?

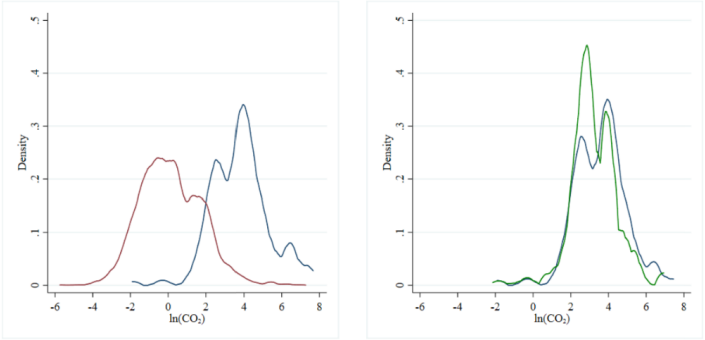
Table S5: The Effect of the EU ETS on Imports (Full Sample)

	(1)	(2)
	Δ log(Imports) Total	Δ log(Imports) CO_2 intensive
Pre-Announcement	-0.008	0.049
	(0.083)	(0.094)
Announcement Period	-0.062	-0.090
	(0.063)	(0.087)
Trading Phase I	-0.109	-0.102
	(0.103)	(0.101)
Trading Phase II	-0.047	-0.151
	(0.122)	(0.134)
Mean in 2000	113.041	0.884
Observations	42,106	41,497
Total Firms	3,837	3,782
Treated Firms	163	163
Adjusted R^2	0.095	0.153

We compute the carbon content of imports using detailed product classes

Robustness – Matching DiD

Figure S2: Density plots showing differences between regulated and unregulated firms in the pre- and post-match samples (CO_2 Emissions, Value Added)



(a) CO_2 (Unmatched) (b) CO_2 (Matched)

We find NN in terms of CO2 based on 2 digit sector

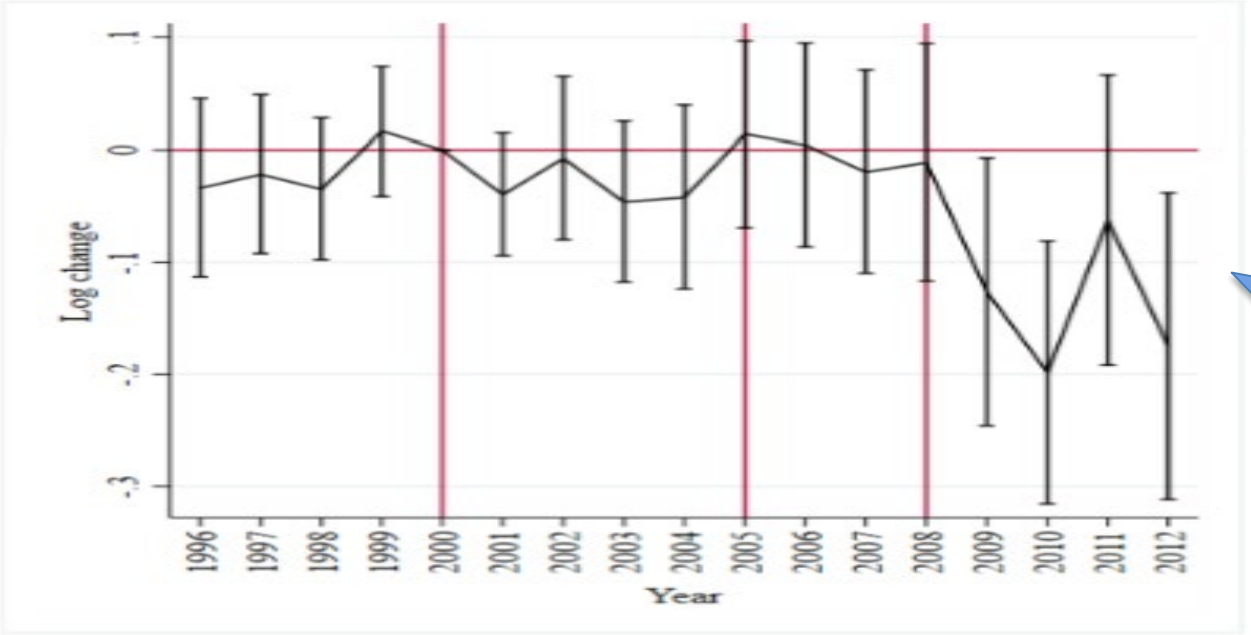
Gaming the system?

For some we cant find NN

Table S2: The Effect of the EU ETS on Firm Outcomes

	(1) $\Delta \log(CO_2)$	(2) $\Delta \log$(Value Added)	(3) $\Delta \log$(Emp)
Pre-Announcement	0.016	0.037	-0.012
	(0.022)	(0.026)	(0.018)
Announcement Period	0.060***	0.032	0.018
	(0.022)	(0.044)	(0.019)
Trading Phase I	-0.002	-0.028	-0.040
	(0.054)	(0.056)	(0.041)
Trading Phase II	-0.117**	0.001	-0.064
	(0.054)	(0.083)	(0.049)
Mean in 2000	90.440	51.751	706
Observations	1,954	1,954	1,954
# of Regulated Firms	149	149	149
Adjusted R^2	0.026	0.002	0.011

How are ETS firms doing it?



(b) Carbon Intensity

Efficiency improvements: CO2/VA

- *Fuel switching?*
- *More efficient equipment?*
- *Other ways of improving efficiency?*

How are ETS firms doing it?

Table 1: The Effect of the EU ETS on the Environmental and Economic Performance of Firms

	(1) $\Delta \log(CO_2)$	(2) $\Delta \log$(Value Added)	(3) $\Delta \log$(Emp)	(4) $\Delta \log$(Capital)	(5) $\Delta \log(CO_2/VA)$
Pre-Announcement	-0.019	0.015	0.025	0.010	-0.034
	(0.020)	(0.023)	(0.016)	(0.017)	(0.028)
Announcement Period	-0.035	0.003	-0.009	-0.001	-0.038
	(0.022)	(0.024)	(0.014)	(0.014)	(0.028)
Trading Phase I	-0.044	-0.041	-0.015	0.024	-0.003
	(0.032)	(0.036)	(0.025)	(0.028)	(0.038)
Trading Phase II	-0.082**	0.025	0.024	0.064*	-0.107**
	(0.041)	(0.048)	(0.034)	(0.037)	(0.048)
Mean in 2000	135.354	91.934	1,213	197.954	0.003
Observations	42,733	42,733	42,733	42,733	42,733
Total # of Firms	3,837	3,837	3,837	3,837	3,837
# of Regulated Firms	163	163	16	163	163
Adjusted R^2	0.028	0.075		0.449	0.049

Suggestive of investment in more efficient equipment

Antipol

Integrated investment to reduce Air and GHG pollution

Annual Survey on Environmental Protection Studies and Investments (Anti Pollution)

	(1)	(2)	(3)
	Pollution Control: Air Quality & Climate Change		
	Δ arcsinh (Measurement)	Δ arcsinh (Integrated)	Δ arcsinh (Specific)
Pre-Announcement	0.177	-	-
	(0.307)	-	-
Announcement Period	-0.085	0.041	0.061
	(0.318)	(0.231)	(0.233)
Trading Phase I	-0.159	0.975***	0.006
	(0.362)	(0.359)	(0.334)
Trading Phase II	-0.270	1.079***	0.072
	(0.511)	(0.401)	(0.341)
Mean in 2001	18.828	56.726	47.008
Observations	17,073	17,507	17,507
Total # of Firms	1,732	2,936	2,936
# of Regulated Firms	128	158	158
Adjusted R^2	0.061	0.037	0.07

What do firms actually do?

Some quotes:

Heat recovery

- **Reuse steam** to heat water
- **Recycling of hot water**
- Own power plant, burning in boilers optimized, **heat recovery**, programmes of cleaning system are being checked and water consumption and heat is being checked
- **Biggest impact: Heat recovery**
- **Multiple utilization of waste heat from steam boilers**, reducing temperature of waste heat in chimney/funnel, **waste heat recovery**, controlling of supply and exhaust air
- Optimization of drying processes, **waste heat recovery**
- Optimization of pumps (turning down rotation speed), **waste heat recovery**, heat exchangers
- switch to natural gas, renovation, frequency changers, process heat isolation, steam recovery
- Bought new boilers, **waste heat recovery** installed, more efficient drying methods
- Automatic turning off of air conditioning and infrastructure for production, buying of motors with highest energy efficiency, efficiency of compressed air maximized (i.e. repairing of leakage, etc), **waste heat recovery**
- Optimization of energy mix used (some gases are more efficient than others), **making use of previously escaping vapor heat**
- **Heat recovery in low temperature parts**
- Insulation, **heat recovery**
- **Waste heat recovery,** exhaust heat from facilities (heated air is being blown back into the building in order to save heating – it's not a heat pump, but a direct redirection of the exhaust heat)

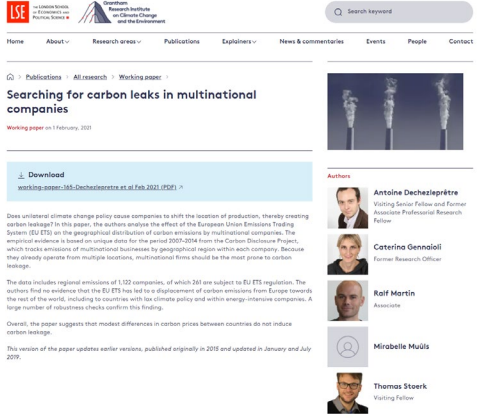
Fuel composition?

Table S6: Effects of the EU ETS on Firm Energy Outcomes (Full Sample)

	(1) $\Delta \log(CO_2)$ Total	(2) $\Delta \log(CO_2)$ from Gas	(3) $\Delta \log(CO_2)$ from Other Fossil Fuels	(4) Δ Share of Gas in CO_2
Pre-Announcement	-0.019	-0.025	0.029	0.003
	(0.020)	(0.038)	(0.103)	(0.013)
Announcement Period	-0.035	-0.029	-0.116	-0.009
	(0.022)	(0.039)	(0.116)	(0.011)
Trading Phase I	-0.044	-0.065	-0.226	-0.035*
	(0.032)	(0.052)	(0.165)	(0.020)
Trading Phase II	-0.082**	-0.120*	-0.331	-0.039
	(0.041)	(0.064)	(0.219)	(0.030)
Mean in 2000	135.354	60.227	75.127	0.721
Observations	42,733	32,103	25,209	42,733
Total # of Firms	3,837	2,888	2,437	3,837
# of Regulated Firms	163	163	163	163
Adjusted R^2	0.028	0.100	0.130	0.085

No evidence for changes in fuel mix

More evidence on leakage



- *Emissions Data (EU vs RoW) for ~1000 MNE firms 2007-2014 (Source: Carbon Disclosure Project)*

CDP
DISCLOSURE INSIGHT ACTION

- *Have emissions in RoW increased as EU emissions reduced for ETS firms?*

Have emissions in RoW increased as EU emissions reduced for ETS firms?

No!

Dependent Variable: million tonnes of CO2

Table 6: Regressions of Emission Levels

	(1)	(2)	(3)	(4)
Sample composition:	All	EU>0 RoW>0 any	EU>0 in t=1	EU>0 in t=1 RoW>0 any
Dependent Variable		Δ Emissions EU		
ETS	-0.515*	-0.414**	-0.424**	-0.488**
	(-1.85)	(-2.51)	(-2.40)	(-2.50)
Average for ETS firms	5.948	5.761	6.383	6.196
Dependent Variable		Δ Emissions RoW		
ETS	0.107	0.0232	0.0797	0.0975
	(0.56)	(0.16)	(0.59)	(0.63)
Average for ETS firms	4.925	6.043	5.273	6.072
Dependent Variable		Δ Emissions Global		
ETS	-0.408	-0.391	-0.344	-0.390
	(-1.06)	(-1.63)	(-1.43)	(-1.43)
Average for ETS firms	10.87	11.80	11.66	12.27
Observations	3802	2589	2441	2134
Firms	1122	676	683	568

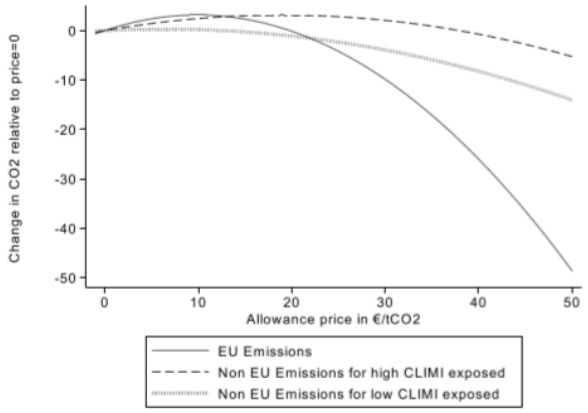
NOTES: t statistics in parentheses. Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. Column 1 includes all firms in the sample. Column 2, firms that have positive emissions in both EU and RoW in some year. Column 3, firms with positive EU emissions in the first period for which the company answered the CDP survey (t=1). Column 4 with positive EU emissions in t=1 and non-zero RoW emissions at some point over the sample.

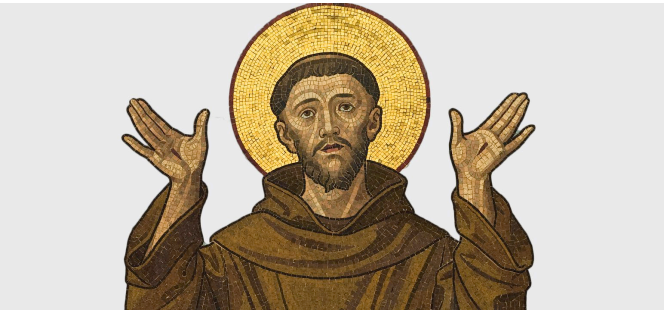
Maybe prices where just too low?

Dependent Variable		Δ Emissions EU		
$Price \times ETS$	-0.188	0.637*	-0.0730	0.603**
	(-1.47)	(1.87)	(-1.14)	(2.62)
$Price^2 \times ETS$		-0.0322*		-0.0266**
		(-1.79)		(-2.71)
$Price \times ETS \times LowRegulation$			-0.222	0.0506
			(-0.92)	(0.08)
$Price^2 \times ETS \times LowRegulation$				-0.0102
				(-0.32)
Minimum Price for Reductions		9.895		8.892
Dependent Variable		Δ Emissions RoW		
$Price \times ETS$	0.00128	0.218*	0.108*	0.330**
	(0.02)	(1.76)	(1.74)	(2.07)
$Price^2 \times ETS$		-0.00844		-0.00871*
		(-1.55)		(-1.71)
$Price \times ETS \times LowRegulation$			-0.206**	-0.236
			(-2.14)	(-1.10)
$Price^2 \times ETS \times LowRegulation$				0.00119
				(0.13)
Minimum Price for Reductions		12.89		6.289

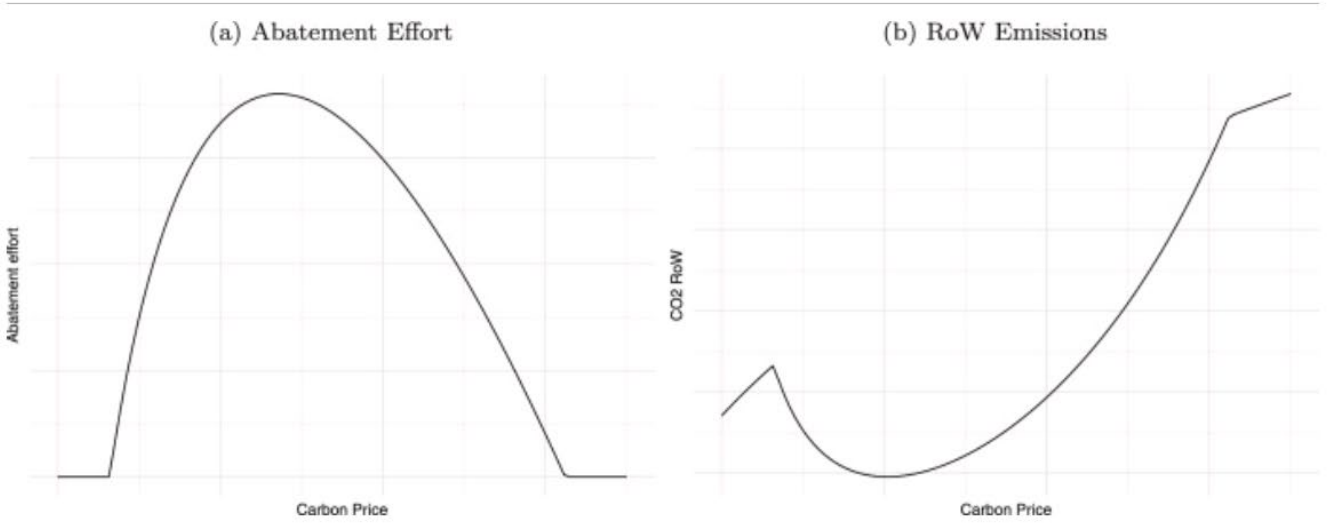
Carbon Halo Effect?

Figure 7: The counterfactual carbon response to the EU ETS allowance price



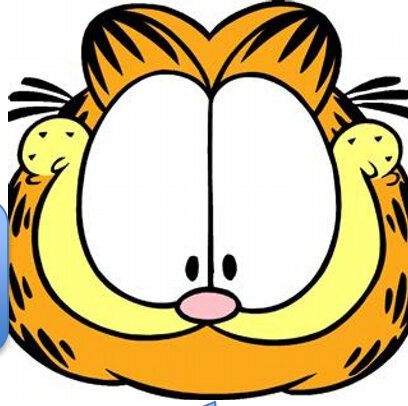


The end of the halo?



What about fat cats?

Independence property (Hahn&Stavins): Market outcome should not depend on allocation of permits



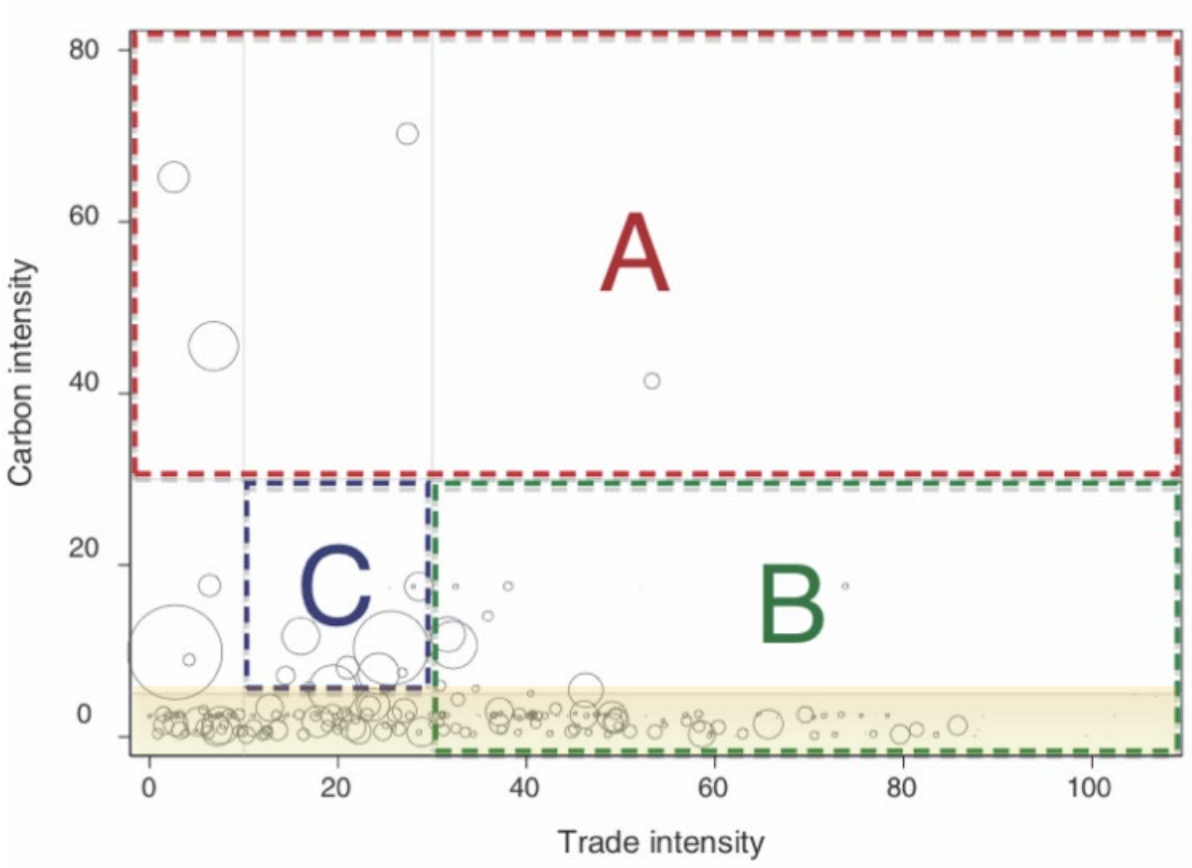
	(1) $\Delta \log(CO_2)$
A. Above-median surplus	
Pre-Announcement	-0.022 (0.024)
Announcement Period	-0.024 (0.029)
Trading Phase I	-0.039 (0.043)
Trading Phase II	-0.029 (0.058)
Mean in 2000	85.143
B. Below-median surplus	
Pre-Announcement	-0.016 (0.028)
Announcement Period	-0.046 (0.028)
Trading Phase I	-0.050 (0.041)
Trading Phase II	-0.126*** (0.047)
Mean in 2000	179.216
Observations	42,733
Total # of Firms	3,837
# of Regulated Firms	163
Adjusted R^2	0.030

As long as the market is efficient economists have no right calling me fat (only heavy boned)

Firms whose permit allocation is tighter respond more

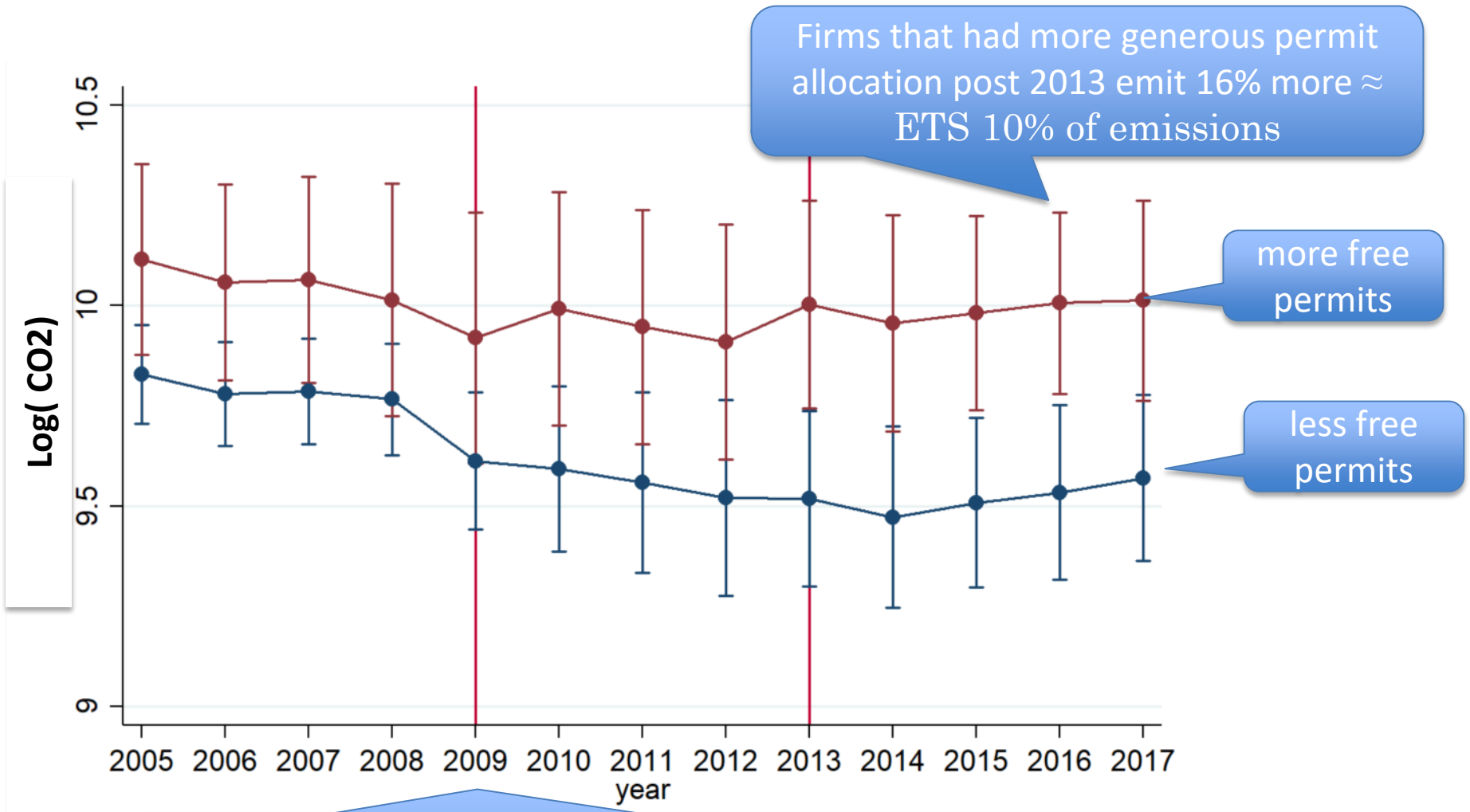
Tightness is possibly endogenous (although no pre treatment trends)

A natural experiment in Phase III



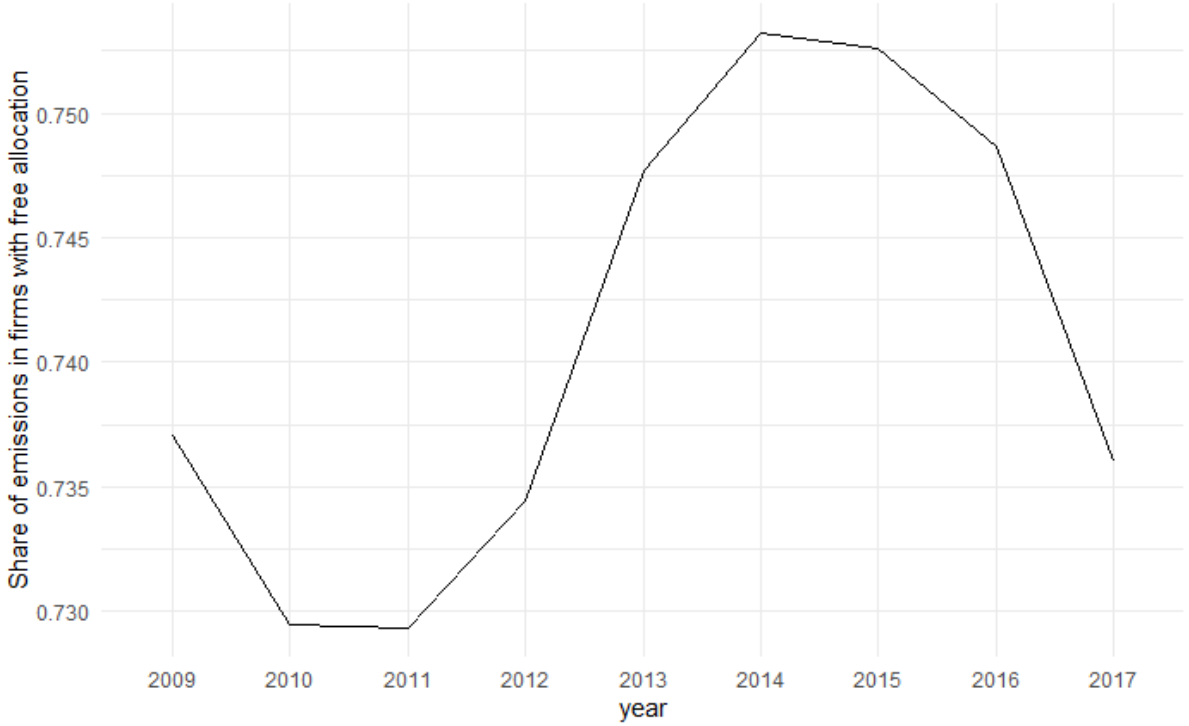
A,B,C = Firms at risk=100% of benchmark in free permits
Others: 30% of benchmark by 2020

The effect of more generous permit allocation on emissions



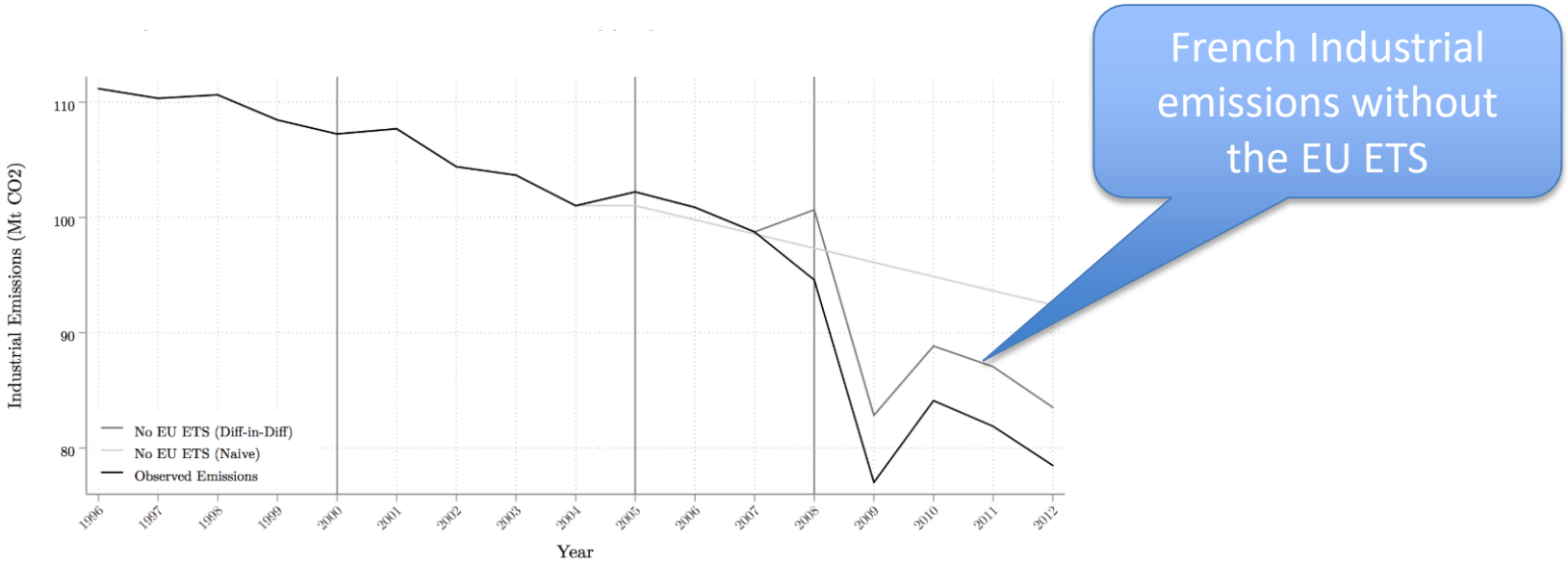
Forthcoming paper Martin, Muuls, Sarapatkova “Permission to pollute”

Share of emissions in firms with free allocation



16% reduction implies more than 11% reduction for aggregate ETS emissions

So what's the net ETS effect?



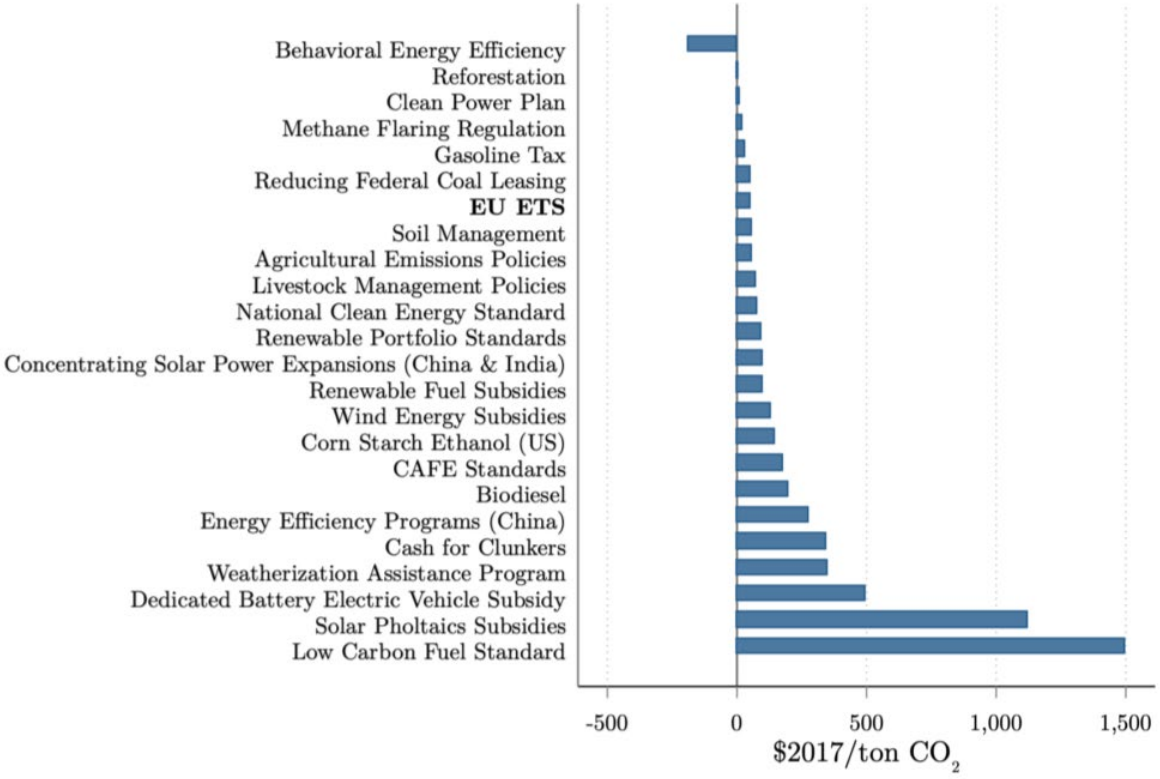
EU wide effect: ~50 MM tons more CO2 per year

Value for money?

- We see effects in Phase II: ~€15
- Cost of saving 50 MMt at most €750MM

- 5MMM trees @ cost of €1.5MMM
- 55Mkm^2 = Croatia

Cost comparison



To conclude: Hence, what has the EU ETS ever done for us?

- *Apart from global the emissions reductions?*
- *The efficiency improvements?*
- *Without having a negative impact on employment and value added?*
- *Apart from saving Croatia*
- *And what about the investment in clean technologies?*

… but then: it has made some fat cats very lazy

Road ahead

- Redo with latest price changes
- Determine when carbon pricing is counter productive
- Fit structural model to determine in-efficiency induced by allocation rules
- UK vs EU ETS?


Thanks
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Extra slides……

UK vs EU carbon price divergence?

Value of ETS firm

UK ETS Price

EU ETS Price

Should only matter if there is a competitiveness issue

(very) emerging result:

```
Call:
lm(formula = returns ~ DeltaUKA_GBP + DeltaEUA_GBP, data = df_u
    filter(UK_ETS == 1))

Residuals:
      Min        1Q    Median        3Q       Max
-0.233072 -0.007934 -0.000127  0.008220  0.178100

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)   0.0004445  0.0002362   1.882   0.0599 .
DeltaUKA_GBP -0.0257599  0.0107910  -2.387   0.0170 *
DeltaEUA_GBP  0.0793448  0.0103014   7.702 1.54e-14 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.01862 on 6330 degrees of freedom
  (83025 observations deleted due to missingness)
Multiple R-squared:  0.01086,    Adjusted R-squared:  0.01055
F-statistic: 34.74          and 6330 DF,  p-value: 9.85e-16
```

10% increase in the UK CO2 price reduces the value of a UK ETS regulated company by 0.2%

10% decrease in the EU CO2 price reduces the value of a UK ETS regulated company by 0.7%

Conclusion: UK companies are vulnerable to EU UK carbon price divergence, hence better make sure there is none

More matching robustness

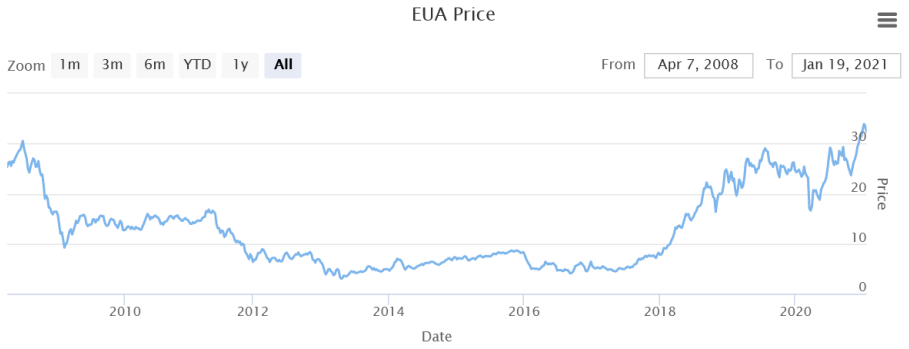
	(1)	(2)	(3)	(4)
	$\Delta \log(CO_2)$	$\Delta \log(CO_2)$	$\Delta \log(CO_2)$	$\Delta \log(CO_2)$
Pre-Announcement	0.016	0.031	0.025	0.022
	(0.022)	(0.024)	(0.023)	(0.022)
Announcement Period	0.060***	0.021	0.071**	0.061***
	(0.022)	(0.024)	(0.030)	(0.023)
Trading Phase I	-0.002	0.036	0.124**	0.021
	(0.054)	(0.057)	(0.061)	(0.055)
Trading Phase II	-0.117**	-0.112*	-0.112**	-0.115**
	(0.054)	(0.057)	(0.054)	(0.051)
Observations	1,954	2,016	1,977	1,974
Matching Variables	$\ln(CO_2)$	$\ln(CO_2)$ & $\ln(CO_2/VA)$	$\ln(CO_2)$ & ln(Electricity Bought)	$\ln(CO_2)$ & % Emissions Gas

Carbon price

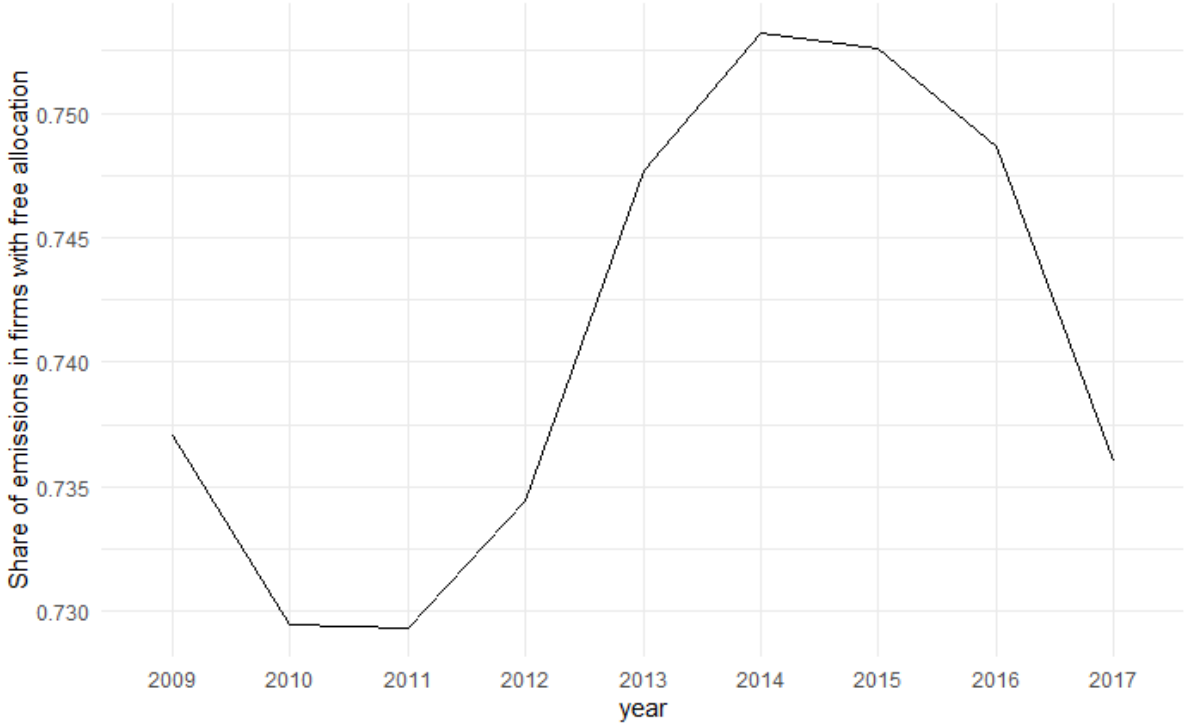
Lower than expected but not negligible….

Phase II: ~15€

Price recovery



Share of emissions in firms with free allocation



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