Revisiting Porter:

Climate Policy and the Efficiency of Firms

Corrado Di Maria (UEA) Balazs Stadler (OECD)

ESRI Dublin – February 21, 2020

Motivation

Two alternative views on the impact of environmental regulation on firms. Compare

- *''The Paris accord is totally disastrous, job-killing, wealth-knocking-out . . . it will undermine (the U.S.) economy'*...

with

- *'Innovation offsets, as we call them, . . . can lead to absolute advantages over firms in foreign countries not subject to similar regulation'*.

Does there exist an inescapable trade-off between business competiveness and environmental protection?

This paper

- Staggering differences in efficiency among manufacturing firms (e.g. Syverson, 2011).
- Empirics that fit the 'theory'?
- *'Strict environmental regulations do not inevitably hinder competitive advantage against rivals* [. . .] *because the world does not fit the Panglossian belief that firms always make optimal choices'*.
- We focus on short-run responses by manufacturing firms – do they pick the 'low-hanging fruit'?

A useful case study

- Finance Act 2000 introduced the Climate Change Levy package to come into force from 1 April 2001.
- A tax on energy delivered to non-residential users (CCL).
- A scheme of negotiated agreements (CCA) to protect energy intensive industries exposed to international competition. Firms within a CCA get a 80% discount.
- Selection into CCAs is not random...

Stochastic frontier with sample selection I

- Let y_{it} be the (log) outcome variable, $\mathbf{x}_{it}$ the (log) productive inputs, and $\mathbf{z}_{it}$ the 'environmental' variables.
- Let $y_{it}^* \geq y_{it}$ be the unobserved frontier and assume that observations on the frontier are distributed as $N(\mathbf{x}_{it}'\beta, \sigma_v^2)$:

$$y_{it}^* = \mathbf{x}_{it}'\beta + v_{it},$$

- The SF model assumes that actual output levels equal y_{it}^* minus a one-sided error whose distribution only depends on the $\mathbf{z}_{it}$:

$$y_{it} = \mathbf{x}_{it}'\beta + v_{it} - u_{it}(\mathbf{z}_{it}, \delta), \ \delta \geq 0. \tag{1}$$

Stochastic frontier with sample selection II

- We assume that the model exhibits the *scaling property*:

$$u_{it}(\mathbf{z}_{it}, \delta) = h(\mathbf{z}_{it}, \delta) \cdot u^*_{it},$$

  where $h(\mathbf{z}_{it}, \delta) \geq 0$, and $u^*_{it} \geq 0$ has a distribution that does not depend on $\mathbf{z}_{it}$.

- We assume $u_{it} = \exp(\mathbf{z}_{it}\boldsymbol{\delta})u^*$, and include exogenous technical change, so that we estimate:

$$y_{it} = \mathbf{x}'_{it}\beta + \xi_t - \exp(\mathbf{z}_{it}\delta)u^* + v_{it}$$

- Since we only observe 'treatment' if firms do not choose CCA, we need to correct for this (Greene, 2010 – half-normal).

Data

- Annual Respondent Database (ARD) – yearly production survey of $\sim$10,000 plants (all $>$100 or $>$250 employees, plus a sample of smaller ones).
- Capital Stock Database (derived from the ARD).
- Quarterly Fuels Inquiry (QFI), quarterly survey of a sample of $\sim$1,000 – 1993-2004. Annualized following Martin (2006).
- So far results for 4 sectors – Food and beverages (15), Basic Metals (27), Fabricated Metal Products (28), and Machinery and Equipment (29).

▸ stats

CCL and inefficiency

	(1) SIC 15	(2) SIC 27	(3) SIC 28	(4) SIC 29
Inefficiency				
CCL	-1.984***	-2.014***	-3.523***	-3.009***
	(-5.21)	(-5.01)	(-10.68)	(-10.20)
Prod. func. [ln(Turnover)]				
ln(Capital)	0.579***	0.429***	0.409***	0.320***
	(10.19)	(7.46)	(9.44)	(9.72)
ln(Employment)	0.243***	0.145**	0.638***	0.670***
	(4.42)	(2.43)	(10.04)	(12.15)
ln(Energy)	0.136***	0.154***	-0.00112	0.0322
	(3.67)	(4.09)	(-0.04)	(1.38)
$\widehat{CCA}$	1.913**	9.053***	-0.924	155.9***
	(2.03)	(8.07)	(-0.23)	(5.23)
R^2	0.823	0.838	0.737	0.883
N	364	271	387	546
Time effects	Y	Y	Y	Y

▸ first stage

▸ bias

CCL impacts over time

	(1) SIC 15	(2) SIC 27	(3) SIC 28	(4) SIC 29
Inefficiency				
CCL×(Year=2001)	-1.779***	-1.973***	-3.396***	-2.840***
	(-5.53)	(-5.96)	(-10.95)	(-9.62)
CCL×(Year=2002)	-1.984***	-2.014***	-3.523***	-2.845***
	(-5.18)	(-6.03)	(-11.31)	(-10.06)
CCL×(Year=2003)	-1.791***	-2.008***	-3.465***	-2.929***
	(-5.66)	(-6.06)	(-11.17)	(-10.34)
CCL×(Year=2004)	-1.777***	-2.061***	-3.576***	-3.009***
	(-5.40)	(-6.15)	(-11.63)	(-10.69)
Prod. func. [ln(Turnover)]				
ln(Capital)	0.579***	0.429***	0.409***	0.320***
	(10.35)	(7.46)	(9.49)	(9.32)
ln(Employment)	0.243***	0.145**	0.638***	0.670***
	(4.50)	(2.28)	(9.92)	(11.96)
ln(Energy)	0.136***	0.154***	-0.00112	0.0322
	(3.76)	(4.04)	(-0.04)	(1.27)
$\widehat{CCA}$	1.913**	9.053***	-0.924	155.9***
	(2.00)	(8.01)	(-0.25)	(4.97)
R^2	0.823	0.838	0.737	0.883
N	364	271	387	546
Time effects	Y	Y	Y	Y

CCL impacts and energy intensity

	SIC 15		SIC 27		SIC 28		SIC 29	
	Below median	Above median	Below median	Above median	Below median	Above median	Below median	Above median
Inefficiency								
CCL	-10.26***	-3.556***	-4.786***	-2.359***	-5.871***	-4.214***	-3.458***	-4.487***
	(-9.00)	(-8.65)	(-12.41)	(-5.72)	(-9.99)	(-11.51)	(-8.13)	(-13.36)
Prod. func. [ln(Turnover)]								
ln(Capital)	0.231***	0.540***	0.110**	0.314***	0.377***	0.321***	0.360***	0.195***
	(3.63)	(10.58)	(2.24)	(5.37)	(3.50)	(6.66)	(8.77)	(3.44)
ln(Employment)	0.206***	0.136***	-0.0324	0.136**	0.153	0.572***	0.552***	0.558***
	(3.39)	(3.07)	(-0.48)	(2.33)	(0.81)	(8.31)	(8.19)	(6.25)
ln(Energy)	0.145***	0.0487*	0.340***	0.223***	0.110***	0.0669*	0.110***	0.0669*
	(3.40)	(1.90)	(14.11)	(5.33)	(3.17)	(1.72)	(3.17)	(1.72)
$C\hat{C}A$	-18.90***	3.040***	5.429***	4.955***	15.47***	-0.672	-11.54***	14.46***
	(-7.19)	(3.92)	(9.27)	(6.28)	(2.58)	(-0.15)	(-4.13)	(4.72)
R^2	0.867	0.749	0.893	0.903	0.709	0.714	0.870	0.752
N	301	259	100	171	96	291	293	253
Time effects	Y	Y	Y	Y	Y	Y	Y	Y

Robustness?

	(1) SIC 15	(2) SIC 27	(3) SIC 28	(4) SIC 29
Inefficiency				
CCL	-1.984***	-2.567***	-3.790***	-2.981***
	(-4.97)	(-5.88)	(-11.44)	(-9.55)
Prod. func. [ln(Turnover)]				
ln(Capital)	0.579***	0.429***	0.404***	0.324***
	(10.43)	(7.34)	(9.57)	(9.79)
ln(Employment)	0.243***	0.144**	0.583***	0.707***
	(4.39)	(2.41)	(9.25)	(14.19)
ln(Energy)	0.136***	0.154***	0.0121	0.0298
	(3.64)	(3.85)	(0.39)	(1.28)
$\widehat{CCA}$	1.913**	9.058***	-1.083	126.8***
	(2.01)	(7.99)	(-0.27)	(5.43)
R^2	0.823	0.820	0.723	0.887
N	364	267	378	540
Time effects	Y	Y	Y	Y

Conclusions and to do list

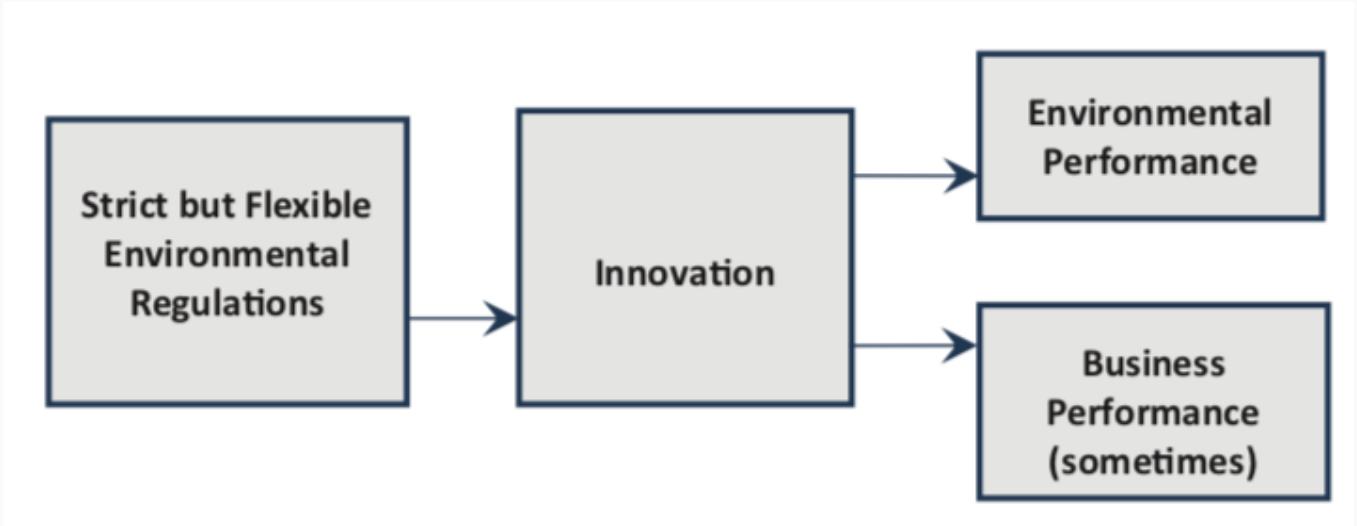
Still very preliminary:

- We revisit familiar PH ground, with a new methodology.
- We started by looking at the ‘low-hanging fruit’ claim.
- Preliminary results support the idea that inefficiency is reduced under regulatory pressure.

Still to do:

- Modelling frontier & inefficiency, focus on mechanisms, more sectors/countries.
- Other PH related questions pertain to innovation (SFA/DEA?) and to higher costs vs increased profitability...
- Identification with overlapping instruments (EU ETS). Beyond Brexit?

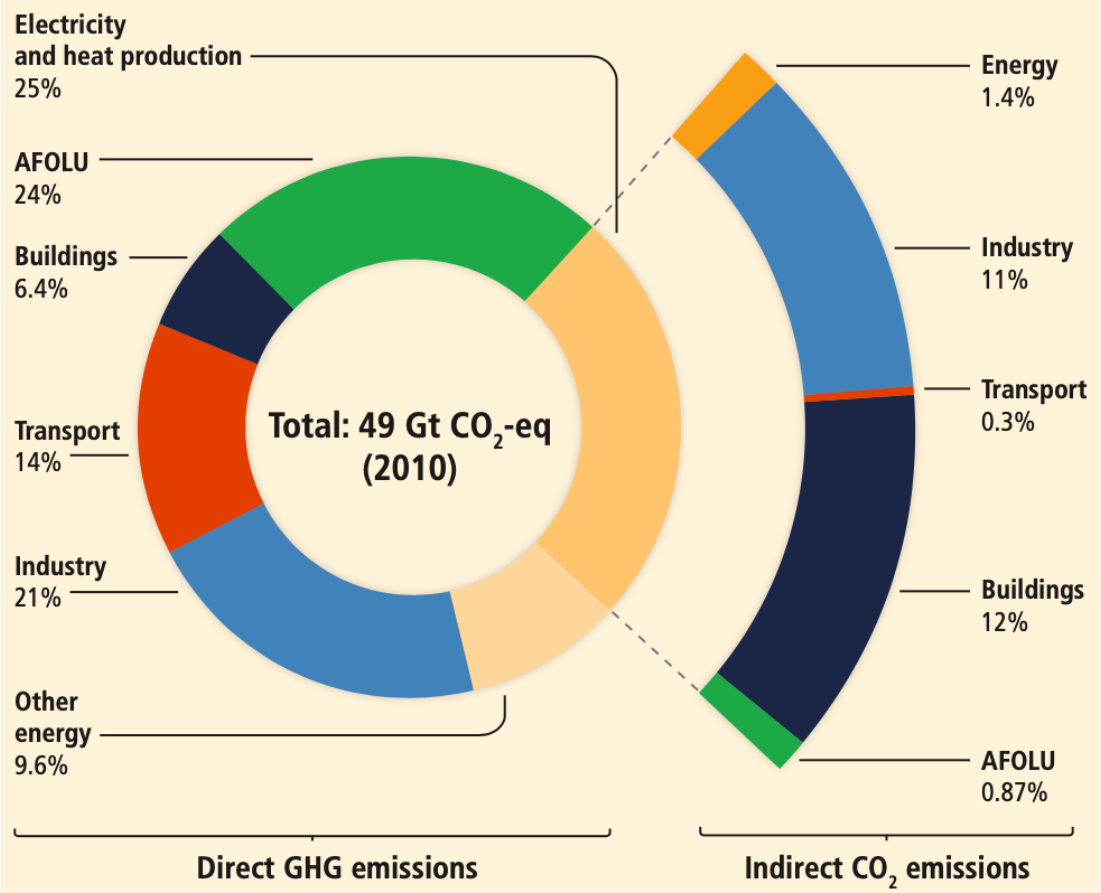
Causal links in the Porter hypothesis



Ambec et al. (2013)

back

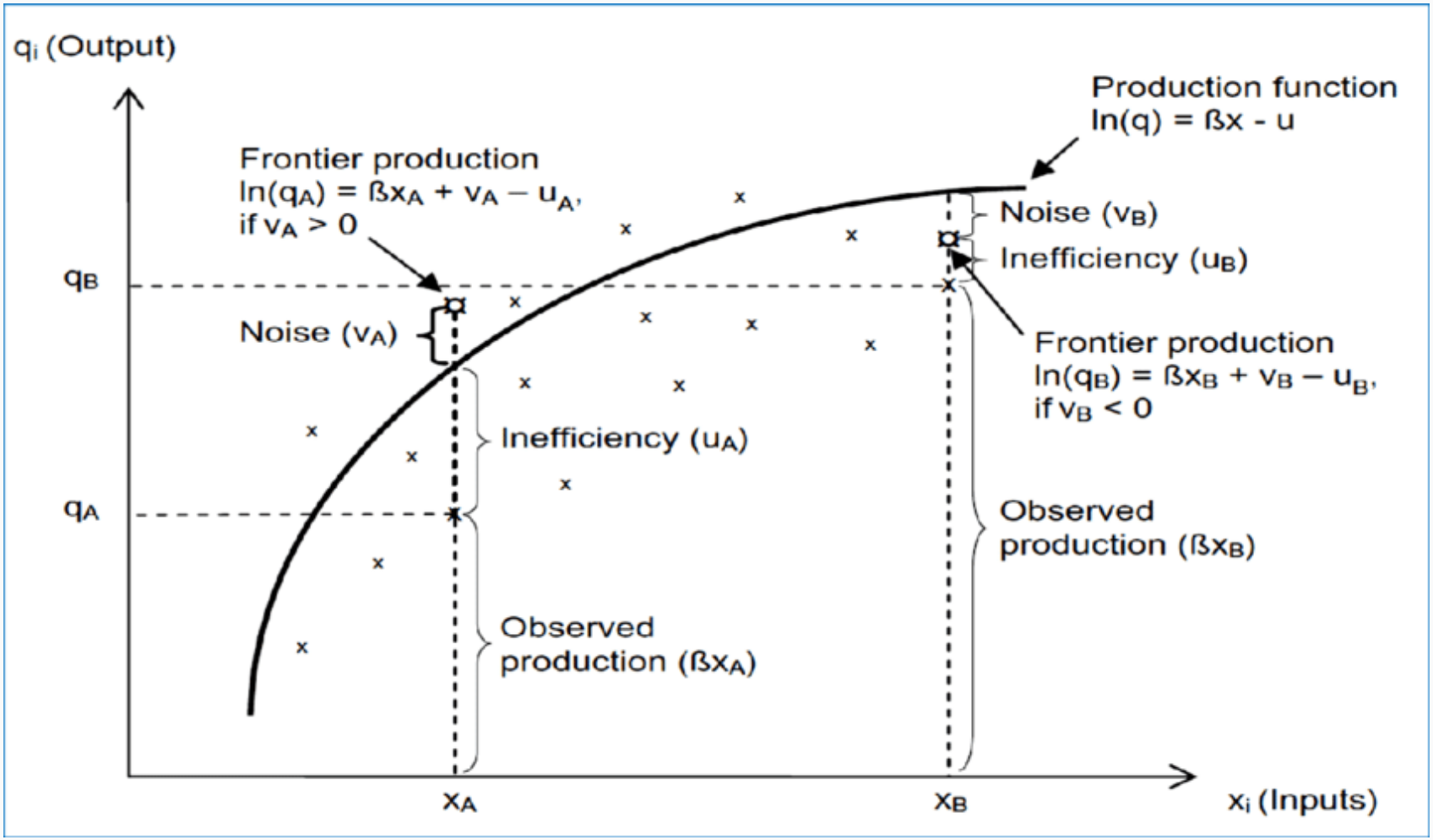
Global emissions of CO_2 by sector



Source: IPCC AR5 Synthesis Report (2014)

back

Stochastic frontier approach



▸ back

CCL rates

	Unit tax (p/kWh)	Tax rate (%)	Implicit carbon tax (£/t)
Natural gas	0.15	16.5	30
Coal	0.15	6.1	16
Electricity	0.43	10.1	31
LPG	0.07	8.2	22

Source: Martin et al. (2014), Pearce (2006).

back

Summary statistics

Variable	Mean	Std. Dev.	N
log(Turnover)	10.1191	1.3355	2,341
log(Employment)	5.4617	0.9697	2,341
log(Real capital stock)	9.7860	1.3424	1,711
log(Energy)	16.0699	1.7906	2,341
Climate Change Levy (dummy)	0.7104	0.4536	2,341
Climate Change Agreement (dummy)	0.0748	0.2630	2,341
CO_2 intensity	4.8370	47.0345	2,341
Energy intensity	0.0002	0.0044	2,341

▸ back

First stage regressions

	(1) SIC 15	(2) SIC 27	(3) SIC 28	(4) SIC 29
CCA				
CO_2 intensity	0.00264**	0.00113	0.0700***	0.0300
	(2.44)	(0.15)	(3.48)	(0.15)
Energy intensity	-5687.9*	-37306.4*	-3932.4	-63258.2
	(-1.89)	(-1.92)	(-0.35)	(-0.49)
Constant	-0.937***	-0.897***	-2.278***	-2.456***
	(-14.59)	(-9.50)	(-14.85)	(-10.98)
N	572	424	613	732
Time effects	Y	Y	Y	Y

back

Without sample selection

	(1) SIC 15	(2) SIC 27	(3) SIC 28	(4) SIC 29
Inefficiency				
CCL	-0.129	-0.0155	-0.144	-0.363
	(-1.51)	(-0.11)	(-0.68)	(-0.93)
Prod. func. [ln(Turnover)]				
ln(Capital)	0.583***	0.597***	0.413***	0.358***
	(12.55)	(9.81)	(9.77)	(10.26)
ln(Energy)	0.139***	0.165***	-0.00232	0.0276
	(4.51)	(3.74)	(-0.08)	(1.15)
ln(Employment)	0.272***	0.128*	0.649***	0.798***
	(5.81)	(1.95)	(10.35)	(16.41)
R^2	0.812	0.763	0.743	0.861
N	439	326	396	550
Time effects	Y	Y	Y	Y

▸ back