Why do more productive firms pollute less?

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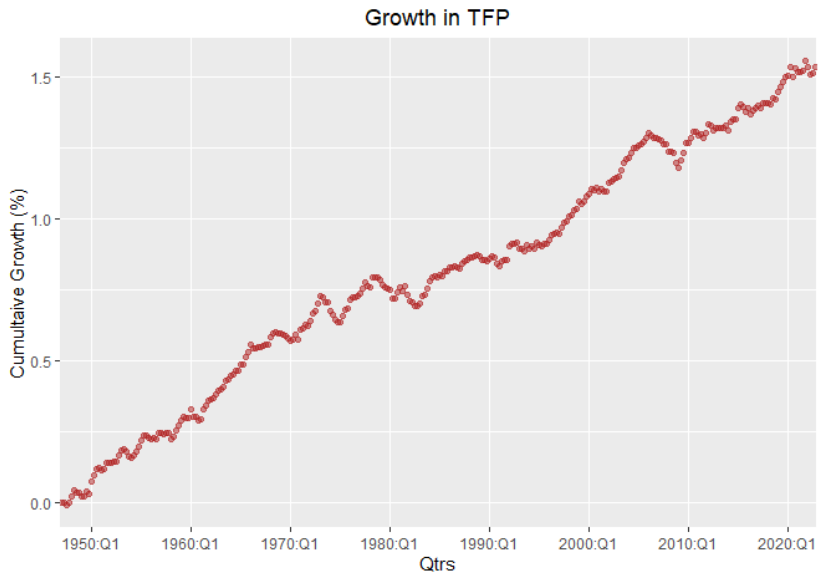
The evolution of firm productivity

- Over the last few decades there has been a tremendous growth in firm productivity (Fernald (2015))



Sources of variation in firm productivity

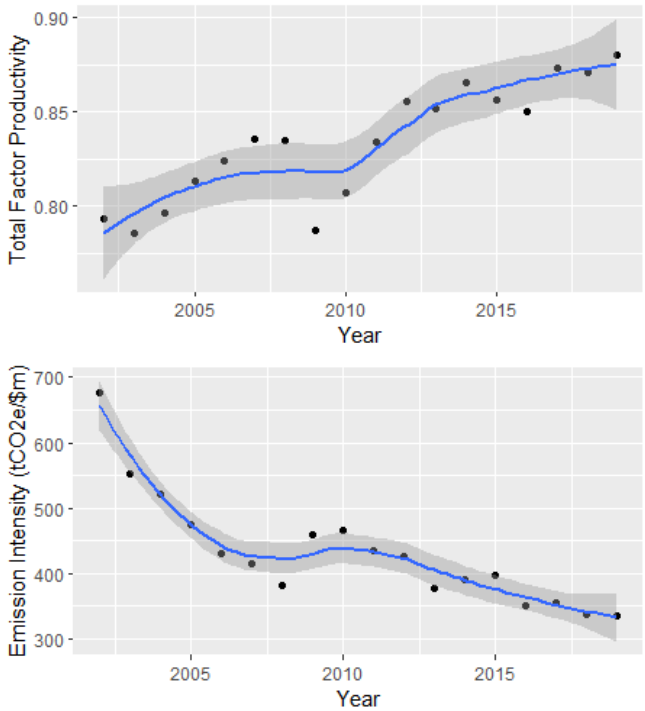
- Over the past couple of decades, researchers have documented substantial and persistent differences in productivity across firms (Syverson (2004))
- Differences in quality of inputs, quality of labour, managerial processes, Information Technology, R&D, structure of the firm, can result in differences in productivity of a firm, even within the same industry (Syverson (2011))
- External factors such as competition, regulation, externalities can also lead to productivity differences

What is the environmental impact of higher productivity?

- Does productivity come with an environmental cost?
  - Do more efficient production technologies pollute more?
- Or, does higher efficiency in utilizing inputs reduces the carbon footprint of firms?
- Why, and how, does productivity relate with firms' GHG emissions?

Emission Intensity has been on the decline

- On avergae, the decline in emission intensity (i.e. CO2e over sales) correlates with increase in TFP



- Is there any causal link? What is the underlying mechanism?

Data sources

- Sample consists of manufacturing firms (SIC codes between 0100 amd 3999) from 2003 to 2019
- I collect data on Emission Intensity from Trucost
- Financial data from Compustat
- Data on internet broadband speed from National Neighborhood Data Archive (NaNDA): Broadband Internet Availability and Speed by Zip code

Measuring firm productivity

- I use Production Function estimation to derive my estimates on productivity (Ackerberg, Caves, and Frazer (2015))
- The basic idea is to estimate the output as a function of observable input and the unobservable productivity

$$Y_t = A_t F(K_t, L_t, M_t, E_t),$$

where Y_t is output, K_t, L_t, M_t, E_t are observable inputs capital, labour, maerials, and energy, respectively. A_t is a factor neutral shifter and is a measure of total factor productivity (TFP)

Estimating the Production Function

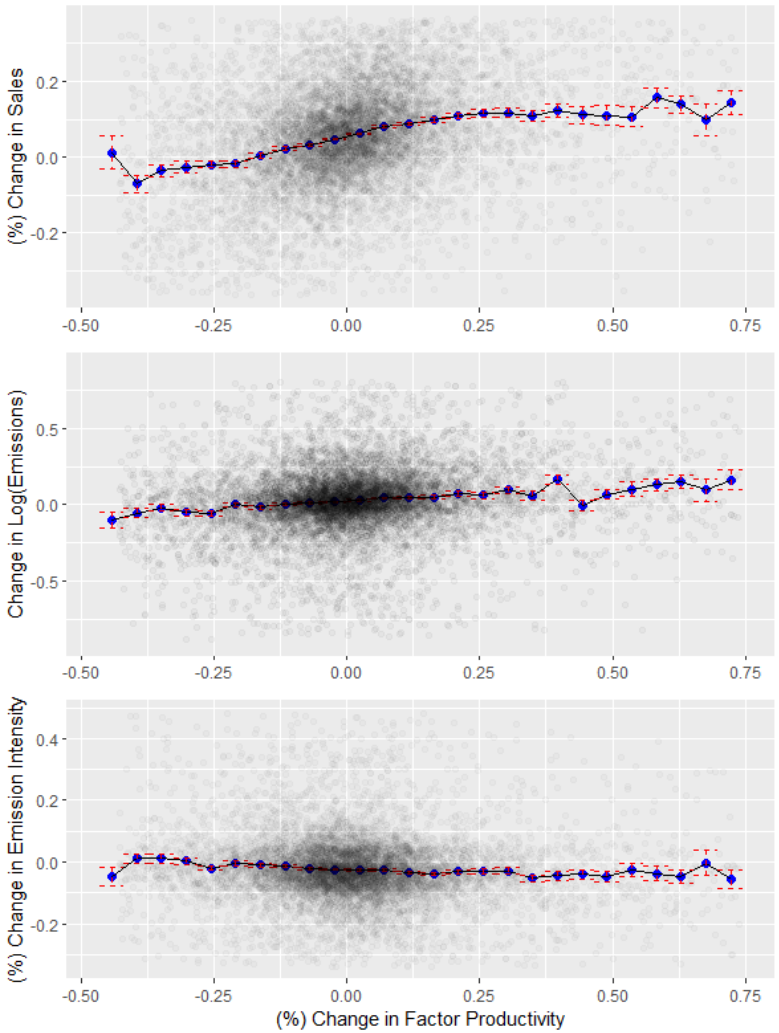
- I follow Olley and Pakes (1996) approach in estimating the production function
- Assume a Cobb-Douglas production function

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_m m_{it} + \beta_e e_{it} + \beta_k k_{it} + \omega_{it} + \epsilon_{it} \quad (1)$$

where the lower case variables are the respective log values of inputs, the associated β's are the technological parameters, and ω_{it} is the TFP ($\omega_{it} = Ln(\Omega_{it})$)

- If we can consistently estimate $\hat{\beta}_l$, $\hat{\beta}_m$, $\hat{\beta}_e$ and $\hat{\beta}_k$, we can back out the TFP

Increase in emissions but decrease in intensity

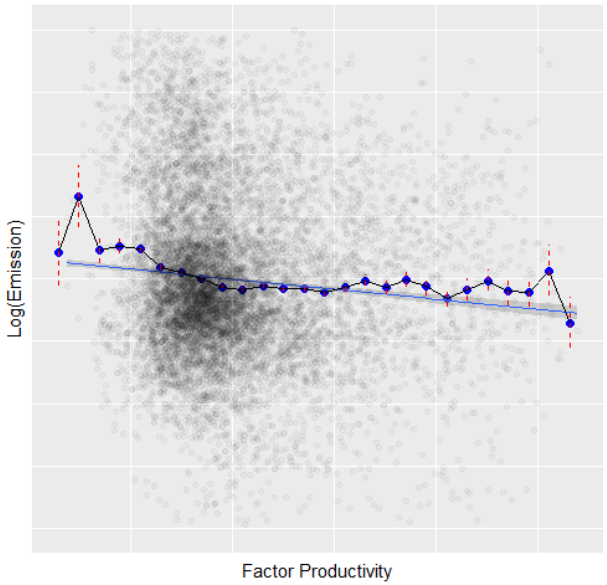


The economic magnitudes are substantial

	Δ Sales (%)			Δ Emissions (%)			Δ Emission Intensity (%)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Δ TFP (%)	0.250***	0.245***	0.233***	0.131***	0.129***	0.123***	-0.056***	-0.047***	-0.039***
	(0.013)	(0.012)	(0.013)	(0.017)	(0.017)	(0.018)	(0.010)	(0.009)	(0.010)
Year Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Firm Fixed Effect	No	No	Yes	No	No	Yes	No	No	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7831	7831	7831	7831	7831	7831	7831	7831	7831
Adjusted R^2	0.122	0.257	0.360	0.023	0.037	0.055	0.010	0.127	0.116

- 1 s.d. increase in TFP leads to **28% to 36% decrease** in Emission Intensity relative to its mean

Productive firms emit less CO2e



	Log(Emissions)		
	(1)	(2)	(3)
TFP	-0.367***	-0.376***	-0.058
	(0.104)	(0.106)	(0.055)
Firm Controls	Yes	Yes	Yes
Year Fixed Effects	No	Yes	Yes
Firm Fixed Effect	No	No	Yes
Observations	7831	7831	7831
Adjusted R^2	0.603	0.610	0.944

Addressing omitted variable bias

- Naturally, one needs to be cautious before drawing any causal link between the two
- Unobservables could drive changes in both
- For example, stakeholder pressure can cause firms to become more productive and also more environmentally sustainable
- Need an alternative identification strategy

Using broadband download speed as IV

- I use broadband internet speed as instrument
- Arguably, firms which operate in zip codes with higher broadband speed have faster speeds of communication and operation, thereby increasing productivity
- It is difficult to think of a mechanism in which broadband speeds would decrease firm emissions without impacting the production technology of the firm
  - Thus, the exclusion restriction is likely satisfied

Some casual evidence

First Stage

	TFP		
	(1)	(2)	(3)
Internet Speed (Mbps)	0.253***	0.261***	0.004
	(0.076)	(0.084)	(0.042)
F-Stat	11.01	9.72	0.01

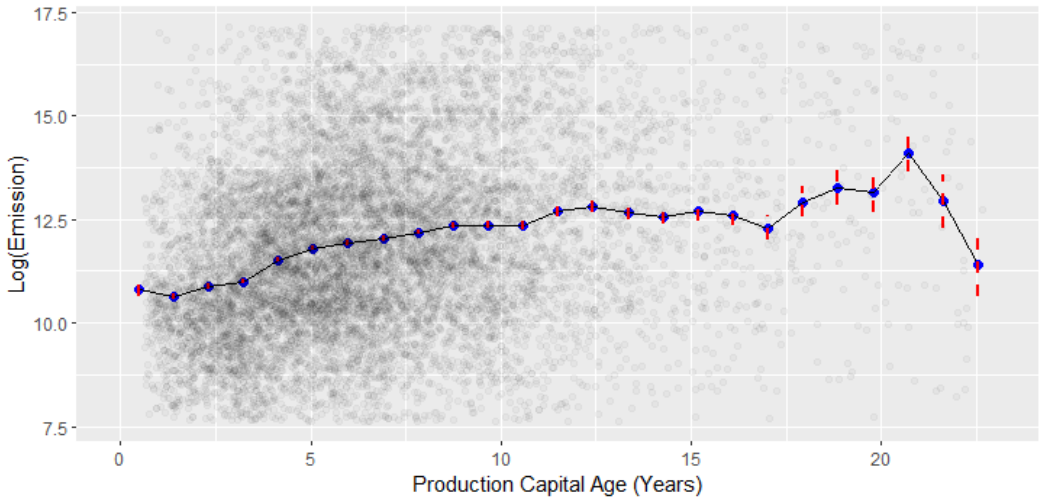
Second Stage

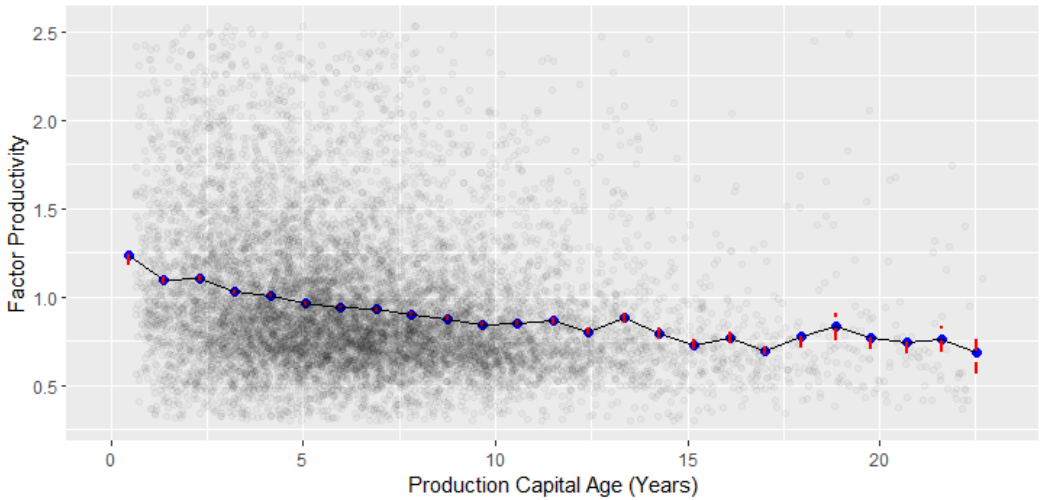
	Log(Emissions)		
	(1)	(2)	(3)
TFP	-3.186**	-3.081**	-24.312
	(1.275)	(1.328)	(273.916)
Firm Controls	Yes	Yes	Yes
Year Fixed Effects	No	Yes	Yes
Firm Fixed Effect	No	No	Yes
Observations	3018	3018	3018
Adjusted R^2	0.441	0.434	-80.754

Why does emission intensity decrease with productivity?

- To understand why emission decreases with productivity, I explore determinants of firm productivity
- Managerial Talent, Quality of inputs, R&D, Innovation, and Firm Structure are a few dimensions along which firm level productivity differs
- I focus on a more fundamental variable, the tehcnology at the disposal of the firm
- I investigate whether the age of the production capial can explain the relation

Production capital age ↓ productivity ↑ emissions ↓





Estimates with capital age

	TFP		
	(1)	(2)	(3)
Capital Age	-0.038***	-0.038***	-0.016***
	(0.003)	(0.003)	(0.003)
Firm Controls	Yes	Yes	Yes
Year Fixed Effects	No	Yes	Yes
Firm Fixed Effect	No	No	Yes
Observations	7831	7831	7831
Adjusted R^2	0.299	0.301	0.783
	Log(Emissions)		
	(1)	(2)	(3)
Capital Age	0.163***	0.166***	0.010
	(0.012)	(0.012)	(0.008)
Firm Controls	Yes	Yes	Yes
Year Fixed Effects	No	Yes	Yes
Firm Fixed Effect	No	No	Yes
Observations	7831	7831	7831
Adjusted R^2	0.491	0.502	0.942

Replacing existing technologies with new technology

- The evidence indicates that when firms replace existing production technology with new technology to increase production they also become more climate friendly
- Productivity gains is a key driver of replacing existing production technology with newer ones
- What drives firms to update their production technology?
- Syverson (2011) explores several external drivers of productivity differences across firms
- Some of key external drivers are **productivity spillovers**, **competition**, and **(de)regulation**

Competitive industries have higher productivity

- Firms in more competitive industries have newer production capital

	Production Capital Age (Years)			
	(1)	(2)	(3)	(4)
HHI (%)	17.898**	17.349**	17.501*	17.290*
	(8.788)	(8.829)	(9.144)	(9.166)
ROA			2.970***	2.854***
			(0.876)	(0.891)
LN(Assets)			-0.003	-0.011
			(0.058)	(0.059)
Constant	6.318***	6.326***	6.185***	6.259***
	(0.164)	(0.166)	(0.457)	(0.470)
Year Fixed Effects	No	Yes	No	Yes
Observations	8723	8723	8723	8723
Adjusted R^2	0.003	0.004	0.008	0.008

Putting it all together

- Productivity is negatively related to emissions
- Newer technology drives productivity increases
- Newer technology also emits less green house gases
- Competition is an important driver of firms adopting newer technology - climate sustainability is a positive spillover

Policy makers can incentivize firms to replace old production capital

- My results inform the debate about policy tools that can help us move towards climate neutrality
- Policy makers can consider providing firms incentives to replace old production technology
- Anti-trust policies could also take into the climate impact through the documented mechanism

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