Management Practices and Climate Policy in China

Mirabelle Muûls
Imperial College London Business School and Grantham Institute

joint with Soo Keong, Yong, Ulrich Wagner, Peiyao Shen, Laure de Preux, Ralf Martin and Jing Cao

EAERE-OECD pre-conference workshop
The joint environmental, social and economic impacts of environmental policies
June 21, 2021

Climate Policy in China

- "Factory of the world" + strong dependence on fossil fuels
- World's largest emitter of CO_2 (28% of global emissions)
- Key role for international efforts to avoid dangerous climate change
- Recent pledge to achieve carbon neutrality by the year 2060.
- Plans to launch a nation-wide cap-and-trade program for CO_2 emissions.

Why do we care about management practices?

- Theory: Pollution permit markets mitigate environmental externalities at minimum cost
- Practice: Agents decide to use, sell, or bank permit
- Not trivial for *any* manager:
    - awareness of all available abatement options
    - identify those with least cost
    - forecast future availability of abatement technologies and their cost
    - procure technology or conduct R&D within the firm

⇒ Firms' fortune in the carbon market depends on the attitude and aptitude of its management.

⇒ Success of China's national carbon market depends on the quality of its management resources.

This study

What:

- Analyze how management quality affects the effectiveness of cap-and-trade using pilot carbon trading schemes in two regions.
- Learn about the effects of future nation-wide market.

How:

- Key ingredient: new index of management practices related to climate change
- Interviews with plant managers or lead engineers at 216 randomly selected firms.
- Combine this with program evaluation of Beijing ETS

Preview of Main Results

- 1-SD increase in management quality is associated with 7.4% improvement in revenue productivity.
- Beijing ETS has reduced consumption of coal and electricity by treated firms relative to control firms
- Statistically significant effect only for well-managed firms.
- Overall reduction in coal use due to ETS would have been $3\times$ smaller in the absence of good managers

Contribution

1. First evidence that better management can leverage the effect of market-based instruments for climate change regulation in China.
2. Timely and policy-relevant:
   - imminent roll-out of the world's largest carbon market to-be.
   - other emerging economies are considering cap-and-trade for GHG emissions
3. Connects new empirical management lit. with emerging program evaluation lit. on carbon pricing
4. Contribute novel data on management practices at Chinese firms relating to energy use and climate change mitigation

Outline

Carbon Trading in China

Timeline

- **2011** Cap-and-trade for GHG Emissions officially adopted.
- **2013-14** Pilot ETS in 5 cities and 2 provinces launched.
- **2021** 1*st* phase of nation-wide ETS: 2,267 power companies, 40% of China's GHG emissions
- **202?** Nation-wide market encompassing 3.5 Gt CO_2

Pilot ETS:

- Energy-intensive industries such as power and heating, cement, chemicals, iron and steel
- Non-industrial sectors such as hospitals, hotels and buildings
- 1.2 Gt CO_2, $\sim$ 16% of CO_2 emissions, 20% of energy use
- Participation thresholds: Beijing 10 kt CO_2. Hubei 60 kt of coal equivalent

Performance of ETS | Literature

Outline

Data sources and sampling

1. Financials: ORBIS (Bureau Van Dijk)
2. Management practices:
   - Industrial firms located in Beijing and Hubei drawn at random from ORBIS and contacted for an interview.
   - Oversampling of ETS companies.
   - 219 interviews between summer 2016 and end of 2017
3. Patent filings: China National Intellectual Property Administration database (CNIPA)
4. Fuel and water use: Chinese State Administration of Tax (CSAT)

Interviewing Managers

- **Interviewers:** Chinese graduate students at ShanghaiTech, Imperial College and LSE.
- **Interviewee:** Manager or engineer in charge of environmental issues on site
- Telephone survey tool minimizes cognitive bias (Bloom & van Reenen, 2007):
  - open-ended questions
  - double-blind scoring
  - interviewer fixed effects
- Average interview lasted 35 minutes.
- Questionnaire previously used in Europe (Martin et al., 2012, 2014):

The Climate Change Management (CCM) Index

- Summary measure of management practices related to climate change
- Computed as the average of 21 z-scores to answers about
  - awareness of issues of climate change and pollution
  - energy and GHG emissions monitoring
  - targets and enforcement
  - competitive and customer pressures w.r.t. climate change

Index Components

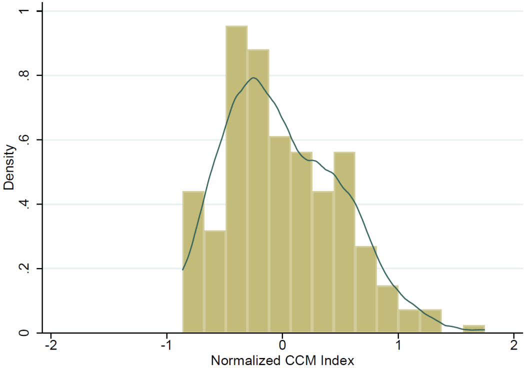


Figure: Distribution of the Climate Change Management Index

Descriptive Statistics

Outline

CCMI and Firm Productivity

OLS Regression

$$\log(TURNOVER_{it}) = \alpha_0 + \beta_M CCMI_i + \mu' c_{it} + x_{it}'\gamma + z_i'\delta + u_{it}. \quad (1)$$

c_{it} employment, capital, cost of goods sold

β_M CCMI contribution to productivity residual

x_i firm controls
age, exporter status, state ownership, region and industry at the two-digit NACE level.

z_i: interview 'noise' controls
day-of-week interview, interviewer fixed effects, tenure, educational background and gender of interviewee.

Climate Change Management Index and Productivity

	(1)	(2)	(3)
		Log Turnover	
CCM index	0.919***	0.695***	0.144**
	(0.201)	(0.174)	(0.061)
Hubei firm		-0.056	-0.001
		(0.224)	(0.079)
State-owned		0.483***	0.071
		(0.158)	(0.061)
Log(Employment)		0.492***	0.065
		(0.090)	(0.050)
Log(Capital)			0.151***
			(0.038)
Log(Cost of Goods Sold)			0.733***
			(0.071)
Number of observations	1601	1601	1601
Number of firms	216	216	216
R-squared	0.478	0.613	0.901

Notes: OLS regressions of log turnover (2007-2016) on CCM index include year, industry, interview, interviewee and interviewer controls. Controls for the region (Hubei vs Beijing) of the firm, state-ownership, log of employment as well as exporter status, age and age squared of the firm are included in columns (2) and (3). Column (3) includes (log) cost of goods sold and capital. Robust standard errors given in parenthesis are clustered at the firm level. Significance levels are indicated as * 0.10, ** 0.05, *** 0.01.

Better Management - better performance

- CCM index is positively and significantly associated with (log) turnover.
- A one-standard-deviation increase (0.50) in the CCM index is associated with a 7.4% increase in revenue productivity.
- Closely mirrors results obtained for UK manufacturing firms where the associated increase in revenue productivity is 5% (Martin et al., 2012)
- Also consistent with Bloom et al. (2013) who estimate that increasing a general management score by one standard deviation causes a 17% increase in productivity (Indian textile manufacturing)
- No conditional correlation between CCMI and fuel intensity (unlike Bloom et al., 2010; Martin et al., 2012; Boyd & Curtis, 2014)

Patents and innovation

Outline

How do CCM practices interact with climate change policies?

- Carbon pricing in the Beijing pilot ETS
- Focus on firm-level adjustments to energy usage following the introduction of the ETS
- Examine heterogeneity in these adjustments between well-managed firms and the rest of the pack.

Fuel Use in Response to Carbon Trading

Let firm i's fuel demand be given by

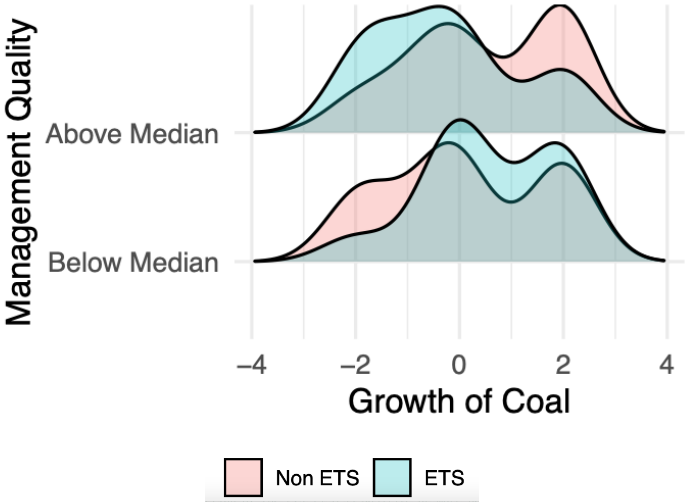
$$e_{i,t} = \theta_i f(x_{i,t}, \epsilon_{i,t}) \geq 0. \tag{2}$$

Growth rate based on average energy use in pre- (e_i^{pre}) and post-treatment periods (e_i^{post}):

$$\gamma_i = \frac{e_i^{post} - e_i^{pre}}{0.5 \times (e_i^{post} + e_i^{pre})}. \tag{3}$$

- accommodates zero energy consumption
- unobserved heterogeneity θ_i drops out.
- simple DiD estimator compares γ_i between treated and untreated

Distribution of γ by ETS Status and CCM Index



Econometric Evidence on γ

Regression model

$$\gamma_i = \mathbf{d}_i'\beta + \varepsilon_i \tag{4}$$

Vector $\mathbf{d}_i$ partitions the sample into different groups of firms.

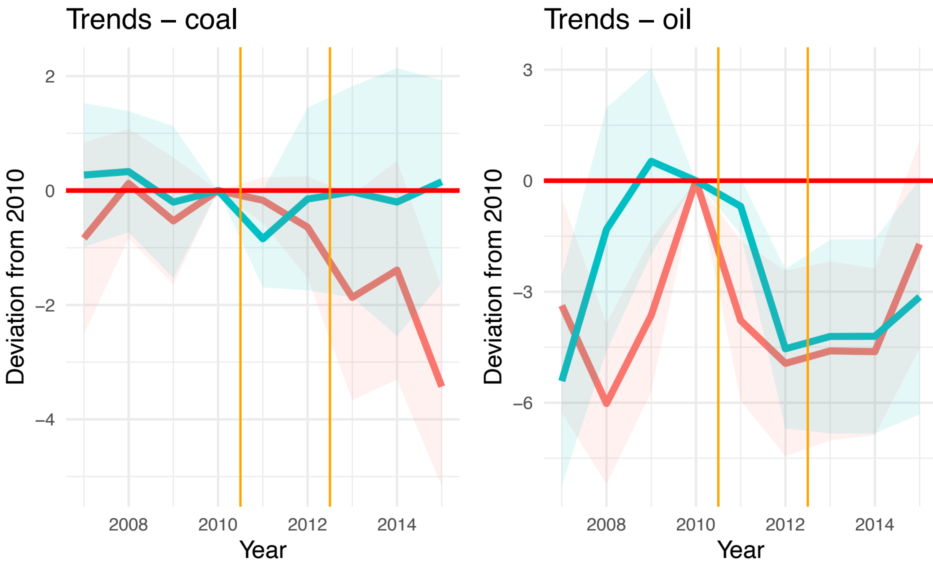
Table: ETS Impact on Growth of Energy Use

Dependent Variables:	ΔCoal		ΔOil		ΔElectricity		ΔWater	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ETS firm	-0.3454	0.6675	0.1890	-0.3206	-0.3387*	-0.1424	0.0049	-0.0739
	(0.2965)	(0.5245)	(0.2439)	(0.4386)	(0.1848)	(0.3845)	(0.1653)	(0.3074)
Above-median CCM index		0.4677		-0.2037		-0.0968		-0.2705
		(0.4497)		(0.2749)		(0.2572)		(0.2311)
ETS firm× above-median CCM index		-1.541**		0.7893		-0.1887		0.2751
		(0.6811)		(0.5410)		(0.4637)		(0.3848)
Observations	110	110	125	125	127	127	128	128
R^2	0.01221	0.05412	0.00522	0.02334	0.02630	0.03293	6.88×10^{-6}	0.00966
Adjusted R^2	0.00306	0.02735	-0.00287	-0.00087	0.01852	0.00934	-0.00793	-0.01430

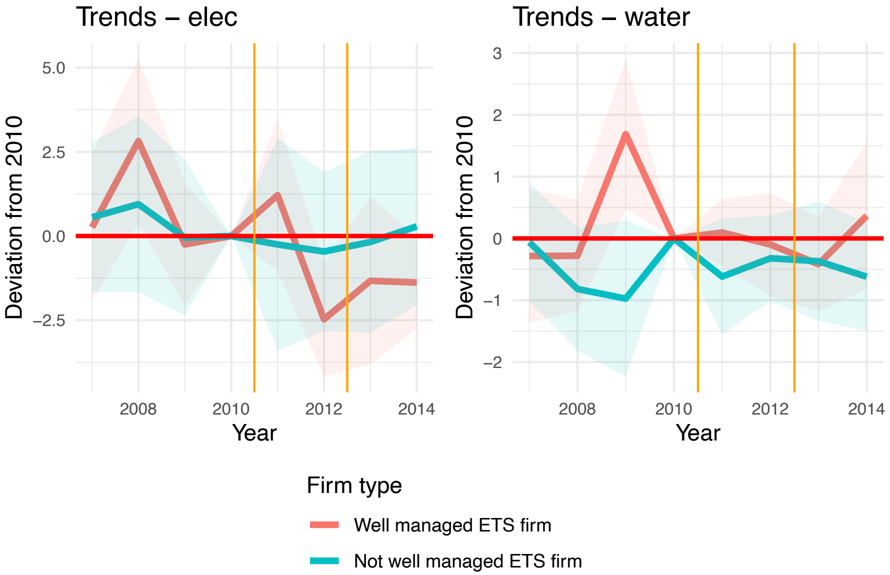
Notes: OLS regressions include a constant (omitted). The dependent variables are the arc growth rates, as defined in eq. (3), for tons of coal (columns (1) and (2)), tons of oil (columns (3) and (4)), electricity (in 10,000 Watts) (columns (5) and (6)), and water consumption in litres (columns (7) and (8)). Robust standard-errors in parentheses. Significance levels are indicated as * 0.10, ** 0.05, *** 0.01.

Fuel usage by firm

Trends in Fossil Fuel Consumption (2007-2015)



Trends in Electricity and Water Consumption (2007-2014)



Robustness I: Size Differences in Initial Fuel Use

Table: ETS Impact on Growth of Energy Use with Management and Size

Dependent variables:	ΔCoal (1)	ΔOil (2)	ΔElectricity (3)	ΔWater (4)
ETS firm	0.9163**	0.3792	0.3265	-0.0314
	(0.4015)	(0.4511)	(0.5972)	(0.5528)
Above-median CCM index	0.4805*	-0.0829	-0.0398	-0.1883
	(0.2447)	(0.2607)	(0.2457)	(0.2359)
Above-median coal consumer	-2.341***			
	(0.2818)			
ETS Firm × above-median CCM index	-1.071**	0.9708**	-0.1783	0.1900
	(0.4326)	(0.4456)	(0.4278)	(0.3912)
ETS Firm × above-median coal consumer	-0.0667			
	(0.4455)			
Above-median oil consumer		-0.9810***		
		(0.2652)		
ETS Firm × above-median oil consumer		-0.7685*		
		(0.4329)		
Above-median electricity consumer			-0.4780**	
			(0.2271)	
ETS Firm × above-median electricity consumer			-0.2942	
			(0.5594)	
Above-median water consumer				-0.5930**
				(0.2348)
ETS Firm × above-median water consumer				0.3914
				(0.5173)
Observations	110	125	127	128
R^2	0.57375	0.25253	0.09165	0.05520
Adjusted R^2	0.55325	0.22112	0.05412	0.01648

Notes: OLS regressions include a constant (omitted). Above-median are dummies indicating the firm is above the sample's median for the CCM Index, or for their pre-2013 average water or energy consumption for each fuel. Robust standard-errors in parentheses. Significance levels are indicated as * 0.10, ** 0.05, *** 0.01.

Robustness II: Panel data

Alternative regression model is Poisson (Silva & Tenreyro, 2006)

$$e_{it} = \exp(\beta_0 ETS_i \times POST_t + \beta_1 ETS_i \times CCM_i \times POST_t' + \alpha_i + \alpha_t + \epsilon_{it})$$

Table: ETS Impact - Poisson Specification (2007-2015)

Dependent Variables:	Coal	Oil	Electricity	Water
Model:	(1)	(2)	(3)	(4)
Variables				
ETS firm x After 2012	0.5818	-2.553**	1.338	0.1564
	(0.5181)	(1.161)	(1.006)	(0.2593)
ETS firm x Above Median CCMI x After 2012	-1.697*	2.509*	-2.818***	-0.3459
	(0.9832)	(1.410)	(1.058)	(0.6192)
Fixed-effects				
Year	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Fit statistics				
Observations	781	862	880	880
Squared Correlation	0.94102	0.58844	0.99495	0.71346
Pseudo R^2	0.92722	0.72998	0.94755	0.84335
BIC	9,037,626.2	5,625,891.9	14,258,427.1	305,864,833.5

Notes: Poisson fixed-effect regressions. The dependent variables are consumption of energy by the firm in each year between 2007 and 2015, i.e. tons of coal (column 1), tons of oil (column 2), electricity (in 10,000 Watts) (column 3), and water consumption in liters (columns 4). Above-median CCMI is a dummy indicating the firm is above the sample's median for the CCM index that is interacted with two dummies, one indicating participation in the ETS (ETS firm) and the other the time period (post 2012, i.e. years in which the ETS is in place). Robust standard-errors (clustered at the firm level) in parentheses. Significance levels are indicated as * 0.10, ** 0.05, *** 0.01.

How much does management matter?

Counterfactual:

Compute impact of ETS on coal use assuming that all firms are not-so-well managed (below-median CCMI).

$$e_{post}^{CF} = \gamma^{CF} \cdot 0.5(e_{post} + e_{pre}) + e_{pre} \tag{5}$$

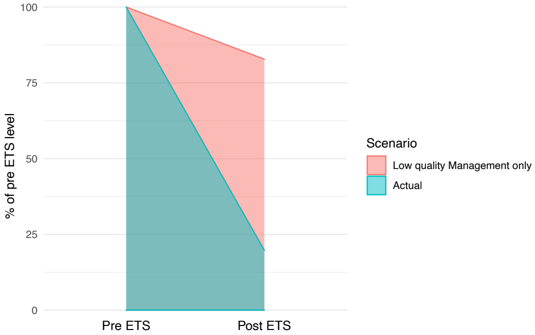
where

$$\gamma_i^{CF} = \gamma_i - \beta_{CCM \times ETS} \times ETSFirm_i \times AboveMedianCCM_i \tag{6}$$

We assess this counterfactual scenario using our most conservative estimate of the effect on coal consumption, $\beta_{CCM \times ETS} < 0$.

Management matters for effectiveness of carbon pricing

Figure: Counterfactual Reduction in Coal Consumption



Reduction in coal use is three times larger with well-managed firms

⇒ Management quality a bottle-neck for cost effective trading in China?

Outline

Conclusions

- **Main finding:** ETS-regulated firms reduced their consumption of carbon-intensive fuels more strongly than unregulated firms, but only if well managed.
- **Interpretation:** Understanding trade-off between using, selling or banking a pollution permit, is more demanding on manager skills than complying with a quota or standard.
- **Implication:** Complementary policies are needed to enhance the effectiveness of China's nation-wide ETS to be rolled out later this year.