The Real Effects of China's Carbon Dioxide Emissions Trading Program

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Research Background

- China's emissions trading system (ETS) is the world's largest by emissions volume coverage and was first established in an emerging economy
  - National + 7 regional pilots
  - The national market is estimated to cover 5 billion tCO_2e as of 2023
- China’s ETS applies a salient two-stage emissions intensity-based compliance allowance allocation scheme, different from the “cap-and-trade” scheme prevalent in the developed economies

Research Questions

- The real effects of China's emissions trading program on capital investment, R&D, and employment decisions
- The implications for output, profit, productivity, and operating efficiency
- The interactions with state ownership, industry heterogeneity, and region disparity

Institutional Backgrounds

- China has chosen ETS over carbon taxation as the primary policy tool
  - Weak legal framework, region disparity, industrial heterogeneity, and continuously evolving climate policies (Duan and Zhou, 2017; Goulder et al., 2017; Karplus and Zhang, 2017)
  - Market-based carbon pricing gives greater autonomy for firms in determining how to achieve the emissions target
- The implementation has followed a learning-by-doing approach
  - 7 regional pilot programs (East: Beijing, Shanghai, Tianjin; South: Guangdong, Shenzhen; Central: Hubei; West: Chongqing) were established in 2013-2014
  - The national program was launched in 2021

Institutional Backgrounds: Industry Coverage

- Regional pilots
  - Energy-intensive sectors: power, petrochemicals, chemicals, iron and steel, nonferrous metals, construction materials, paper, and civil aviation
  - Reflecting regional characteristics, e.g., seaports and airports in Shanghai; hotels and hospitals in Beijing
- The national market
  - Long-term scope: the energy-intensive sectors, over 7000 entities, and 70% of China's carbon emissions
  - Current (initial) coverage: 2162 entities with annual emissions over 26,000 tCO_2e in the power sector
  - The Ministry of Ecology and Environment (MEE) has required firms in the other 7 sectors with annual emissions exceeding 26,000 tCO_2e to report carbon emissions in 2021

Institutional Backgrounds: Allowance Allocation

- Two-stage allowance allocation scheme:
  - Firms first receive a fraction (typically 60-70%) of the allowance benchmarked to historical emissions, following the "grandfather" rule
  - Firms obtain the rest of the allowance based on the actual production at the end of the compliance period
- Effectively intensity-based (carbon per unit of output) allocation constitutes an output subsidy (Goulder and Morgenstern, 2018; Goulder et al. 2022)
- Policymakers have hinted that China will switch to the emissions-based allowance allocation scheme when the ETS becomes more mature

Institutional Backgrounds: Auction and Trading

- In the regional markets, nearly 95% of the emissions allowances are allocated for free, and 3% to 10% of the budgeted allowances are reserved for auction
- Allowances are currently allocated for free in the national market. It has been announced that auctions will be introduced and gradually expanded, but there is no specific timeline
- The average price in the national ETS was about USD 10 per tCO_2e in 2023
  - Korea ETS (USD 8) and Tokyo C&T (USD 5)
  - European Union ETS (USD 90) and California C&T (USD 33)

Institutional Backgrounds: MRV and Penalty

- Monitoring, reporting, and verifying (MRV) emissions have been a significant challenge (Zhang et al., 2019)
  - The MEE has been amending the MRV guidelines and technical specifications for the national ETS every year
  - Provincial-level ecological and environmental authorities are responsible for the verification of the emissions reports
- Penalties for violations have been increased but are still lenient
  - Fines for failing to submit a report have increased from CNY 10,000-30,000 (USD 1,411-4,234) to CNY 50,000-200,000 (USD 7,058-28,232)
  - Fines for compliance failure have increased from CNY 20,000-30,000 (USD 2,822-4,234) to five to ten times the market value of the exceeded emissions
- Borrowing from future compliance periods is permitted (with a flavor of carbon credit)

Empirical Methodology

- The baseline DiD model:

$$Decision/Performance_{i,t} = \beta ETS_{i,t} + \gamma Controls_{i,t} + \epsilon_{i,t}$$

- Decisions: *capital expenditure, R&D, number of employee, wage*
- Performance: *revenue, EBITDA, TFP, revenue per capita, Tobin's Q, ROA*
- Control variables: size, age, leverage, cash, tangibility, growth, BM, stock returns, stock return volatility + the dependent variable lagged by one period + firm and year fixed effects
- The level variables are CPI-adjusted

Data

- Compliance entities include listed firms or their subsidiaries or holding companies. Manually matched the compliance entities to the listed firms.
  - Treated firms: the listed firms if themselves, or their subsidiaries or holding companies are covered by the ETS (regional or national) at time *t*
  - Control firms: listed firms not covered by the ETS at time *t*
- The final sample contains 28,797 firm-ETS-year observations from 3,796 individual firms in 2009-2021, among which 510 compliance firms provide 2,459 observations.

Key Findings

	$logCAPX_{i,t}$			$logRDSpend_{i,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$ETS_{i,t}$	0.177***	0.142***	0.088***	0.220***	0.174**	0.082
	(3.44)	(3.27)	(2.90)	(3.01)	(2.30)	(1.15)
$logASSETS_{i,t}$		1.160***	0.713***		0.667***	0.526***
		(34.82)	(26.27)		(13.54)	(9.67)
$logAGE_{i,t}$		-0.900***	-0.597***		-0.756**	-0.358

	$logCAPX_{i,t}$	$logRDSpend_{i,t}$
	(1)	(2)
$ETS_{i,t}$	0.074***	0.074
	(3.42)	(1.15)
$ETS_{i,t} \times SOE_{i,t}$	0.056*	0.160
	(1.83)	(1.47)
$SOE_{i,t}$	-0.122***	-0.172***
	(-7.91)	(-3.53)
$logASSETS_{i,t}$	0.362***	0.893***
	(30.45)	(44.93)
$logAGE_{i,t}$	-0.157***	-0.002
	(-7.73)	(-0.04)

- Compliance firms significantly invested additionally in capital assets, more prominent for state-owned enterprises (SOEs)
- R&D is not significantly correlated with ETS coverage after controlling the previous year's R&D

Key Findings

	$logEMP_{i,t}$			$logWAGES_{i,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$ETS_{i,t}$	0.061*	0.056**	0.025**	0.012	0.008	0.012
	(1.79)	(2.10)	(1.98)	(0.37)	(0.38)	(1.34)
$logASSETS_{i,t}$		0.652***	0.274***		0.730***	0.268***
		(33.20)	(21.14)		(42.24)	(21.82)
$logAGE_{i,t}$		0.136	-0.043		0.265***	-0.060*
		(1.12)	(-0.86)		(2.85)	(-1.72)
$LEVERAGE_{i,t}$		0.066	-0.004		0.022	-0.036
		(1.07)	(-0.12)		(0.42)	(-1.50)
$ROA_{i,t}$		0.108	0.096*		0.183**	0.102**
		(1.23)	(1.81)		(2.37)	(2.39)
$CASH_{i,t}$		-0.167***	-0.033		-0.243***	-0.023
		(-3.18)	(-1.21)		(-5.51)	(-1.15)
$TANGIBILITY_{i,t}$		0.634***	0.213***		0.530***	0.152***
		(7.81)	(5.18)		(7.97)	(4.74)
$GROWTH_{i,t}$		0.017	0.184***		-0.025***	0.230***
		(1.58)	(18.53)		(-2.99)	(25.17)
$SOE_{i,t}$		0.059*	0.023		0.080***	0.034***
		(1.73)	(1.36)		(3.14)	(2.69)
$BM_{i,t}$		-0.115***	-0.033**		-0.205***	-0.073***
		(-3.99)	(-2.48)		(-8.17)	(-6.74)
$RET_{i,t}$		-0.023***	0.001		-0.069***	-0.032***
		(-2.84)	(0.25)		(-10.34)	(-7.00)
$VOL_{i,t}$		-0.005	-0.003		0.028**	0.006
		(-0.31)	(-0.26)		(2.07)	(0.65)
$logEMP_{i,t-1}$			0.650***			
			(54.27)			
$logWAGES_{i,t-1}$						0.711***
						(66.71)
Firm FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	28320	24634	24626	28318	24632	24629
Adjusted R^2	0.899	0.937	0.969	0.917	0.961	0.984

- Compliance firms hired more workers
- No significant differences between the wages of compliance firms and non-compliance counterparts

Key Findings

	$LOWSKILL_pct_{i,t}$	$HIGHSKILL_pct_{i,t}$	$RDPerson_pct_{i,t}$	$ADM_pct_{i,t}$	$SALEMAN_pct_{i,t}$
	(1)	(2)	(3)	(4)	(5)
$ETS_{i,t}$	0.018***	-0.017***	0.002	-0.002	-0.000
	(2.82)	(-3.36)	(0.58)	(-0.49)	(-0.09)
$logASSETS_{i,t}$	0.001	0.005	0.001	-0.005**	-0.007**
	(0.25)	(1.51)	(0.40)	(-2.17)	(-1.96)
$logAGE_{i,t}$	0.001	-0.033	-0.021	0.018	0.004
	(0.03)	(-1.35)	(-0.91)	(1.03)	(0.18)
$LEVERAGE_{i,t}$	0.036**	-0.022*	-0.025***	-0.015**	-0.012
	(2.56)	(-1.96)	(-2.80)	(-2.20)	(-0.98)
$ROA_{i,t}$	0.075***	-0.019	-0.022*	-0.017	-0.023
	(3.40)	(-1.11)	(-1.67)	(-1.51)	(-1.25)
$CASH_{i,t}$	0.000	-0.004	-0.002	-0.007	0.009
	(0.00)	(-0.42)	(-0.26)	(-1.10)	(0.99)
$TANGIBILITY_{i,t}$	0.142***	-0.049***	-0.022**	-0.015*	-0.080***
	(7.20)	(-2.90)	(-2.12)	(-1.69)	(-5.26)
$GROWTH_{i,t}$	-0.002	0.002	-0.001	0.000	0.004**
	(-0.80)	(0.83)	(-0.46)	(0.07)	(2.09)
$SOE_{i,t}$	0.002	-0.008	-0.006	0.007	0.001
	(0.18)	(-1.19)	(-1.36)	(1.64)	(0.17)
$BM_{i,t}$	0.001	-0.013**	-0.004	0.001	0.004
	(0.12)	(-2.43)	(-0.93)	(0.22)	(0.80)
$RET_{i,t}$	0.005*	-0.005**	-0.003**	-0.000	0.000
	(1.87)	(-2.48)	(-2.26)	(-0.01)	(0.31)
$VOL_{i,t}$	-0.007	0.001	-0.001	0.000	0.000
	(-1.53)	(0.28)	(-0.56)	(0.18)	(0.13)
Firm FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
Observations	20022	22227	15038	19908	21554
Adjusted R^2	0.877	0.868	0.908	0.669	0.876

- The percentage of low-skilled workers is positively correlated with ETS coverage, while the percentage of high-skilled workers is negatively correlated, implying a workforce structure adjustment

Key Findings

	$logOUTPUT_{i,t}$			$logEBITDA_{i,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$ETS_{i,t}$	0.051	0.018	0.002	0.130***	0.038*	0.010
	(1.49)	(0.88)	(0.41)	(3.03)	(1.82)	(0.69)
$logASSETS_{i,t}$		0.807***	0.082***		0.983***	0.660***
		(52.01)	(7.18)		(67.55)	(42.46)
$logAGE_{i,t}$		0.346***	0.007		0.146	0.243***
		(3.97)	(0.36)		(1.60)	(3.76)
$LEVERAGE_{i,t}$		0.344***	0.055***		-0.098*	0.046
		(6.55)	(3.55)		(-1.83)	(1.15)
$ROA_{i,t}$		1.709***	0.299***		8.286***	6.846***
		(20.94)	(9.38)		(42.77)	(36.10)
$CASH_{i,t}$		-0.203***	0.002		-0.076	-0.086**
		(-4.51)	(0.21)		(-1.63)	(-2.41)
$TANGIBILITY_{i,t}$		0.321***	0.067***		0.803***	0.622***
		(4.79)	(3.57)		(12.57)	(13.15)
$GROWTH_{i,t}$		0.202***	0.781***		0.132***	0.363***
		(23.86)	(99.29)		(11.45)	(24.41)
$SOE_{i,t}$		0.058*	0.011		0.006	0.041
		(1.91)	(1.34)		(0.17)	(1.50)
$BM_{i,t}$		-0.173***	0.004		-0.239***	-0.111***
		(-6.89)	(0.55)		(-8.37)	(-4.90)
$RET_{i,t}$		-0.058***	0.004		-0.012	0.054***
		(-8.66)	(1.50)		(-1.27)	(6.26)
$VOL_{i,t}$		0.026**	-0.005		-0.023	-0.067***
		(1.97)	(-0.88)		(-1.23)	(-3.93)
$logOUTPUT_{i,t-1}$			0.921***			
			(88.91)			
$logEBITDA_{i,t-1}$						0.315***
						(26.89)
Firm FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	28319	24633	24632	26903	23367	22700
Adjusted R^2	0.912	0.966	0.995	0.828	0.931	0.946

- Production output and profit are not significantly correlated with ETS coverage

Key Findings

	$TFP_{i,t}$	$logREVperCapita_{i,t}$	$TobinQ_{i,t}$	$ROA_{i,t}$
	(1)	(2)	(3)	(4)
$ETS_{i,t}$	0.015	-0.021	-0.018	0.004***
	(0.85)	(-0.76)	(-0.39)	(2.62)
$logASSETS_{i,t}$	0.585***	0.139***	-0.557***	0.008***
	(41.39)	(7.03)	(-15.29)	(6.18)
$logAGE_{i,t}$	0.265***	0.206*	-0.543***	0.009
	(3.41)	(1.75)	(-2.75)	(1.16)

	$logCAPX_{i,t}$	$logRDSpend_{i,t}$	$logEMP_{i,t}$	$logWAGES_{i,t}$	$logOUTPUT_{i,t}$	$logEBITDA_{i,t}$	$TFP_{i,t}$	$ROA_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$ETS_{i,t}$	0.074***	0.074	0.008	0.221***	-0.001	0.037***	0.041	0.002
	(3.42)	(1.15)	(0.88)	(4.97)	(-0.26)	(3.09)	(1.53)	(1.14)
$ETS_{i,t} \times SOE_{i,t}$	0.056*	0.160	0.004	-0.060	0.009*	-0.009	0.025	-0.004**
	(1.83)	(1.47)	(0.38)	(-1.04)	(1.71)	(-0.50)	(0.63)	(-1.99)
$SOE_{i,t}$	-0.122***	-0.172***	-0.015***	0.178***	0.005**	-0.016**	0.035	0.002***
	(-7.91)	(-3.53)	(-3.32)	(6.61)	(2.45)	(-1.97)	(1.63)	(2.94)

- Compliance firms exhibit higher profitability (ROA) but no differences in TFP, revenue per capita, and Tobin's Q
- ETS coverage harms the SOEs' profitability

Key Findings (continued)

Panel A: Power	$logCAPX_{i,t}$ (1)	$logRDSpend_{i,t}$ (2)	$logEMP_{i,t}$ (3)	$logWAGES_{i,t}$ (4)	$logOUTPUT_{i,t}$ (5)	$logEBITDA_{i,t}$ (6)	$TFP_{i,t}$ (7)	$ROA_{i,t}$ (8)
$ETS_{i,t}$	0.288***	0.860*	0.119*	0.056	-0.005	-0.028	-0.022	-0.004
	(3.42)	(1.68)	(1.79)	(1.04)	(-0.08)	(-0.60)	(-0.40)	(-0.72)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	794	224	794	794	794	783	794	767
Adjusted R^2	0.894	0.837	0.940	0.970	0.976	0.950	0.965	0.526
Panel B: Manufacturing	$logCAPX_{i,t}$ (1)	$logRDSpend_{i,t}$ (2)	$logEMP_{i,t}$ (3)	$logWAGES_{i,t}$ (4)	$logOUTPUT_{i,t}$ (5)	$logEBITDA_{i,t}$ (6)	$TFP_{i,t}$ (7)	$ROA_{i,t}$ (8)
$ETS_{i,t}$	0.028	0.091*	0.006	0.013	0.036	0.024	0.033*	0.004**
	(0.84)	(1.75)	(0.44)	(0.62)	(1.62)	(1.50)	(1.65)	(2.12)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	16315	7336	16319	16322	16323	15129	16322	15361
Adjusted R^2	0.820	0.950	0.971	0.966	0.972	0.945	0.962	0.587
Panel C: Transportation	$logCAPX_{i,t}$ (1)	$logRDSpend_{i,t}$ (2)	$logEMP_{i,t}$ (3)	$logWAGES_{i,t}$ (4)	$logOUTPUT_{i,t}$ (5)	$logEBITDA_{i,t}$ (6)	$TFP_{i,t}$ (7)	$ROA_{i,t}$ (8)
$ETS_{i,t}$	0.112	-1.690**	0.117	-0.222**	-0.187	-0.004	-0.119	0.009
	(0.81)	(-2.15)	(1.40)	(-2.42)	(-1.34)	(-0.06)	(-0.98)	(0.78)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	840	204	844	845	845	821	845	812
Adjusted R^2	0.868	0.831	0.974	0.981	0.964	0.980	0.944	0.627
Panel D: Real Estate	$logCAPX_{i,t}$ (1)	$logRDSpend_{i,t}$ (2)	$logEMP_{i,t}$ (3)	$logWAGES_{i,t}$ (4)	$logOUTPUT_{i,t}$ (5)	$logEBITDA_{i,t}$ (6)	$TFP_{i,t}$ (7)	$ROA_{i,t}$ (8)
$ETS_{i,t}$	-0.004	0.752	0.055	0.100	0.183**	-0.015	0.152***	0.002
	(-0.02)	(1.45)	(0.90)	(1.02)	(2.61)	(-0.16)	(2.70)	(0.44)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	802	86	804	804	804	728	804	760
Adjusted R^2	0.826	0.804	0.963	0.963	0.949	0.906	0.923	0.528
Panel E: Others	$logCAPX_{i,t}$ (1)	$logRDSpend_{i,t}$ (2)	$logEMP_{i,t}$ (3)	$logWAGES_{i,t}$ (4)	$logOUTPUT_{i,t}$ (5)	$logEBITDA_{i,t}$ (6)	$TFP_{i,t}$ (7)	$ROA_{i,t}$ (8)
$ETS_{i,t}$	0.179**	0.257	0.053	-0.042	-0.091**	-0.011	-0.078*	0.005
	(2.00)	(1.51)	(1.26)	(-0.65)	(-2.02)	(-0.25)	(-1.68)	(1.25)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	5808	2263	5809	5811	5811	5178	5810	5424
Adjusted R^2	0.841	0.934	0.970	0.960	0.965	0.945	0.954	0.499

- Different sectors exhibit different patterns
  - Additional investment and hiring largely happened in the power and manufacturing sectors
  - Firms in the transportation sector only trimmed R&D and wages
  - Real estate firms boosted outputs and TFP

Key Findings

Panel A: Nation	$logCAPX_{i,t}$ (1)	$logRDSpend_{i,t}$ (2)	$logEMP_{i,t}$ (3)	$logWAGES_{i,t}$ (4)	$logOUTPUT_{i,t}$ (5)	$logEBITDA_{i,t}$ (6)	$TFP_{i,t}$ (7)	$ROA_{i,t}$ (8)
$ETS_{i,t}$	-0.042	0.219**	-0.035**	-0.054*	0.024	-0.030	0.040	0.020***
	(-0.70)	(2.52)	(-2.29)	(-1.68)	(0.81)	(-1.01)	(1.49)	(3.68)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	20969	8919	20981	20986	20987	19261	20985	19691
Adjusted R^2	0.807	0.932	0.964	0.953	0.959	0.934	0.947	0.552
Panel B: Local	$logCAPX_{i,t}$ (1)	$logRDSpend_{i,t}$ (2)	$logEMP_{i,t}$ (3)	$logWAGES_{i,t}$ (4)	$logOUTPUT_{i,t}$ (5)	$logEBITDA_{i,t}$ (6)	$TFP_{i,t}$ (7)	$ROA_{i,t}$ (8)
$ETS_{i,t}$	0.123***	0.279	0.040***	0.019	0.024	0.022	0.018	0.003*
	(3.54)	(0.90)	(2.72)	(0.84)	(1.07)	(1.33)	(0.90)	(1.75)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	23111	9453	23122	23128	23129	21256	23127	21745
Adjusted R^2	0.831	0.942	0.967	0.960	0.966	0.945	0.954	0.552
Panel C: East	$logCAPX_{i,t}$ (1)	$logRDSpend_{i,t}$ (2)	$logEMP_{i,t}$ (3)	$logWAGES_{i,t}$ (4)	$logOUTPUT_{i,t}$ (5)	$logEBITDA_{i,t}$ (6)	$TFP_{i,t}$ (7)	$ROA_{i,t}$ (8)
$ETS_{i,t}$	0.180***	0.386	0.045**	-0.021	-0.016	0.001	-0.009	0.001
	(3.62)	(0.95)	(1.99)	(-0.60)	(-0.49)	(0.03)	(-0.32)	(0.21)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	21420	8966	21431	21437	21438	19665	21436	20123
Adjusted R^2	0.818	0.939	0.965	0.957	0.963	0.940	0.951	0.551
Panel D: South	$logCAPX_{i,t}$ (1)	$logRDSpend_{i,t}$ (2)	$logEMP_{i,t}$ (3)	$logWAGES_{i,t}$ (4)	$logOUTPUT_{i,t}$ (5)	$logEBITDA_{i,t}$ (6)	$TFP_{i,t}$ (7)	$ROA_{i,t}$ (8)
$ETS_{i,t}$	0.075	0.090***	0.054*	0.074*	0.097**	0.054**	0.075**	0.005
	(1.15)	(2.60)	(1.78)	(1.69)	(2.30)	(2.36)	(1.96)	(1.60)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	20656	8800	20668	20673	20674	18917	20672	19396
Adjusted R^2	0.800	0.939	0.963	0.953	0.959	0.932	0.946	0.546
Panel E: Midwest	$logCAPX_{i,t}$ (1)	$logRDSpend_{i,t}$ (2)	$logEMP_{i,t}$ (3)	$logWAGES_{i,t}$ (4)	$logOUTPUT_{i,t}$ (5)	$logEBITDA_{i,t}$ (6)	$TFP_{i,t}$ (7)	$ROA_{i,t}$ (8)
$ETS_{i,t}$	0.081	-0.219	-0.008	0.026	0.014	-0.003	0.006	0.009**
	(0.85)	(-1.37)	(-0.37)	(0.55)	(0.27)	(-0.08)	(0.14)	(2.15)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	20304	8678	20316	20321	20322	18598	20320	19048
Adjusted R^2	0.800	0.939	0.964	0.953	0.959	0.932	0.947	0.548

- Different markets
  - Firms covered by both the national and regional programs reduced hiring and wages but boosted R&D
  - Compliance firms only covered by the regional markets boosted investment and hiring
  - Stronger commitment in South China (Guangdong and Shenzhen), followed by East China (Beijing, Shanghai, and Tianjin), but weak in less developed Central and West China (Hubei and Chongqing)

Takeaway

- China's ETS is in an early and rapidly developing stage
  - Free allowance
  - Lenient intensity-based emissions allowance allocation scheme
  - Monitoring, reporting, and verifying framework under development
  - Light penalties
- The ETS has evoked firms' climate awareness and stimulated real actions (Duan and Zhou, 2017)
- No adverse shocks to output, profit, productivity, and efficiency
- State ownership tends to reinforce the ETS effects
- Heterogenous effects across sectors and regions

Thanks!