Supplementary information

The Incremental Impact of China's Carbon Trading Pilots

This document provides additional information and is divided into five supplements.

Supplement A

Robustness Checks

Different research period

To avoid the possibility that our results could be influenced by using a different research period, we made a robust check using another time span as our research period. The 12th Five-Year Plan starting in 2011, involves the carbon abatement targets for the first time, which represents a new type of mandatory policy being implemented. Hence, we reexamined the impact of ETS pilots using data beginning from 2011. The results are robust.

Results are presented in Supplement B.

Additional controls

As some provinces and industries rely more on particular fuels, changes in fuel prices may affect the energy costs of certain industries in some provinces more than others. It is possible that those industries relying more on the fuel will suffer more if there is a shock in the fuel's price. To address this problem, we gathered annual fuel prices at province level for each of these fuels. It bears mention that the changes of fuel prices may affect industries disproportionately according to each industry's energy structure. Accordingly, we interacted energy prices with each fuel's proportion of each industry to indicate fuel prices of each industry at province level, and then logged weighted prices before regression. In addition, we multiplied weighted prices by 1000 and then plus 1 to avoid a surfeit of negative numbers and negative infinity when we utilised the logarithm form. Results are shown to be robust when including these energy prices in the regressions.

Results are represented in Supplement C.

Supplement D shows the results when we control fuel prices using data from 2011.

Eliminate pilots with poor performance

To exclude the situation that pilots with poor performance drive the result, we dropped the pilots with the

poorest performance. In aspects of the carbon price level and trading volume, Tianjin and Chongqing pilots performed the worst, combined with other market scale, market structure and market efficiency indicators, Tianjin and Chongqing ranked the lowest in the assessment of maturity. So, we dropped Tianjin and Chongqing to do a robust check.

Results are represented in Supplement E.

Supplement B:

In this section, we use data from 2011 to 2019 (for CO_2 intensity and output, it's 2011-2017). The results of all outcome variables are robust. The results show that ETS pilots have no impact on carbon abatement and abatement cost saving of covered industries.

Table B1: Effects of ETS pilots on CO_2 emissions (weighted by denominator of CO_2 emission)

Panel A	(1)	(2)	(3)	(4)
Post × ETS × Ind	-0.179	-0.0430*	-0.116***	-0.0105
	(0.391)	(0.0229)	(0.0312)	(0.0790)
Panel B				
Post × ETS × Rate	0.426	-0.0210	-0.0937**	-0.00483
	(0.387)	(0.0267)	(0.0382)	(0.0760)
Post × ETS × Mass	-1.207***	-0.0803**	-0.153***	-0.0209
	(0.275)	(0.0355)	(0.0459)	(0.0971)
Observations	8,460	8,460	8,460	8,460
Province-industry FE		Yes	Yes	Yes
Industry-year FE			Yes	Yes
Province-year FE				Yes

Notes: Standard errors in parentheses *p < 0.10, **p < 0.05, ***p < 0.01. Regressions are weighted by the denominator (2012) of CO_2 emissions to account for differences in cell size. The standard errors are clustered at the province-industry level.

Table B2: Effects of ETS pilots on CO_2 intensity (weighted by the denominator of CO_2 intensity)

Panel A	(1)	(2)	(3)	(4)
Post × ETS × Ind	-0.485	-0.234***	-0.134	0.290
	(0.453)	(0.0395)	(0.111)	(0.213)
Panel B				
Post × ETS × Rate	0.0192	-0.273***	-0.0678	0.311
	(0.470)	(0.0599)	(0.0570)	(0.194)
Post × ETS × Mass	-0.907*	-0.201***	-0.189	0.275
	(0.493)	(0.0512)	(0.191)	(0.268)
Observations	6,577	6,577	6,577	6,577
Province-industry FE		Yes	Yes	Yes
Industry-year FE			Yes	Yes
Province-year FE				Yes

Notes: Standard errors in parentheses *p < 0.10, **p < 0.05, ***p < 0.01. Regressions are weighted by the denominator (2012) of CO_2 intensity. The standard errors are clustered at the province-industry level.

Table B3: Effects of ETS pilots on output (weighted by the denominator of CO_2 emissions)

Panel A	(1)	(2)	(3)	(4)
Post × ETS × Ind	0.437	0.163***	-0.0171	0.0225
	(0.270)	(0.0523)	(0.0480)	(0.0307)
Panel B				
Post × ETS × Rate	0.719**	0.204***	0.00136	0.0469
	(0.344)	(0.0599)	(0.0592)	(0.0465)
Post × ETS × Mass	-0.0420	0.0939	-0.0480	-0.0225
	(0.220)	(0.0916)	(0.0740)	(0.0678)
Observations	6,577	6,577	6,577	6,577
Province-industry FE		Yes	Yes	Yes
Industry-year FE			Yes	Yes
Province-year FE				Yes

Notes: Standard errors in parentheses *p < 0.10, **p < 0.05, ***p < 0.01. Regressions are weighted by the denominator (2012) of CO_2 emissions. The standard errors are clustered at the province-industry level.

Supplement C:

In this section, we control energy prices in our estimations. The results are robust.

Table C1: Effects of ETS pilots on CO_2 emissions (weighted by denominator of CO_2 emissions, controlling energy prices)

Panel A	(1)	(2)	(3)	(4)
Post × ETS × Ind	0.227	-0.0506	-0.180***	-0.0196
	(0.321)	(0.0328)	(0.0382)	(0.0642)
ln coal price	0.497***	0.0711***	0.0793***	0.0462*
	(0.0887)	(0.0209)	(0.0203)	(0.0242)
ln oil price	-0.325***	-0.108***	-0.0575***	-0.0715***
	(0.0547)	(0.0161)	(0.0159)	(0.0143)
ln gas price	0.0292	0.0315***	0.00349	0.000186
	(0.0245)	(0.00489)	(0.00445)	(0.00406)
ln electricity price	0.0208	0.0484*	0.0117	0.00229
	(0.0637)	(0.0290)	(0.0116)	(0.0161)
Panel B				
Post × ETS × Rate	0.895***	-0.0349	-0.150***	0.0190
	(0.306)	(0.0361)	(0.0461)	(0.0658)
Post × ETS × Mass	-0.904***	-0.0773	-0.230***	-0.0908
	(0.222)	(0.0527)	(0.0542)	(0.0825)
ln coal price	0.490***	0.0710***	0.0795***	0.0465*
	(0.0846)	(0.0209)	(0.0203)	(0.0242)
ln oil price	-0.327***	-0.108***	-0.0572***	-0.0717***
	(0.0530)	(0.0161)	(0.0160)	(0.0143)
ln gas price	0.0313	0.0315***	0.00357	0.000289
	(0.0243)	(0.00489)	(0.00447)	(0.00408)
ln electricity price	-0.00484	0.0482*	0.0114	0.00160
	(0.0603)	(0.0289)	(0.0115)	(0.0161)
Observations	12,703	12,703	12,703	12,703
Province-industry FE		Yes	Yes	Yes
Industry-year FE			Yes	Yes
Province-year FE				Yes

Notes: Standard errors in parentheses *p < 0.10, **p < 0.05, ***p < 0.01. Regressions are weighted by the denominator (2012) of CO_2 emissions. The standard errors are clustered at the province-industry level.

Table C2: Effects of ETS pilots on CO_2 intensity (weighted by the denominator of CO_2 intensity, controlling energy prices)

Panel A	(1)	(2)	(3)	(4)
Post × ETS × Ind	-0.786***	-0.446***	-0.0982	0.0203
	(0.255)	(0.0907)	(0.100)	(0.130)
ln coal price	0.0741*	-0.0129	-0.0151	-0.0116
	(0.0381)	(0.0445)	(0.0165)	(0.0162)
ln oil price	-0.128***	0.00741	0.00200	-0.00658
	(0.0252)	(0.0141)	(0.0123)	(0.0114)
ln gas price	0.0391**	-0.0142	0.0230**	0.0160*
	(0.0178)	(0.0215)	(0.0107)	(0.00943)
ln electricity price	0.117*	0.191***	0.183***	0.195***
	(0.0624)	(0.0503)	(0.0408)	(0.0411)
Panel B				
Post × ETS × Rate	-0.268	-0.480***	-0.155	-0.0799
	(0.276)	(0.117)	(0.104)	(0.156)
Post × ETS × Mass	-1.222***	-0.417***	-0.0514	0.0891
	(0.302)	(0.115)	(0.160)	(0.150)
ln coal price	0.0739*	-0.0129	-0.0152	-0.0117
	(0.0382)	(0.0445)	(0.0165)	(0.0162)
ln oil price	-0.128***	0.00741	0.00205	-0.00645
	(0.0252)	(0.0141)	(0.0123)	(0.0114)
ln gas price	0.0397**	-0.0142	0.0230**	0.0160*
	(0.0178)	(0.0215)	(0.0107)	(0.00942)
ln electricity price	0.116*	0.191***	0.184***	0.195***
	(0.0627)	(0.0503)	(0.0408)	(0.0411)
Observations	10,800	10,767	10,767	10,767
Province-industry FE		Yes	Yes	Yes
Industry-year FE			Yes	Yes
Province-year FE				Yes

Notes: Standard errors in parentheses *p < 0.10, **p < 0.05, ***p < 0.01. Regressions are weighted by the denominator (2012) of CO_2 intensity. The standard errors are clustered at the province-industry level.

Table C3: Effects of ETS pilots on output (weighted by the denominator of CO_2 emissions, controlling energy prices)

Panel A	(1)	(2)	(3)	(4)
Post × ETS × Ind	0.551**	0.299***	-0.0216	0.0684
	(0.221)	(0.0850)	(0.0632)	(0.0475)
ln coal price	0.0434	-0.00576	0.0184**	0.0201*
	(0.0548)	(0.0212)	(0.00719)	(0.0118)
ln oil price	-0.0286	-0.0884***	0.00398	-0.0100
	(0.0624)	(0.0244)	(0.0141)	(0.00966)
ln gas price	0.0593***	0.0570***	-0.00503	0.00111
	(0.0198)	(0.00960)	(0.00421)	(0.00286)
ln electricity price	0.135*	0.112	-0.00603	-0.00169
	(0.0797)	(0.0723)	(0.00659)	(0.00749)
Panel B				
Post × ETS × Rate	0.808***	0.280***	-0.0285	0.0901
	(0.266)	(0.106)	(0.0833)	(0.0684)
Post × ETS × Mass	0.116	0.330***	-0.0101	0.0289
	(0.248)	(0.121)	(0.0863)	(0.0851)
ln coal price	0.0417	-0.00579	0.0184**	0.0204*
	(0.0538)	(0.0212)	(0.00722)	(0.0119)
ln oil price	-0.0285	-0.0886***	0.00391	-0.0100
	(0.0622)	(0.0244)	(0.0141)	(0.00966)
ln gas price	0.0599***	0.0570***	-0.00503	0.00106
	(0.0198)	(0.00959)	(0.00420)	(0.00286)
ln electricity price	0.127	0.112	-0.00593	-0.00214
	(0.0786)	(0.0727)	(0.00659)	(0.00737)
Observations	10,800	10,767	10,767	10,767
Province-industry FE		Yes	Yes	Yes
Industry-year FE			Yes	Yes
Province-year FE				Yes

Notes: Standard errors in parentheses *p < 0.10, **p < 0.05, ***p < 0.01. Regressions are weighted by the denominator (2012) of CO_2 emissions. The standard errors are clustered at the province-industry level.

Supplement D:

In this section, we control energy prices in our estimations and use data from 2011. The results are similar to the corresponding results in section B.

Overall, results are robust across a variety of specifications. These results provide evidence that ETS pilots didn't work, neither as an additional instrument achieving more carbon abatement nor as a substitutional instrument decreasing the abatement cost.

Table D1: Effects of ETS pilots on CO_2 emissions (weighted by the denominator of CO_2 emissions , controlling energy prices)

Panel A	(1)	(2)	(3)	(4)
Post × ETS × Ind	0.202	-0.0872***	-0.105***	-0.0360
	(0.332)	(0.0242)	(0.0294)	(0.0743)
ln coal price	0.559***	0.0675***	0.0832***	0.0743***
	(0.0677)	(0.0193)	(0.0184)	(0.0259)
ln oil price	-0.335***	-0.0686***	-0.0618***	-0.0811***
	(0.0490)	(0.00895)	(0.0151)	(0.0168)
ln gas price	0.0179	0.0157***	0.00968*	0.00192
	(0.0224)	(0.00564)	(0.00576)	(0.00612)
ln electricity price	0.0636	0.0228*	0.0232**	0.0159
	(0.0616)	(0.0135)	(0.0118)	(0.0152)
Panel B				
Post × ETS × Rate	0.854***	-0.0573**	-0.0752**	-0.0244
	(0.326)	(0.0269)	(0.0356)	(0.0706)
Post × ETS × Mass	-0.903***	-0.138***	-0.155***	-0.0571
	(0.218)	(0.0320)	(0.0401)	(0.0947)
ln coal price	0.551***	0.0678***	0.0836***	0.0745***
	(0.0616)	(0.0193)	(0.0184)	(0.0260)
ln oil price	-0.338***	-0.0688***	-0.0620***	-0.0812***
	(0.0466)	(0.00894)	(0.0151)	(0.0167)
ln gas price	0.0208	0.0158***	0.00988*	0.00199
	(0.0220)	(0.00564)	(0.00576)	(0.00614)
ln electricity price	0.0322	0.0226*	0.0231**	0.0158
	(0.0551)	(0.0135)	(0.0118)	(0.0152)
Observations	8,209	8,209	8,209	8,209
Province-industry FE		Yes	Yes	Yes
Industry-year FE			Yes	Yes
Province-year FE				Yes

Notes: Standard errors in parentheses *p < 0.10, **p < 0.05, ***p < 0.01. Regressions are weighted by the denominator (2012) of CO_2 emissions. The standard errors are clustered at the province-industry level.

Table D2: Effects of ETS pilots on CO_2 intensity (weighted by the denominator of CO_2 intensity, controlling energy prices)

Panel A	(1)	(2)	(3)	(4)
Post × ETS × Ind	-0.579**	-0.201***	-0.00844	0.183
	(0.246)	(0.0715)	(0.0690)	(0.209)
ln coal price	0.138***	0.0927**	0.0101	0.0152
	(0.0421)	(0.0410)	(0.0181)	(0.0169)
ln oil price	-0.153***	-0.00431	0.00462	-0.00439
	(0.0306)	(0.0148)	(0.0125)	(0.0110)
ln gas price	0.0341*	-0.00375	0.0187	0.0134
	(0.0188)	(0.0340)	(0.0164)	(0.0125)
ln electricity price	0.0999**	0.135***	0.133***	0.152***
	(0.0502)	(0.0445)	(0.0474)	(0.0453)
Panel B				
Post × ETS × Rate	-0.0539	-0.250***	-0.0974	-0.00593
	(0.266)	(0.0775)	(0.0716)	(0.153)
Post × ETS × Mass	-1.022***	-0.160*	0.0653	0.312
	(0.282)	(0.0857)	(0.105)	(0.248)
ln coal price	0.138***	0.0927**	0.00989	0.0152
	(0.0421)	(0.0410)	(0.0181)	(0.0169)
ln oil price	-0.153***	-0.00426	0.00482	-0.00418
	(0.0306)	(0.0148)	(0.0125)	(0.0110)
ln gas price	0.0351*	-0.00377	0.0186	0.0134
	(0.0188)	(0.0341)	(0.0164)	(0.0124)
ln electricity price	0.0973*	0.135***	0.133***	0.152***
	(0.0505)	(0.0445)	(0.0475)	(0.0452)
Observations	6,327	6,326	6,326	6,326
Province-industry FE		Yes	Yes	Yes
Industry-year FE			Yes	Yes
Province-year FE				Yes

Notes: Standard errors in parentheses *p < 0.10, **p < 0.05, ***p < 0.01. Regressions are weighted by the denominator (2012) of CO_2 intensity. The standard errors are clustered at the province-industry level.

Table D3: Effects of ETS pilots on output (weighted by the denominator of CO_2 emissions, controlling energy prices)

Panel A	(1)	(2)	(3)	(4)
Post × ETS × Ind	0.340	0.0649	-0.00807	0.0230
	(0.236)	(0.0529)	(0.0502)	(0.0314)
ln coal price	0.00988	-0.111***	0.0347	0.0330
	(0.0612)	(0.0277)	(0.0238)	(0.0226)
ln oil price	-0.0275	-0.0460***	-0.00257	-0.0180
	(0.0656)	(0.0154)	(0.0157)	(0.0118)
ln gas price	0.0530***	0.00969**	-0.00332	-0.000664
	(0.0190)	(0.00397)	(0.00397)	(0.00456)
ln electricity price	0.0794	0.0124	-0.00262	-0.00156
	(0.0673)	(0.00780)	(0.00448)	(0.00592)
Panel B				
Post × ETS × Rate	0.617**	0.101*	0.0118	0.0485
	(0.284)	(0.0582)	(0.0632)	(0.0475)
Post × ETS × Mass	-0.129	0.00480	-0.0409	-0.0236
	(0.238)	(0.0919)	(0.0741)	(0.0675)
ln coal price	0.00706	-0.110***	0.0354	0.0337
	(0.0597)	(0.0277)	(0.0238)	(0.0226)
ln oil price	-0.0277	-0.0462***	-0.00274	-0.0181
	(0.0652)	(0.0154)	(0.0158)	(0.0119)
ln gas price	0.0539***	0.00970**	-0.00321	-0.000640
	(0.0191)	(0.00399)	(0.00400)	(0.00457)
ln electricity price	0.0665	0.0119	-0.00276	-0.00193
	(0.0649)	(0.00782)	(0.00451)	(0.00585)
Observations	6,327	6,326	6,326	6,326
Province-industry FE		Yes	Yes	Yes
Industry-year FE			Yes	Yes
Province-year FE				Yes

Notes: Standard errors in parentheses *p < 0.10, **p < 0.05, ***p < 0.01. Regressions are weighted by the denominator (2012) of CO_2 emissions. The standard errors are clustered at the province-industry level.

Supplement E:

In this section, we drop Tianjin and Chongqing pilots to do a robust check to avoid those pilots with poor performance driving our results.

Table E1: Effects of pilots on CO_2 emissions (weighted by the denominator of CO_2 emissions, treated pilots are Beijing, Shanghai, Hubei and Guangdong)

Panel A	(1)	(2)	(3)	(4)
Post × ETS × Ind	0.0771	0.0875***	-0.190***	-0.0423
	(0.429)	(0.0333)	(0.0468)	(0.0706)
Panel B				
Post × ETS × Rate	0.587	0.120***	-0.146***	-0.0153
	(0.389)	(0.0344)	(0.0494)	(0.0711)
Post × ETS × Mass	-1.337***	-0.00372	-0.308***	-0.130
	(0.376)	(0.0651)	(0.0770)	(0.0980)
Observations	12,236	12,236	12,236	12,236
Province-industry FE		Yes	Yes	Yes
Industry-year FE			Yes	Yes
Province-year FE				Yes

Notes: Standard errors in parentheses *p < 0.10, **p < 0.05, ***p < 0.01. Regressions are weighted by the denominator (2012) of CO_2 emissions. The standard errors are clustered at the province-industry level.

Table E2: Effects of pilots on CO_2 intensity (weighted by the denominator of CO_2 intensity, treated pilots are Beijing, Shanghai, Hubei, and Guangdong)

Panel A	(1)	(2)	(3)	(4)
Post × ETS × Ind	-0.891**	-0.367***	-0.125	-0.0632
	(0.450)	(0.0986)	(0.0996)	(0.161)
Panel B				
Post × ETS × Rate	-0.287	-0.415***	-0.0921	-0.0173
	(0.462)	(0.132)	(0.108)	(0.202)
Post × ETS × Mass	-1.707***	-0.302**	-0.168	-0.117
	(0.400)	(0.150)	(0.173)	(0.178)
Observations	10,464	10,464	10,464	10,464
Province-industry FE		Yes	Yes	Yes
Industry-year FE			Yes	Yes
Province-year FE				Yes

Notes: Standard errors in parentheses *p < 0.10, **p < 0.05, ***p < 0.01. Regressions are weighted by the denominator (2012) of CO_2 intensity. The standard errors are clustered at the province-industry level.