The impact of export tax rebate reform on industrial exporters' soot emissions: Evidence from China

Qian Tian[1], Anqin Hu[1], Yuexing Zhang[2]* and Yagang Meng[3]

[1]School of Accounting, Hebei Finance University, Baoding City, China, [2]PBC School of Finance, Tsinghua University, Beijing, China, [3]Offshore Oil Engineering Co., Ltd., Tianjin City, China

In this paper, we systematically explore the environmental effects of the export tax rebate rate reduction policy using the China Industrial Enterprise Database, the China Industrial Enterprise Pollution Database, and the China Customs Import and Export Database from 2005 to 2013. Our difference-in-difference (DID) estimates show that the reduction in the export tax rebate rate significantly reduces the intensity of corporate soot emissions, and this finding holds after a series of robustness tests. For every 1-unit reduction in export tax rebate rate, industrial exporters' soot emission intensity decreases by 2.63%. The mechanism analysis shows that the decrease in soot generation, the decrease in coal use intensity, the increase in total amount and efficiency of soot treatment are important channels. Heterogeneity analysis shows that the reduction of export tax rebate rate has a more significant impact on the intensity of soot emissions of high pollution, high energy consumption and resource-based enterprises. This study may provide a reference for other developing countries that also rely on export tax rebates to adjust their policies to combine economic growth with pollution control.

KEYWORDS

export tax rebate, China, soot emissions, industrial exporters, DID method

1 Introduction

1978, C ' . 20 , C O 2001 (H , 2016; L , 2018; K ., 2021; ., 2022). M C ' x C ' x , x x (C L , 2013; L ., 2021). x x x C DA x x x (., 2015). Ex x . I , C , K , P , , M , M x x x (M , 2007; A ., 2014; A F x , 2014).

A x , . M x C x fi (P ., 2007; P H , 2008; ., 2008;

2 Literature review

2.1 The impact of export tax rebates on trade

2.2 Environmental impacts of trade

10.3389/fenvs.2022.1101102

2.3 Environmental impact of export tax rebates

TABLE 1 Descriptive statistics.

Variables	Measurement	Observations	Mean	S.D.	Min	Max
[illegible]	[illegible]	61,904	−7.498	4.267	−18.65	13.73
[illegible]	[illegible]	61,946	−4.587	4.323	−15.90	14.86
[illegible]	[illegible]	93,420	.826	.379	0	1
[illegible]	[illegible] (%)	93,420	2.955	3.912	0	13
[illegible]	[illegible] (%)	93,406	2.972	3.741	0	13
[illegible]	[illegible]	93,420	.108	.311	0	1
[illegible]	[illegible]	93,415	11.88	1.586	0	19.44
[illegible]	[illegible]	92,496	4.500	1.468	−10.20	14.72
[illegible]	[illegible]	93,410	2.286	.710	0	5.081
[illegible]	[illegible]	93,367	.551	.287	−.891	18.38
[illegible]	[illegible]	93,420	.187	.390	0	1
[illegible]	[illegible]	62,103	4.6162	3.9584	0	17.0483
[illegible]	[illegible]	36,317	5.8577	3.6716	0	16.4175
[illegible]	[illegible]	17,170	2.2109	4.6439	0	21.6664
[illegible]	[illegible]	40,132	7.6499	4.0107	0	21.6025

[illegible]

10.3389/fenvs.2022.1101102

TABLE 2 Impact of the reduction of export tax rebate rate on industrial exporters' soot emission intensity.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Lnsootdensity	Lnsootdensity	Lnsootdensity	Lnsootdensity	Lnsootdensity	Lnsootdensity
x $Post_t$	−.0314***	−.0317***	−.0266***	−.0258***	−.0259***	−.0263***
	(.0098)	(.0098)	(.0095)	(.0095)	(.0095)	(.0096)
[illegible]		.1915**	.1963**	.1970**	.1949**	.2077**
		(.0892)	(.0886)	(.0888)	(.0887)	(.0922)
F			−.6436***	−.6336***	−.6361***	−.6017***
			(.0450)	(.0473)	(.0473)	(.0511)
L KL				−.0102	−.0094	−.0176
				(.0158)	(.0158)	(.0216)
L					.0637	.0304
					(.0569)	(.0610)
LED						−.0539
						(.0666)
P						.2160***
						(.0591)
FE	✓	✓	✓	✓	✓	✓
P FE	✓	✓	✓	✓	✓	✓
I FE	✓	✓	✓	✓	✓	✓
F FE	✓	✓	✓	✓	✓	✓
C	−5.5233***	−5.5262***	2.2369***	2.1535***	2.0897***	1.4720*
	(.3820)	(.3824)	(.6574)	(.6739)	(.6741)	(.8044)
O	61,904	61,904	61,900	61,418	61,417	40,056
-	.7036	.7037	.7102	.7075	.7075	.7114

N : fi FE, fix , P FE, P fix , I FE, I fix , F FE, F fix . *, **, *** fi 10%, 5%, 1% , .

3 Materials and methods

3.1 Data and variables

O . - C I E D (2005–2013), C C (2005–2013) I E P E D (2005–2013). C I E D , , fi M 2011 20 M 2011) (L ., 2022). C C , H , x , x (., 2017). I E P E D , , C (., 2018).

x x x fi , . C I E D , C C I E P E D , x , . fi : fi , C I E D (., 2012), , fix , , R&D x , 0, fix , , - , . A , , . , I E P E D . , x x x , x . x x M F G A x

$Retaxgap_i$ $Post_t$, $Retaxgap_i$. $Post_t$ $Post_t$ 0 2007, $Post_t$ 2007 .

(C, 2020), (1) , - 0 - - . (2) F , . (3) F ’ . (4) KL, fix . (5) LED, ’ , ’ . (6) P , , 0 .

1 2.95%, 13%. - 10.8%, - 55.1%.

. ’ , . D ( ) ( ). D ( ) L (,).

3.2 Methods

, DID C . :

$$lnSI_{ijkt} = \beta_1 * Retaxgap_i \quad Post_t + \beta_2 * X_{it} + \gamma_i + \mu_j + \delta_k + \lambda_t + \varepsilon_{ijkt} \tag{1}$$

H , , , , . $lnSI_{ijkt}$ $Retaxgap_i$ $Post_t$. β_1 , ’ . X_{it} , , F , L KL, L , LED P . γ_i fix . δ_k fix fix . μ_j fix . λ_t fix . ε_{ijkt} .

H (H) 8- , 2007. H - - . I , - 2007. - 2006. A , . F , C C I E P E D .

TABLE 4 Impact of export tax rebate rate reduction on the firms' soot emission intensity (Replace dependent variables).

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Lnsootdensity1	Lnsootdensity1	Lnsootdensity1	Lnsootdensity1	Lnsootdensity1	Lnsootdensity1
x $Post_t$	−.0215**	−.0219**	−.0196**	−.0184*	−.0184*	−.0196*
	(.0100)	(.0100)	(.0100)	(.0100)	(.0100)	(.0100)
		.1447	.1419	.1445	.1440	.1430
		(.1028)	(.1027)	(.1031)	(.1031)	(.1031)
L			−.2905***	−.2685***	−.2692***	−.3516***
			(.0548)	(.0571)	(.0573)	(.0487)
L				−.0212	−.0211	−.0182
				(.0178)	(.0178)	(.0177)
L					.0190	.0278
					(.0647)	(.0644)
LED						−.1139
						(.0724)
P						.1098
						(.0686)
FE	Y	Y	Y	Y	Y	Y
P FE	Y	Y	Y	Y	Y	Y
I FE	Y	Y	Y	Y	Y	Y
F FE	Y	Y	Y	Y	Y	Y
C	−2.0767***	−2.0770***	1.4279*	1.3073	1.2874	2.3274***
	(.4262)	(.4267)	(.7767)	(.7968)	(.7986)	(.7204)
O	61,932	61,932	61,927	61,268	61,267	61,248
2	.6941	.6942	.6954	.6917	.6917	.6924

N : fi FE, fix , P FE, P fix , I FE, I fix , F FE, F fix . *, **, *** fi 10%, 5%, 1% , .

x ' . fix , fix , fix fi fix x x fi x , . (6) 1- x x x , fi ' 2.63%.

4.2 Robustness tests

4.2.1 Parallel trend test

DID fi . A 2 x x fi x , , -

fi x . I , , x x , fi . :

$$lnSI_{ijkt} = \sum_{t=2005}^{2013}\beta_t{*}Retaxgap_i \quad D_t + \beta_2{*}X_{it} + \gamma_i + \mu_j + \delta_k + \lambda_t + \varepsilon_{ijkt} \quad (5)$$

D_t , β_t , (1). I , , . ., 2006, fi . , fi β_t fi x x 2006. fi β_t fi 0 ' x x 2007. F 1 β_t 95% fi . I

10.3389/fenvs.2022.1101102

TABLE 5 Mediation mechanism of the effect of export tax rebate rate reduction on the firms' soot emission intensity.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Lnsootdischarge	Lncoal	Lnsoottreat	Lngovegasability	Lnsootdensity	Lnsootdensity	Lnsootdensity	Lnsootdensity
$Retaxgap_{ij}$ $Post_t$	−.0221***	−.0036***	.0326**	.0133***	−.0051***	−.0103	−.0103	−.0261***
	(.0060)	(.0014)	(.0162)	(.0045)	(.0015)	(.0075)	(.0149)	(.0094)
[illegible]	.1971***	.0366	.1715	−.0158	−.0079	.0547	.4375**	.1714*
	(.0650)	(.0616)	(.2145)	(.1101)	(.0165)	(.0720)	(.2015)	(.0953)
L	−.0751***	.1244***	.4642***	.0201	−.5141***	−.5242***	−.3034***	−.6904***
	(.0279)	(.0330)	(.1194)	(.0569)	(.0071)	(.0444)	(.1079)	(.0561)
L	−.0401***	−.0276*	−.1234*	−.0029	.0257***	.0269	.0191	.0046
	(.0121)	(.0162)	(.0708)	(.0278)	(.0031)	(.0257)	(.0632)	(.0268)
L	.1813***	.0915**	.0778	.1116*	−.1044***	−.0337	.3231***	.0958
	(.0368)	(.0373)	(.1216)	(.0649)	(.0094)	(.0459)	(.1101)	(.0597)
LED	−.1355***	−.0659	−.1384	−.1398	.0932***	.1551*	.2495	−.0884
	(.0524)	(.0693)	(.2403)	(.1059)	(.0133)	(.0910)	(.2145)	(.0815)
P [illegible]	.0986***	−.1474***	.0256	−.0128	.0538***	−.1546***	−.5495***	−.0070
	(.0381)	(.0395)	(.1419)	(.0666)	(.0097)	(.0515)	(.1297)	(.0624)
L [illegible]					.9963***			
					(.0015)			
L						.0673***		
						(.0144)		
L							.6752***	
							(.0270)	
L [illegible]								.2076***
								(.0133)
[illegible] FE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P [illegible] FE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I [illegible] FE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
F FE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(C[illegible])

DID
.

4.2.2 Placebo test

C 2006, 2007, 4498
x x 5582
x x . D (C .,
2016), - -
4498 fi
10,380 -
x x ,
5882 - . P -

TABLE 6 Effect of lower export tax rebate rate on the intensity of soot emissions from SOEs and non-SOEs.

Variables	SOEs			Non-SOEs		
	Lnsootdensity	Lnsootdensity	Lnsootdensity	Lnsootdensity	Lnsootdensity	Lnsootdensity
$Retaxgap_{ij}$ $Post_t$	−.0463*	−.0473*	−.0474*	−.0350***	−.0274**	−.0281***
	(.0272)	(.0273)	(.0270)	(.0110)	(.0107)	(.0107)
L		−.2761**	−.2823**		−.7040***	−.6296***
		(.1352)	(.1362)		(.0521)	(.0497)
L		.0509	.0458		−.0269	−.0306*
		(.0592)	(.0625)		(.0182)	(.0181)
L			.1659			−.0120
			(.1187)			(.0725)
LED			−.0401			−.0086
			(.0945)			(.0840)
P			−.0055			.1516**
			(.1641)			(.0732)
FE	✓	✓	✓	✓	✓	✓
P FE	✓	✓	✓	✓	✓	✓
I FE	✓	✓	✓	✓	✓	✓
F FE	✓	✓	✓	✓	✓	✓
C	−6.3105***	−2.7223	−3.0519	−3.4752***	4.4387***	3.6844***
	(.7712)	(1.9047)	(1.9686)	(.3409)	(.7085)	(.6866)
O	7301	7242	7237	54,589	54,162	54,147
2	.7550	.7526	.7529	.7273	.7333	.7327

N FE, fix , P FE, P fix , I FE, I fix , F FE, F fix . *, **, *** fi 10%, 5%, 1% , .

(7) (8) 4. I

C (5), (6),

(3 33.1(x)- 33.3(x)-731.7( )-1.1( )6.5( )- 33.1( )-1.1(4.74% - OE 2.81%.

4.3 Mechanism analysis

I 3, 5.

(1), (2), (3) (4) 5

References

A , J. (2009). F , : E I 2 . J. Econ. Dev. 34, 43–58. :10.35866/ . 2009.34.1.003

A , F. , G , A., , A. (2014). : . World Dev. 56, 258–271. :10.1016/ . .2013.11.001

A , L., H C., , . (2017). x x x fi : E . Rev. Int. Econ. 25, 774–798. :10.1111/ .12284

A , ., C , ., , M. . (2001). I . Am. Econ. Rev. 4, 877–908. :10.1257/ .91.4.877

A , M. (2013). D ' ? P . Int. J. Sci. Res. Environ. Sci. 6, 92–100. :10.12983/ -2013- 092-100

A , A. A., N. G., A , M., , H., A , M., , . E., . (2022). : fi , , . Front. Environ. Sci. 10, 875577. :10.3389/ .2022.875577

A , A. H., F x , J. (2014). I x : . Eval. Program Plann 46, 38–46. :10. 1016/ . .2014.05.005

, ., H J., L , K., , . (2017). x x : ' x x A. Asia Pac Econ. Lit. 31, 79–89. :10. 1111/ .12175

, . M., K , D. A. (1986). - : C , . J. Pers. Soc. Psychol. 51, 1173–1182. :10.1037//0022-3514.51.6.1173

, G. A. (2017). F A : . Res. Int. Bus. Finance 39, 239–247. :10. 1016/ . .2016.07.038

, D. (2019). x . Energy Policy 129, 13–22. :10.1016/ . .2019.01.069

, F., M , A. C., D A , A. (2017). x - x : A fi - . China Econ. Rev. 46, 87–96. :10.1016/ . .2017.08.013

, N., G , ., M , . (2020). D : E . China Econ. Rev. 63, 101536. :10.1016/ . .2020.101536

, L., D , J., , . (2012). C ? F - . J. Dev. Econ. 97, 339–351. :10.1016/ . .2011.02.002

M., L , ., J , L. (2019). F : F - . Energy Econ. 80, 366–376. :10.1016/ . .2019.01.003

C , ., L ., M., L. (2016). D ? E - x . J. Dev. Econ. 123, 73–85. :10.1016/ . .2016.08.003

, P., L , C. (2013). D x : F - . J. Public Econ. 102, 13–22. :10.1016/ . .2013.03.005

, C., . L., E. . H. (2001). Ex x : ' x . J. Comp. Econ. 29, 314–326. :10.1006/ .2001.1713

, C., M , C., H. (2006). x x x : . China Econ. Rev. 17, 226–235. :10. 1016/ . .2005.06.001

, D. (2020). F - . Econ. Res. J. 55, 98–114. ( ).

'E , ., , ., , . (2011). A x x ' x . China Econ. Q. 10, 799–819.

, . (2014). E : E K . J. Dev. Econ. 108, 222–236. :10.1016/ . .2014.01.003

C , F., M D , ., F , . (2007). x E ? L I . Environ. Resour. Econ. 38, 1–11. :10.1007/ 10640-006-9059-2

E , . (2017). I ? J. Environ. Econ. Manage 82, 74–103. :10.1016/ . .2016.10.001

E , G. ., H , A. E. (2003). M ? M . J. Dev. Econ. 70, 1–23. :10.1016/ 0304-3878(02) 00084-6

F , J., L , ., , ., , ., , . (2015). x 2 ? A - . J. Clean. Prod. 103, 120–129. :10.1016/ . .2014.03.020

H , P., N , J., ., , H., , H., J , H. (2019). C x ? A . Sustainability 11, 4384. :10.3390/ 11164384

H D D , ., , . (2022). ' . Energy Policy 163, 112797. :10.1016/ . .2022.112797

H C., , . (2016). Ex x . China Econ. Rev. 41, 75–89. :10.1016/ . .2016.08.008

J , ., , A. (2020). D ' x x ? China Popul. Resour. Environ. 30, 100–106. :10. 12062/ .20200102

K , ., P , D., N ., J , ., , . (2021). : E . Financ. Res. Lett. 38, 101488. :10.1016/ . .2020.101488

L , ., M , H., . (2021). Ex x x : P - - x . Int. Tax. Public Financ. 28, 386–404. :10.1007/ 10797-020-09633-2

L , J., L , . (2022). E x, , . Front. Environ. Sci. 10, 982132. :10.3389/ .2022. 982132

L , J., L . (2015). A x . China Popul. Resour. Environ. 25, 84–91. :10. 3969/ . .1002-2104.2015.08.011

L , ., C , H., L , ., L , ., . (2022). . Resour. Policy 79, 103092. :10.1016/ . .2022. 103092

L , ., L , . (2011). x 2 . Energy Policy 39, 5137–5146. :10.1016/ . .2011.05.050

L , ., G , . (2018). fi x x ? E fi . Stud. Agric. Econ. 120, 97–104. :10.7896/ .1806

L , F., L J., , L. (2022). - : E . Sustain Cities Soc. 80, 103787. :10.1016/ . .2022.103787

M , J. . (2007). x : K . J. Asian Econ. 18, 967–973. :10.1016/ . .2007.08.001

M , J., , A. (2015). C - . Can. J. Econ. 48, 1067–1098. :10.1111/ .12168

M ., , H., , ., D , L. (2021). ' . Resour. Policy 74, 102287. :10.1016/ . .2021. 102287

N , . D. (2014). E J ' x . Int. trade J. 28, 169–191. :10.1080/08853908. 2013.863170

P , G. P., H , E. G. (2008). C 2 . Environ. Sci. Technol. 42, 1401–1407. :10.1021/ 072023

P , G. P., , C. L., G , D., H , K. (2007). ' 2 fi . Environ. Sci. Technol. 41, 5939–5944. :10.1021/ 070108

P G. C., ă, C. L. (2012). A x . Procedia Econ. Finance 3, 728–733. :10.1016/ 2212-5671(12)00221-3

, M., , N. (2021). D : . J. Bus. Res. 123, 516–528. :10.1016/ . .2020.10.007

, P., M , ., C , G. (2015). A x x : L . J. Environ. Manage 161, 408–416. :10.1016/ . .2015.07.029

, . (2007). F x : A . Energy Policy 35, 3194–3202. :10.1016/ . .2006.10.025

, ., M , ., L G., , ., , . (2020). M x ' . Ecol. Modell. 431, 109200. :10.1016/ . .2020.109200

, A. K., , L., D , L., M , C. N., A - , F., A M , I. (2020). fl 18 . Environ. Sci. Pollut. Res. Int. 27, 35535–35555. :10.1007/ 11356-020- 09718-9

, P. L. (1999). I ? A . J. Econ. Stud. 3, 201–209. :10.1108/01443589910284381

, C., , P., H , ., D , A. A. (2022). x — fi . Front. Environ. Sci. 10, 1067534. :10.3389/ .2022.1067534

, D., , ., , ., L . (2018). C : M . Energy Econ. 70, 244–257. :10.1016/ . .2018.01.004

[illegible], H., [illegible], [illegible]. (2020). C [illegible] 2 [illegible] : [illegible]. *Energy Econ.* 87, 104510. [illegible]:10.1016/ [illegible] .2019.104510

[illegible], P., L [illegible], [illegible]. (2022). E [illegible] fi [illegible]: [illegible]. *Front. Environ. Sci.* 10, 909082. [illegible]:10.3389/ [illegible] .2022.909082

[illegible], [illegible], [illegible] N., [illegible] J., H [illegible]., N [illegible], M. (2022). [illegible] x [illegible] fi [illegible] C [illegible]. *Front. Environ. Sci.* 10, 959939. [illegible]:10.3389/ [illegible] .2022.959939

[illegible], C. L., P [illegible], G. P., G [illegible], D., H [illegible], K. (2008). [illegible] C [illegible] x [illegible]. *Energy Policy* 36, 3572–3577. [illegible]:10.1016/ [illegible] .2008.06.009

[illegible], [illegible]., D [illegible], [illegible]. (2007). A [illegible] x I [illegible]. *Ecol. Econ.* 61, 671–683. [illegible]:10.1016/ [illegible] .2006.07.034

[illegible], [illegible]., M [illegible] - [illegible], E. (2021). D [illegible] x [illegible] 2 ? E [illegible] 7 [illegible]. *Environ. Sci. Pollut. Res. Int.* 28, 22392–22408. [illegible]:10.1007/ 11356-020-11475-8

[illegible] J., L [illegible], J., L [illegible] C. (2022). H [illegible] fi [illegible]? E [illegible] C [illegible]. *Front. Environ. Sci.* 10. [illegible]:10.3389/ [illegible] .2022.979177

[illegible]. (2018). C [illegible] ’ x [illegible], x [illegible] x [illegible] x [illegible]. *World Econ.* 41, 1288–1308. [illegible]:10.1111/ [illegible] .12570

[illegible] C., L [illegible], [illegible]. (2018). [illegible] C [illegible] ’ [illegible] ? M [illegible] C [illegible] ’ x [illegible]. *China Econ. Rev.* 47, 263–273. [illegible]:10.1016/ [illegible] .2017.08.010

[illegible], [illegible]., C [illegible], [illegible]., G [illegible], H. (2018). D [illegible] ? [illegible] - x [illegible] C [illegible]. *J. Public Econ.* 164, 70–90. [illegible]:10.1016/ [illegible] .2018.05.009

[illegible], D. (2019). C [illegible] x [illegible] x [illegible] fi [illegible] fi [illegible]? E [illegible] C [illegible]. *Int. Rev. Econ. Financ.* 64, 529–540. [illegible]:10.1016/ [illegible] .2019.09.005

[illegible], [illegible]., [illegible]., [illegible], [illegible]. (2022). A [illegible] x [illegible] x [illegible] C [illegible] fi [illegible] ? A [illegible]. *China Econ. Rev.* 75, 101844. [illegible]:10.1016/ [illegible] .2022.101844

[illegible], [illegible]. (2012). [illegible], [illegible] - [illegible] C [illegible]. *Environ. Resour. Econ.* 51, 371–389. [illegible]:10.1007/ 10640-011-9503-9

[illegible], [illegible]., D [illegible], [illegible]., [illegible], D., [illegible], [illegible]., C [illegible]. (2023). D [illegible] C [illegible] ’ [illegible] - [illegible] - [illegible] ? A [illegible] - [illegible]. *Financ. Res. Lett.* 51, 103432. [illegible]:10.1016/ [illegible] .2022.103432