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Supplementary Material

The Impacts of Climate Change on Wastewater Treatment Costs: Evidence from the Wastewater Sector in China

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Table S1. Simulated future climate change impacts on wastewater treatment costs under 1.4% interest rate assumption.

Variables	Annual O&M Costs (Million $)						Per Unit of Wastewater Treated O&M Cost ($/m^3)		
	Entire Sample (θ^S)			Average Plant ($\bar{\theta}^P$)			Average Plant ($\bar{\mu}^P$)		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
Base		302.03			1.85			0.11	
G1	722.65	767.44	762.21	4.43	4.71	4.68	0.33	0.35	0.35
G2	616.73	653.10	693.07	3.78	4.01	4.25	0.29	0.31	0.34
G3	173.67	179.42	164.79	1.07	1.10	1.01	0.07	0.07	0.06
G4	764.91	767.01	773.14	4.69	4.71	4.74	0.29	0.29	0.29
G5	695.91	714.54	698.29	4.27	4.38	4.28	0.31	0.32	0.30
G6	727.87	743.22	714.41	4.47	4.56	4.38	0.31	0.32	0.30
G7	382.70	400.18	416.91	2.35	2.46	2.56	0.16	0.16	0.17

Table S2. Simulated future climate change impacts on wastewater treatment costs under 5.5% interest rate assumption.

Variables	Annual O&M Costs (Million $)						Per Unit of Wastewater Treated O&M Cost ($/m^3)		
	Entire Sample (θ^S)			Average Plant ($\bar{\theta}^P$)			Average Plant ($\bar{\mu}^P$)		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
Base		302.03			1.85			0.11	
G1	121.43	135.88	122.71	0.74	0.83	0.75	0.05	0.06	0.05
G2	104.73	111.94	109.22	0.64	0.69	0.67	0.04	0.05	0.05
G3	30.71	30.86	28.11	0.19	0.19	0.17	0.01	0.01	0.01
G4	128.61	129.91	129.47	0.79	0.80	0.79	0.04	0.05	0.05
G5	114.20	118.29	115.52	0.70	0.73	0.71	0.05	0.05	0.05
G6	124.08	125.70	121.92	0.76	0.77	0.75	0.05	0.05	0.05
G7	65.99	70.01	73.54	0.40	0.43	0.45	0.02	0.03	0.03

Table S3. List of symbols used in the manuscript.

Symbol	Remarks
k	Set of treatment plant characteristics
m	Set of continuous treatment plant parameters
i	Set of treatment plants
t	Time periods
g	Climate prediction models
r	Greenhouse gas emission scenarios
p	Policy design scenarios
v	Wastewater volume scenarios
s	Simulations
$\mathbf{T}$	Vector of treatment technology dummy variables
$\mathbf{P}$	Vector of provincial dummy variables
$\mathbf{D}$	Vector of decadal dummy variables
I	Investment level in wastewater treatment plants
V	Volume treated in wastewater treatment plants
C	Designed capacity of wastewater treatment plants
Y	Year wastewater treatment plant established
$\mathbf{Q}$	Vector of wastewater inflow and outflow quality parameters
$\mathbf{W}$	Vector of climate indicators
TVC	Sample year observed total variable costs of wastewater treatment plants
α	Coefficients of estimated wastewater treatment cost function
β	Coefficients of estimated wastewater treatment cost function
$\mathbf{Z}$	Set of explanatory dummy variables
$\mathbf{X}$	Set of explanatory continuous variables
z_k	Variable included in the set of dummy explanatories
x_m	Variable included in the set of continuous explanatories
$\mathbf{Z}_t^s$	Set of explanatory dummy variables for specific simulation in future time-period
$\mathbf{X}_{rgpvt}^s$	Set of explanatory continuous variables for specific simulation in future time-period for a combination of policy, climate and wastewater volume scenarios
$\mathbf{\Omega}^s$	Set of estimated coefficients of the wastewater treatment cost function for a specific simulation
β_I	Cost function coefficient estimate of investment level
β_C	Cost function coefficient estimate of designed capacity
β_V	Cost function coefficient estimate of treated volume
β_Y	Cost function coefficient estimate of tenure
$\beta_{Q_{In}}$	Cost function coefficient estimate of influent BOD level
$\beta_{Q_{Out}}$	Cost function coefficient estimate of enfluent BOD level
$\beta_{tmp_{av}}^{pst}$	Cost function coefficient estimate of past annual average temperature

Table S3. Continued.

Symbol	Remarks
$\beta_{tmp_{\text{var}}}^{pst}$	Cost function coefficient estimate of past intra-annual variance in temperature
$\beta_{tmp_{av}}^{rat}$	Cost function coefficient estimate of the ratio between observed and past annual average temperature
$\beta_{tmp_{\text{var}}}^{rat}$	Cost function coefficient estimate of the ratio between observed and past intra-annual variance in temperature
μ_i^P	Plant level average per volume treated predicted wastewater treatment cost
θ^S	Total costs of wastewater treatment over the entire sample
$\overline{\mu}^P$	Sample average of per volume treated predicted wastewater treatment cost
$\overline{\theta}^P$	Sample average of plant level predicted wastewater treatment cost
$\mu_{\min}^P$	Sample minimum of per volume treated predicted wastewater treatment cost
$\theta_{\min}^P$	Sample minimum of plant level predicted wastewater treatment cost
$\mu_{\max}^P$	Sample maximum of per volume treated predicted wastewater treatment cost
$\theta_{\max}^P$	Sample maximum of plant level predicted wastewater treatment cost