A Supplementary Tables (For Online Publication)

Table A.1: Summary statistics of the major ports in United States

	Vessel Tonnage (100,000 Mt)				Vessel Counts			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Houston, TX	12.4	3.4	1.34	35.9	53.9	12.2	8.00	157.0
Long Beach, CA	9.8	3.4	0.00	24.7	18.7	5.8	0.00	55.0
New York, NY and NJ	8.2	2.8	0.41	49.3	21.0	7.2	1.00	142.0
Los Angeles, CA	7.4	3.0	0.00	26.1	15.3	5.6	0.00	49.0
South Louisiana, LA, Port of	7.2	2.7	0.98	17.9	22.7	7.2	4.00	51.0
New Orleans, LA	4.9	1.5	0.29	11.7	19.4	5.7	2.00	46.0
Baltimore, MD	4.9	2.1	0.09	15.6	12.9	4.3	1.00	50.0
Savannah, GA	3.9	1.7	0.00	12.1	10.5	3.5	0.00	29.0
Oakland, CA	3.7	1.9	0.00	23.5	6.9	3.5	0.00	53.0
Seattle, WA	3.5	1.5	0.24	10.6	24.4	5.1	1.00	46.0
Miami, FL	3.5	1.9	0.11	10.7	24.4	7.2	5.00	57.0
Port Everglades, FL	3.3	2.2	0.04	14.4	17.7	4.4	4.00	40.0
Charleston, SC	3.2	1.2	0.00	9.1	8.4	2.9	0.00	26.0
Tacoma, WA	2.9	1.5	0.04	13.7	14.4	4.5	1.00	34.0
Beaumont, TX	2.7	1.2	0.00	7.7	7.3	2.9	0.00	20.0
Mobile, AL	2.7	1.0	0.06	7.2	12.2	3.9	1.00	31.0
Jacksonville, FL	2.2	1.0	0.00	7.6	8.1	3.0	0.00	23.0
Portland, OR	1.8	1.0	0.00	7.0	7.7	3.9	0.00	29.0
Tampa, FL	1.6	0.8	0.00	6.1	7.6	3.3	0.00	30.0
Philadelphia, PA	1.6	1.0	0.00	6.2	3.7	2.1	0.00	21.0
Baton Rouge, LA	1.5	0.8	0.00	6.1	5.3	2.5	0.00	17.0
Galveston, TX	1.5	1.0	0.00	7.1	10.9	4.7	0.00	31.0
Lake Charles, LA	1.4	0.7	0.00	4.3	7.7	3.4	0.00	23.0
San Diego, CA	0.8	0.7	0.00	6.0	4.3	2.4	0.00	15.0
Port Hueneme, CA	0.5	0.4	0.00	2.4	1.7	1.3	0.00	6.0
Palm Beach, FL	0.3	0.2	0.00	3.0	6.2	3.3	0.00	19.0
San Francisco, CA	0.3	0.5	0.00	3.9	0.7	1.1	0.00	11.0

Notes: This table presents the summary statistics of daily vessel tonnage and daily mean vessel counts for the 27 major ports in the United States. The data are obtained from the US Army Corps of Engineers.

Table A.2: ICD-9-CM, ICD-10-CM, and MS-DRG codes

	ICD-9 Code	ICD-10 Code	MS-DRG Code
Panel A: Respiratory			
Asthma	493	J45	202, 203
Upper Respiratory	460-465	J00-J06	011-013, 152, 153
All Respiratory	460-519	J00-J99	011-013, 152-156, 177-182, 186-206, 793, 865, 866, 919-921, 928, 929, 951
Panel B: Heart			
All Heart	410-429	I20-I52	175, 176, 222-227, 280-285, 288-293, 296-298, 302, 303, 306-311, 314-316, 793
Panel C: Psychiatric			
Anxiety	300.0, 300.2	F40, F41	880, 882
All Psychiatric	300.0, 300.2, 296.0, 296.4-296.9, 309.0, 309.2-309.4, 295, 308.9, 309.8, 314.0, 314.2, 314.9, 312.0-312.2, 312.8, 312.9, 313.8, 299.0, 299.8, 312.3, 307.9, 311, 296.2, 296.3, 296.8, 296.9, 298.0, 300.4, 625.4, 301.10, 301.12, 301.13, 301.0, 301.3, 301.4, 301.6-301.9, 301.50, 301.59	F43.2, F43.8, F43.9, F20, F22-F25, F28, F29, F43.0, F43.1, F90, F91, F84.0, F84.5, F84.8, F63, F32, F33, F34.0, F34,1, F60	880-886
Panel D: Placebo			
Arterial Embolism	444	I74	.
Appendicitis	540-543	K35-K38	.

Notes: Table presents the ICD-9-CM, and ICD-10-CM codes for counting hospital visits for the illness groups examined in the paper and the corresponding MS-DRG code for calculating average medical costs for each illness group. The codes include the ranges of themselves and any subcategories. We do not calculate medical costs for the placebo diseases.

Table A.3: Supplementary summary statistics of variables

	Within 25 Miles of US Ports				Within 25 Miles of CA Ports			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Panel A: Pollution								
CO Max (ppb)	839.9	730.3	0.0	49000.0	921.1	854.2	0.0	49000.0
NO_2 Max (ppb)	25.7	15.9	0.0	417.0	29.1	17.0	0.0	270.0
$PM_{2.5}$ Max ($\mu g/m^3$)	11.7	7.5	0.0	265.9	13.5	8.5	0.0	239.2
SO_2 Max (ppb)	5.5	9.5	0.0	462.1	3.0	3.4	0.0	144.2
O_3 Mean (ppb)	26.6	11.6	0.0	100.7	25.5	11.2	0.0	84.8
O_3 Max (ppb)	37.0	14.5	0.0	144.0	35.7	13.2	0.0	114.0
Panel B: Hospital visits per million residents – Placebo illnesses								
Arterial Embolism	.	.	.	.	0.7	5.2	0.0	297.5
Appendicitis	.	.	.	.	4.0	12.7	0.0	431.8

Notes: This table presents supplementary summary statistics for pollution and placebo illness variables, including mean, standard deviation, minimum, and maximum. The data are obtained from the US EPA Air Quality System and the Office of Statewide Health Planning and Development of California.

Table A.4: Summary statistics of hospital visit rate for Hispanics

	Mean	SD	Min	Max
Asthma	53.5	101.1	0.0	2806.4
Upper Respiratory	51.3	93.0	0.0	3089.1
All Respiratory	184.7	211.2	0.0	8917.6
All Heart	71.1	118.6	0.0	2900.7
Anxiety	36.5	83.2	0.0	1870.9
All Psychiatric	96.6	162.1	0.0	3663.0

Notes: This table presents summary statistics of hospital visit rates (i.e., hospital visits per million residents) for Hispanics, including mean, standard deviation, minimum, and maximum. The data are obtained Office of Statewide Health Planning and Development of California.

Table A.5: Average pollution exposure weighted by Black and White population in port areas

	Black	White
CO (ppb)	423.12	406.95
NO_2 (ppb)	15.25	13.68
$PM_{2.5}$ ($\mu g/m^3$)	10.55	10.03
SO_2 (ppb)	0.63	0.60

Notes: This table presents average pollution exposure for Blacks and Whites for 2010–2016, weighted by the zip code-level Black and White population. The population data are obtained from US 2010 Decennial Census. The pollution data are from the US EPA Air Quality System.

Table A.6: Balance statistics for weather variables in port areas

	Standardized Mean Differences	Variance Ratio	Kolmogorov-Smirnov Statistics
Wind Speed (m/s)	-0.005	1.068	0.016
Wind Direction (degree)	-0.009	1.041	0.013
Max Temperature (C)	0.006	0.989	0.009
Min Temperature (C)	-0.005	1.000	0.008
Precipitation (mm)	-0.011	1.068	0.009
Dew Point Temperature (C)	-0.015	0.991	0.014

Notes: This table presents the balance statistics of weather variables in the US port areas, separately for the month-days when there exist seven-day lagged and 500-mile distant tropical cyclones in the ocean and the same month-days when there are no such cyclones. Balanced sub-samples indicate that standardized mean differences are close to zero, variance ratios are close to one, and Kolmogorov-Smirnov (KS) statistics are close to zero. The data are obtained from the NOAA Integrated Surface Database.

Table A.7: First-stage relationship between tropical cyclones and port traffic

	Dependent variable: port traffic							
	Vessel Tonnage				Vessel Counts			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tropical Cyclone	-0.24^{***}	-0.22^{***}	-0.22^{***}	-0.20^{***}	-0.53^{***}	-0.47^{***}	-0.48^{***}	-0.44^{***}
	(0.05)	(0.04)	(0.05)	(0.04)	(0.13)	(0.10)	(0.13)	(0.11)
AR stat. p-val	0.070	0.000	0.019	0.219	0.070	0.000	0.019	0.219
SW S stat. p-val	0.060	0.000	0.017	0.164	0.060	0.000	0.017	0.164
Observations	524,197	604,632	428,220	484,745	524,197	604,632	428,220	484,745

Notes: This table presents the first-stage results for the instrumental variable estimation in Panel A of Table 2. Each entry corresponds to an individual regression. The instrument is an indicator of seven-day lagged and 500-mile distant cyclones in the ocean. All regressions include weather controls, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, precipitation, wind speed, and relative wind direction between a monitor-port pair. All regressions also include county-by-year, month, day-of-week, holiday, and monitor-port pair fixed effects. An observation is a monitor-port-day. Standard errors are clustered by monitor-port pair and day. AR refers to Anderson-Rubin Wald statistic and SW refers to the Stock and Wright LM S statistic. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.8: Effect of vessel tonnage on air pollutant concentrations around California ports

	Dependent variable: pollutant concentration							
	CO	NO_2	$PM_{2.5}$	SO_2	CO	NO_2	$PM_{2.5}$	SO_2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Vessel Tonnage	16.96	1.47**	0.29	−0.02				
	(24.87)	(0.60)	(0.93)	(0.11)				
Vessel Counts					10.25	0.91**	0.19	−0.01
					(15.11)	(0.38)	(0.61)	(0.06)
1st-Stage F Stat.	19.16	17.96	14.31	15.31	14.97	14.12	12.04	13.28
Adjusted R^2	0.52	0.72	0.42	0.46	0.52	0.71	0.41	0.46
Observations	230,582	247,672	115,797	151,808	230,582	247,672	115,797	151,808

Notes: This table presents the instrumental variable estimates of the effect of vessel tonnage on pollutant concentrations within a 25-mile radius of ports in California. Each entry presents an individual regression on a local air pollutant. The endogenous variable, vessel tonnage, is instrumented by an indicator of seven-day lagged cyclones that are at least 500-mile distant from ports. All regressions include weather controls, such as the quadratics of maximum, minimum, and dew point temperature, precipitation, wind speed, and relative wind direction between a monitor-port pair. All regressions also include county-by-year, month, day-of-week, holiday, and monitor-port fixed effects. An observation is a monitor-port-day. Standard errors are clustered by monitor-port pair and day. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.9: 2SLS estimation of the effect of vessels in port on ozone pollution

	Dependent variable: pollutant concentration	
	(1)	(2)
Vessel Tonnage	−1.19	
	(0.78)	
Vessel Counts		−0.55
		(0.38)
1st-Stage F Stat.	36.10	19.60
Adjusted R^2	0.38	0.37
Observations	848,889	848,889

Notes: Panel A presents the OLS estimates of the effect of port traffic on O_3 concentrations within a 25-mile radius of ports in the United States. Panel B presents the IV estimates of the effect of port traffic on O_3 concentrations within a 25-mile radius of ports in the United States. Each entry presents an individual regression on a local air pollutant. The endogenous variables, vessel tonnage and the number of vessels, are instrumented by an indicator of seven-day lagged cyclones that are at least 500-mile distant from ports. All regressions include weather controls, such as the quadratics of maximum, minimum, and dew point temperature, precipitation, wind speed, and relative wind direction between a monitor-port pair. All regressions also include county-by-year, month, day-of-week, holiday, and monitor-port fixed effects. An observation is a monitor-port-day. Standard errors are clustered by monitor-port pair and day. The first-stage F statistics for column (1) is 36 and for column (2) is 20. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.10: Effect of air pollution on hospital visit rates for the overall population in California port areas, 2SLS estimation

	Dependent variable: hospital visits/million residents					
	Respiratory			Heart	Psychiatric	
	Asthma	Upper Respiratory	All Respiratory	All Heart	Anxiety	All Psychiatric
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: CO						
CO	2.79***	3.09***	10.46***	3.16***	0.69**	1.87***
	(0.41)	(0.64)	(1.74)	(0.63)	(0.27)	(0.65)
Adjusted R^2	0.39	0.34	0.47	0.35	0.22	0.40
1st-Stage F Stat.	56.44	56.44	56.44	56.44	56.44	56.44
AR Stat. P-val	3.99e-10	3.99e-10	3.99e-10	3.99e-10	3.99e-10	3.99e-10
SW S Stat. P-val	5.16e-06	5.16e-06	5.16e-06	5.16e-06	5.16e-06	5.16e-06
Observations	1,776,040	1,776,040	1,776,040	1,776,040	1,776,040	1,776,040
Panel B: NO_2						
NO_2	2.39***	2.91***	8.79***	3.09***	0.71***	1.94***
	(0.38)	(0.61)	(1.61)	(0.58)	(0.25)	(0.61)
Adjusted R^2	0.39	0.34	0.47	0.35	0.22	0.40
1st-Stage F Stat.	78.84	78.84	78.84	78.84	78.84	78.84
AR Stat. P-val	3.02e-09	3.02e-09	3.02e-09	3.02e-09	3.02e-09	3.02e-09
SW S Stat. P-val	1.58e-05	1.58e-05	1.58e-05	1.58e-05	1.58e-05	1.58e-05
Observations	1,805,287	1,805,287	1,805,287	1,805,287	1,805,287	1,805,287
Panel C: $PM_{2.5}$						
$PM_{2.5}$	1.84***	2.21***	6.73***	2.19***	0.50**	1.33***
	(0.32)	(0.51)	(1.37)	(0.49)	(0.21)	(0.50)
Adjusted R^2	0.39	0.34	0.47	0.35	0.22	0.40
1st-Stage F Stat.	27.67	27.67	27.67	27.67	27.67	27.67
AR Stat. P-val	5.36e-09	5.36e-09	5.36e-09	5.36e-09	5.36e-09	5.36e-09
SW S Stat. P-val	2.07e-05	2.07e-05	2.07e-05	2.07e-05	2.07e-05	2.07e-05
Observations	1,714,554	1,714,554	1,714,554	1,714,554	1,714,554	1,714,554
Panel D: SO_2						
SO_2	3.28***	4.68***	13.13***	4.40***	1.19***	3.08***
	(0.63)	(0.97)	(2.57)	(0.93)	(0.40)	(0.96)
Adjusted R^2	0.39	0.33	0.47	0.35	0.22	0.40
1st-Stage F Stat.	32.73	32.73	32.73	32.73	32.73	32.73
AR Stat. P-val	5.16e-10	5.16e-10	5.16e-10	5.16e-10	5.16e-10	5.16e-10
SW S Stat. P-val	6.40e-06	6.40e-06	6.40e-06	6.40e-06	6.40e-06	6.40e-06
Observations	1,742,012	1,742,012	1,742,012	1,742,012	1,742,012	1,742,012

Notes: This table presents the detailed results of Panel A in Table 3. Each entry presents an individual regression of an air pollutant on an illness category. Pollution concentrations are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls, such as the quadratics of maximum, minimum, and dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.11: Effect of air pollution on hospital visit rates for Blacks in California port areas, 2SLS estimation

	Dependent variable: hospital visits/million residents					
	Respiratory			Heart	Psychiatric	
	Asthma	Upper Respiratory	All Respiratory	All Heart	Anxiety	All Psychiatric
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: CO						
CO	7.81***	5.38***	20.44***	5.74***	0.92	−0.04
	(1.63)	(1.43)	(4.04)	(1.79)	(0.81)	(1.88)
Adjusted R^2	0.17	0.10	0.23	0.13	0.05	0.19
1st-Stage F Stat.	46.35	46.35	46.35	46.35	46.35	46.35
AR Stat. P-val	0	0	0	0	0	0
SW S Stat. P-val	0.000361	0.000361	0.000361	0.000361	0.000361	0.000361
Observations	877,072	877,072	877,072	877,072	877,072	877,072
Panel B: NO_2						
NO_2	7.18***	8.77***	23.32***	5.95***	1.23	0.66
	(1.68)	(1.48)	(4.23)	(1.85)	(0.85)	(1.96)
Adjusted R^2	0.17	0.10	0.23	0.13	0.05	0.19
1st-Stage F Stat.	61.44	61.44	61.44	61.44	61.44	61.44
AR Stat. P-val	0	0	0	0	0	0
SW S Stat. P-val	0.000338	0.000338	0.000338	0.000338	0.000338	0.000338
Observations	887,300	887,300	887,300	887,300	887,300	887,300
Panel C: $PM_{2.5}$						
$PM_{2.5}$	5.66***	6.28***	18.00***	3.77***	0.38	−0.53
	(1.28)	(1.13)	(3.29)	(1.41)	(0.60)	(1.45)
Adjusted R^2	0.17	0.10	0.23	0.13	0.05	0.19
1st-Stage F Stat.	23.52	23.52	23.52	23.52	23.52	23.52
AR Stat. P-val	3.32e-10	3.32e-10	3.32e-10	3.32e-10	3.32e-10	3.32e-10
SW S Stat. P-val	0.000549	0.000549	0.000549	0.000549	0.000549	0.000549
Observations	846,980	846,980	846,980	846,980	846,980	846,980
Panel D: SO_2						
SO_2	10.87***	16.35***	39.10***	8.23***	1.93	1.54
	(2.54)	(2.41)	(6.65)	(2.88)	(1.35)	(3.07)
Adjusted R^2	0.17	0.10	0.23	0.13	0.05	0.19
1st-Stage F Stat.	21.09	21.09	21.09	21.09	21.09	21.09
AR Stat. P-val	0	0	0	0	0	0
SW S Stat. P-val	0.000292	0.000292	0.000292	0.000292	0.000292	0.000292
Observations	871,296	871,296	871,296	871,296	871,296	871,296

Notes: This table presents the detailed results of Panel B in Table 3. Each entry presents an individual regression of an air pollutant on an illness category. Pollution concentrations are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls, such as the quadratics of maximum, minimum, and dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.12: Effect of air pollution on hospital visit rates for Whites in California port areas, 2SLS estimation

	Dependent variable: hospital visits/million residents					
	Respiratory			Heart	Psychiatric	
	Asthma	Upper Respiratory	All Respiratory	All Heart	Anxiety	All Psychiatric
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: CO						
CO	2.41***	2.10***	9.55***	4.02***	0.11	2.38*
	(0.51)	(0.41)	(1.56)	(1.16)	(0.54)	(1.25)
Adjusted R^2	0.17	0.09	0.34	0.28	0.15	0.32
1st-Stage F Stat.	58.31	58.31	58.31	58.31	58.31	58.31
AR Stat. P-val	8.13e-10	8.13e-10	8.13e-10	8.13e-10	8.13e-10	8.13e-10
SW S Stat. P-val	8.72e-06	8.72e-06	8.72e-06	8.72e-06	8.72e-06	8.72e-06
Observations	1,650,747	1,650,747	1,650,747	1,650,747	1,650,747	1,650,747
Panel B: NO_2						
NO_2	1.78***	1.80***	6.84***	3.51***	0.22	2.32**
	(0.46)	(0.40)	(1.42)	(1.01)	(0.48)	(1.12)
Adjusted R^2	0.17	0.09	0.34	0.28	0.15	0.32
1st-Stage F Stat.	83.18	83.18	83.18	83.18	83.18	83.18
AR Stat. P-val	1.84e-08	1.84e-08	1.84e-08	1.84e-08	1.84e-08	1.84e-08
SW S Stat. P-val	2.95e-05	2.95e-05	2.95e-05	2.95e-05	2.95e-05	2.95e-05
Observations	1,679,994	1,679,994	1,679,994	1,679,994	1,679,994	1,679,994
Panel C: $PM_{2.5}$						
$PM_{2.5}$	1.53***	1.51***	5.55***	2.78***	0.16	1.82*
	(0.41)	(0.35)	(1.29)	(0.91)	(0.43)	(0.99)
Adjusted R^2	0.17	0.09	0.34	0.28	0.15	0.32
1st-Stage F Stat.	27.30	27.30	27.30	27.30	27.30	27.30
AR Stat. P-val	2.31e-08	2.31e-08	2.31e-08	2.31e-08	2.31e-08	2.31e-08
SW S Stat. P-val	4.14e-05	4.14e-05	4.14e-05	4.14e-05	4.14e-05	4.14e-05
Observations	1,598,695	1,598,695	1,598,695	1,598,695	1,598,695	1,598,695
Panel D: SO_2						
SO_2	2.05***	2.63***	8.98***	4.64***	0.35	3.35**
	(0.69)	(0.58)	(2.10)	(1.49)	(0.70)	(1.63)
Adjusted R^2	0.17	0.09	0.33	0.28	0.15	0.32
1st-Stage F Stat.	38.52	38.52	38.52	38.52	38.52	38.52
AR Stat. P-val	9.80e-10	9.80e-10	9.80e-10	9.80e-10	9.80e-10	9.80e-10
SW S Stat. P-val	8.90e-06	8.90e-06	8.90e-06	8.90e-06	8.90e-06	8.90e-06
Observations	1,616,890	1,616,890	1,616,890	1,616,890	1,616,890	1,616,890

Notes: This table presents the detailed results of Panel C in Table 3. Each entry presents an individual regression of an air pollutant on an illness category. Pollution concentrations are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls, such as the quadratics of maximum, minimum, and dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.13: OLS estimates of the effect of air pollution on hospital visit rates in California port areas

	Dependent variable: hospital visits/million residents					
	Respiratory			Heart	Psychiatric	
	Asthma	Upper Respiratory	All Respiratory	All Heart	Anxiety	All Psychiatric
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Overall population						
CO	0.63***	0.24	2.06***	1.20***	0.09	0.25
	(0.19)	(0.23)	(0.76)	(0.30)	(0.09)	(0.23)
NO_2	1.36***	−0.11	3.94***	3.18***	0.66***	2.05***
	(0.24)	(0.37)	(0.98)	(0.44)	(0.16)	(0.44)
$PM_{2.5}$	0.49***	0.32*	1.39***	−0.07	0.06	0.07
	(0.12)	(0.18)	(0.50)	(0.24)	(0.09)	(0.23)
SO_2	0.47***	−0.43***	−0.55	0.35**	0.09	0.27
	(0.13)	(0.16)	(0.45)	(0.17)	(0.08)	(0.19)
Panel B: Black						
CO	2.41***	−0.17	5.00***	2.59***	0.58**	1.52**
	(0.70)	(0.54)	(1.72)	(0.74)	(0.28)	(0.74)
NO_2	4.13***	0.65	11.12***	5.06***	1.50***	4.20***
	(1.02)	(0.91)	(2.65)	(1.11)	(0.43)	(1.16)
$PM_{2.5}$	1.70***	−0.08	2.33*	0.34	0.28	0.01
	(0.54)	(0.45)	(1.35)	(0.59)	(0.22)	(0.58)
SO_2	2.63***	−0.10	2.36	0.81	−0.03	0.64
	(0.70)	(0.56)	(1.64)	(0.59)	(0.26)	(0.67)
Panel C: White						
CO	0.74***	−0.08	2.55***	2.17***	0.19	0.64
	(0.23)	(0.13)	(0.77)	(0.50)	(0.17)	(0.43)
NO_2	2.09***	−0.30	6.87***	6.51***	1.50***	4.84***
	(0.29)	(0.23)	(0.90)	(0.72)	(0.28)	(0.73)
$PM_{2.5}$	0.31**	0.02	0.68	−0.17	0.01	0.14
	(0.15)	(0.11)	(0.44)	(0.38)	(0.16)	(0.38)
SO_2	0.49***	−0.29***	−0.09	0.53*	−0.12	0.02
	(0.15)	(0.10)	(0.38)	(0.31)	(0.15)	(0.33)

Notes: This table presents the OLS estimation of the effect of air pollution on hospital visit rates for the overall population, Blacks, and Whites. Each entry presents an individual regression of an air pollutant on an illness category. Pollution concentrations are standardized to their means and standard deviations. All regressions include weather controls, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, precipitation, wind speed, and relative wind direction between a zip code-port pair. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.14: Elasticities of the effect of pollution on hospital visit rates for Blacks and Whites in California port areas

	Dependent variable: IHS transformation of hospital visit rates					
	Respiratory			Heart	Psychiatric	
	Asthma	Upper Respiratory	All Respiratory	All Heart	Anxiety	All Psychiatric
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Black						
CO	0.103***	0.224***	0.091***	0.124***	0.068	−0.003
	(0.038)	(0.058)	(0.026)	(0.036)	(0.054)	(0.042)
NO_2	0.016	0.189***	0.038*	0.063**	0.051	0.002
	(0.027)	(0.040)	(0.021)	(0.027)	(0.039)	(0.030)
$PM_{2.5}$	0.051*	0.174***	0.059***	0.064**	0.032	−0.015
	(0.027)	(0.041)	(0.020)	(0.026)	(0.038)	(0.030)
SO_2	0.185**	0.531***	0.184***	0.248***	0.209*	0.010
	(0.075)	(0.112)	(0.054)	(0.075)	(0.113)	(0.082)
Panel B: White						
CO	0.125***	0.141***	0.083***	0.084***	0.005	0.056*
	(0.033)	(0.037)	(0.023)	(0.024)	(0.035)	(0.028)
NO_2	0.037*	0.112***	0.039**	0.049***	0.017	0.034*
	(0.021)	(0.027)	(0.015)	(0.015)	(0.023)	(0.018)
$PM_{2.5}$	0.056**	0.111***	0.043**	0.058***	0.021	0.044**
	(0.024)	(0.030)	(0.017)	(0.017)	(0.025)	(0.020)
SO_2	0.191***	0.281***	0.145***	0.153***	0.021	0.099*
	(0.063)	(0.074)	(0.045)	(0.044)	(0.065)	(0.052)

Notes: This table presents the instrumental variable estimation of elasticities of the effect of pollution on hospital visit rates for Blacks and Whites in California port areas. Each entry presents an individual regression of an air pollutant on an illness category. The dependent variables and pollution measures are IHS transformed. The instruments include fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls, such as the quadratics of maximum, minimum, and dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. The first-stage F statistics range from 20 to 91 for Panel A and from 31 to 103 for Panel B. Estimates are weighted by the zip code-specific population. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.15: Test for differences of hospital visit rates of Blacks and Whites in California port areas

	Respiratory			Heart	Psychiatric	
	Asthma	Upper Respiratory	All Respiratory	All Heart	Anxiety	All Psychiatric
	(1)	(2)	(3)	(4)	(5)	(6)
CO	5.40***	3.29**	10.88**	1.73	0.81	-2.43
	[3.15]	[2.21]	[2.51]	[0.81]	[0.83]	[-1.08]
NO_2	5.41***	6.97***	16.48***	2.44	1.01	-1.66
	[3.10]	[4.55]	[3.69]	[1.16]	[1.04]	[-0.73]
$PM_{2.5}$	4.13***	4.77***	12.45***	0.98	0.22	-2.35
	[3.08]	[4.04]	[3.52]	[0.58]	[0.29]	[-1.34]
SO_2	8.83***	13.72***	30.12***	3.59	1.58	-1.81
	[3.35]	[5.53]	[4.32]	[1.11]	[1.04]	[-0.52]

Notes: This table presents the statistical tests for the equality of regression coefficients for Blacks and Whites in Panels B and C in Table 3. Pollution concentrations are standardized to their means and standard deviations. Each entry presents an individual test. The numbers in square brackets are Z-scores. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.16: Effect of air pollution on differences of hospital visit rates between Blacks and Whites in California port areas, 2SLS estimation

	Dependent variable: hospital visit rate for Blacks – hospital visit rate for whites					
	Respiratory			Heart	Psychiatric	
	Asthma	Upper Respiratory	All Respiratory	All Heart	Anxiety	All Psychiatric
	(1)	(2)	(3)	(4)	(5)	(6)
CO	6.75***	5.65***	11.50**	−0.93	−0.26	−6.20
	(2.47)	(1.83)	(5.09)	(3.09)	(1.88)	(4.01)
NO_2	6.62***	9.13***	17.65***	−0.85	−0.52	−5.14
	(2.34)	(1.71)	(4.90)	(2.85)	(1.74)	(3.67)
$PM_{2.5}$	5.31***	6.76***	14.03***	−1.31	−0.39	−4.62
	(1.93)	(1.45)	(4.13)	(2.29)	(1.40)	(3.08)
SO_2	10.01***	14.72***	29.78***	0.18	−0.55	−5.72
	(3.26)	(2.53)	(7.07)	(4.00)	(2.31)	(4.78)

Notes: This table presents the effects of pollution on the differences of hospital visit rates between Blacks and Whites. Each entry presents an individual regression of an air pollutant on an illness category. Pollution concentrations are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls, such as the quadratics of maximum, minimum, and dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. The first-stage F statistics range from 26 to 72. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.17: Effect of air pollution on hospital visit rates in California port areas by age

	Dependent variable: hospital visits/million residents in each age group					
	Respiratory			Heart	Psychiatric	
	Asthma	Upper Respiratory	All Respiratory	All Heart	Anxiety	All Psychiatric
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Ages 5 and under						
CO	2.97**	13.63***	22.97***	0.46*	0.12	0.92***
	(1.27)	(4.46)	(8.62)	(0.27)	(0.09)	(0.23)
NO_2	3.16***	14.05***	20.00**	0.50*	0.10	0.76***
	(1.21)	(4.20)	(8.07)	(0.27)	(0.08)	(0.21)
$PM_{2.5}$	2.27**	9.23***	12.52*	0.27	0.08	0.72***
	(0.96)	(3.36)	(6.53)	(0.20)	(0.06)	(0.17)
SO_2	4.13**	21.71***	27.81**	0.72*	0.16	1.07***
	(2.07)	(6.93)	(13.25)	(0.44)	(0.14)	(0.36)
Panel B: Ages between 5 and 19						
CO	2.41***	3.59***	7.78***	0.14	−0.10	0.46
	(0.71)	(1.08)	(2.30)	(0.11)	(0.20)	(0.55)
NO_2	2.47***	3.46***	6.67***	0.18*	−0.03	0.82
	(0.67)	(1.03)	(2.17)	(0.11)	(0.19)	(0.52)
$PM_{2.5}$	1.90***	2.75***	5.37***	0.09	0.05	0.67
	(0.54)	(0.86)	(1.79)	(0.09)	(0.15)	(0.42)
SO_2	3.52***	6.67***	11.35***	0.23	−0.07	1.55*
	(1.13)	(1.67)	(3.51)	(0.18)	(0.31)	(0.85)
Panel C: Ages between 20 and 64						
CO	2.42***	1.92***	8.19***	1.42***	0.93***	1.44*
	(0.41)	(0.36)	(1.24)	(0.42)	(0.34)	(0.74)
NO_2	1.94***	2.20***	7.35***	1.26***	0.91***	1.50**
	(0.37)	(0.34)	(1.13)	(0.39)	(0.32)	(0.69)
$PM_{2.5}$	1.50***	1.75***	5.76***	0.82***	0.66**	0.97*
	(0.31)	(0.29)	(0.98)	(0.32)	(0.26)	(0.57)
SO_2	2.72***	3.72***	11.36***	1.80***	1.49***	2.37**
	(0.61)	(0.56)	(1.87)	(0.61)	(0.50)	(1.10)
Panel D: Ages 65 and above						
CO	4.31***	0.50	15.80***	17.87***	0.67	5.90***
	(1.08)	(0.51)	(4.02)	(3.96)	(0.96)	(2.11)
NO_2	4.02***	0.93**	14.51***	17.01***	0.86	5.94***
	(0.99)	(0.45)	(3.57)	(3.57)	(0.86)	(1.89)
$PM_{2.5}$	2.98***	0.56	11.04***	12.53***	0.40	4.13***
	(0.83)	(0.38)	(3.10)	(3.06)	(0.71)	(1.58)
SO_2	5.86***	1.60**	20.75***	22.63***	1.69	9.33***
	(1.56)	(0.70)	(5.39)	(5.52)	(1.28)	(2.90)

Notes: This table presents the instrumental variable estimation of the effect of air pollution on hospital visit rates by age. Each entry presents an individual regression of an air pollutant on an illness category. Pollution concentrations are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. The first-stage F statistics range from 27 to 79. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

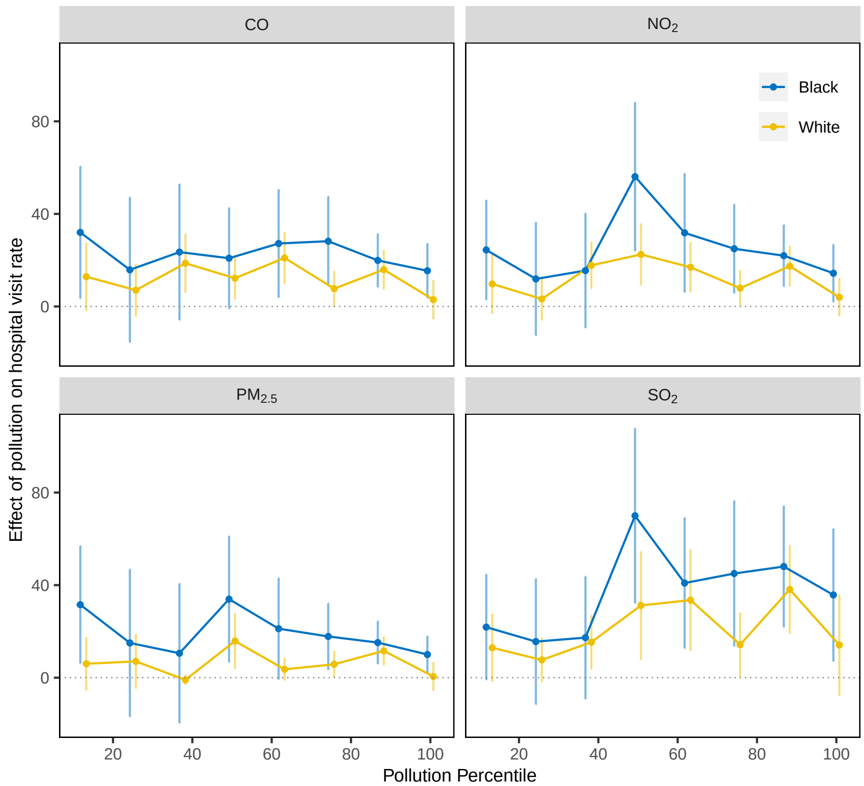

Figure A.1: Effects of pollution on hospital visit rates by pollution percentile.

Notes: This figure plots effects of pollution on total hospital visit rates (related to respiratory, heart, and psychiatric illnesses) in eight $PM_{2.5}$ pollution percentile groups. Pollution concentrations in regressions are from the EPA monitoring data, standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. Error bars correspond to 95% confidence intervals, where standard errors from regressions are clustered by port-zip code and day. An observation is a zip code-port-day.

Table A.18: Placebo test on the effect of the cyclone instrument on air pollutant concentrations in distant areas

	Dependent variable: pollutant concentration			
	CO	NO_2	$PM_{2.5}$	SO_2
	(1)	(2)	(3)	(4)
Tropical Cyclone	15.67	0.01	−0.19	0.004
	(10.28)	(0.06)	(0.12)	(0.03)
Adjusted R^2	0.54	0.72	0.33	0.48
Observations	82,278	135,801	98,568	70,950

Notes: This table presents the placebo test on regressing the instrumental variable of seven-day lagged cyclones that are at least 500-mile distant from ports on air pollutant concentrations in certain areas that are far from ports (i.e., 75–100 miles from major US ports). Each column presents an individual regression on a local air pollutant. All regressions include weather controls, such as quadratics of maximum, minimum, and dew point temperatures, precipitation, wind speed, and wind direction. All regressions also include county-by-year, month, day-of-week, holiday, and pollution monitor fixed effects. An observation is a monitor-day. Standard errors are clustered by pollution monitor and day. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.19: Effect of air pollution on hospital visit rates of placebo illnesses for the overall population in California port areas, instrumental variable estimation

	Dependent variable: hospital visits/million residents	
	Appendicitis	Arterial Embolism
	(1)	(2)
Panel A: CO		
CO	0.09	0.03
	(0.06)	(0.02)
Adjusted R^2	0.01	0.00
Observations	1,776,040	1,776,040
Panel B: NO_2		
NO_2	0.08	0.02
	(0.05)	(0.02)
Adjusted R^2	0.01	0.00
Observations	1,805,287	1,805,287
Panel C: $PM_{2.5}$		
$PM_{2.5}$	0.07	0.02
	(0.04)	(0.02)
Adjusted R^2	0.01	0.00
Observations	1,714,554	1,714,554
Panel D: SO_2		
SO_2	0.14*	0.03
	(0.08)	(0.03)
Adjusted R^2	0.01	0.00
Observations	1,742,012	1,742,012

Notes: This table presents the instrumental variable estimation of the effect of air pollution on hospital visit rates for placebo illnesses. Each entry presents an individual regression of an air pollutant on an illness category. Pollution concentrations are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. The first-stage F statistics range from 28 to 79. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.20: Robustness check for the effect of vessel tonnage in port on air pollution, various model specifications

	Dependent variable: pollutant concentration			
	CO	NO_2	$PM_{2.5}$	SO_2
	(1)	(2)	(3)	(4)
Panel A: No weather controls and temporal fixed effects				
Vessel Tonnage	2,358.96	120.54	4.13	37.07
	(3,618.78)	(263.04)	(3.11)	(110.60)
Adjusted R^2	-167.74	-649.67	-1.34	-514.91
Observations	524,197	604,632	428,220	484,745
Panel B: No weather controls				
Vessel Tonnage	16.76	0.57	1.15*	0.17
	(16.01)	(0.43)	(0.66)	(0.13)
Adjusted R^2	0.45	0.61	0.13	0.39
Observations	524,197	604,632	428,220	484,745
Panel C: No temporal fixed effects				
Vessel Tonnage	233.52***	9.84**	8.16***	0.94
	(88.98)	(4.44)	(2.21)	(0.73)
Adjusted R^2	-1.34	-3.79	-5.23	-0.09
Observations	524,197	604,632	428,220	484,745
Panel D: No quadratic weather terms				
Vessel Tonnage	18.06	0.98***	0.93*	0.05
	(13.53)	(0.33)	(0.56)	(0.12)
Adjusted R^2	0.53	0.72	0.29	0.42
Observations	524,197	604,632	428,220	484,745
Panel E: Monitors within 12.5 miles of ports				
Vessel Tonnage	28.21*	1.04***	1.33**	0.23
	(14.67)	(0.39)	(0.57)	(0.17)
Adjusted R^2	0.59	0.73	0.29	0.39
Observations	263,877	282,449	232,277	279,891

Notes: This table presents the robustness check results for Table 2 with various model specifications. Each panel presents regressions using an alternative model specification. Log vessel tonnage is instrumented by an indicator of seven-day lagged and 500-mile distant cyclones from ports. All regressions include weather controls, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, precipitation, wind speed, and relative wind direction between a monitor-port pair. All regressions also include county-by-year, month, day-of-week, holiday, and monitor-port pair fixed effects. Standard errors are clustered by monitor-port pair and day. The first-stage F statistics for Panel A is 0.1–3, for Panel B is 21–35, for Panel C is 6–16, for Panel D is 22–36, and for Panel E is 20–25. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.21: Robustness check for the effect of vessel tonnage in port on air pollution, various instrumental variable specifications

	Dependent variable: pollutant concentration			
	CO	NO_2	$PM_{2.5}$	SO_2
	(1)	(2)	(3)	(4)
Panel A: Exclude cyclones within 800 miles of ports				
Vessel Tonnage	18.24	0.90***	0.84*	0.06
	(11.80)	(0.31)	(0.51)	(0.12)
Adjusted R^2	0.54	0.73	0.35	0.44
Observations	524,197	604,632	428,220	484,745
Panel B: Six-day lagged cyclones				
Vessel Tonnage	16.90	1.25***	0.97*	0.16
	(13.49)	(0.36)	(0.57)	(0.12)
Adjusted R^2	0.54	0.71	0.34	0.43
Observations	524,197	604,632	428,220	484,745
Panel C: Eight-day lagged cyclones				
Vessel Tonnage	27.75**	0.95***	0.95	0.08
	(13.49)	(0.34)	(0.59)	(0.12)
Adjusted R^2	0.53	0.73	0.34	0.44
Observations	524,197	604,632	428,220	484,745
Panel D: Six-, seven-, and eight-day lagged cyclones (2SLS)				
Vessel Tonnage	22.93*	1.12***	1.07**	0.12
	(12.39)	(0.32)	(0.50)	(0.11)
Adjusted R^2	0.53	0.72	0.33	0.43
Observations	524,197	604,632	428,220	484,745
Panel E: Six-, seven-, and eight-day lagged cyclones (LIML)				
Vessel Tonnage	23.08*	1.13***	1.09**	0.12
	(12.53)	(0.33)	(0.52)	(0.11)
Adjusted R^2	0.53	0.72	0.32	0.43
Observations	524,197	604,632	428,220	484,745
Panel F: Cyclone counts				
Vessel Tonnage	−9.15	0.55**	1.22**	−0.03
	(10.92)	(0.27)	(0.48)	(0.09)
Adjusted R^2	0.55	0.75	0.30	0.44
Observations	524,197	604,632	428,220	484,745

Notes: This table presents the results of robustness check for Table 2 with various instrumental variable specifications. Each panel presents regressions using an alternative instrumental variable specification. All regressions include weather controls, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, precipitation, wind speed, and relative wind direction between a monitor-port pair. All regressions also include county-by-year, month, day-of-week, holiday, and monitor-port pair fixed effects. Standard errors are clustered by monitor-port pair and day. The first-stage F statistics for Panel A is 24–31, for Panel B is 21–33, for Panel C is 18–31, for Panel D is 8–12, and for Panel F is 29–41. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.22: Robustness check for the effect of vessel tonnage in port on air pollution, including and excluding different sets of observations where cyclones hit to ports

	Dependent variable: pollutant concentration			
	CO	NO_2	$PM_{2.5}$	SO_2
	(1)	(2)	(3)	(4)
Panel A: Including 2 days before and after cyclones near ports				
Vessel Tonnage	20.32	1.11***	1.17**	0.15
	(13.61)	(0.34)	(0.57)	(0.12)
Adjusted R^2	0.54	0.72	0.31	0.43
Observations	529,953	611,553	433,831	491,725
Panel B: Excluding 21 days after cyclones near ports				
Vessel Tonnage	22.62	1.20***	1.54**	0.12
	(13.87)	(0.35)	(0.59)	(0.12)
Adjusted R^2	0.54	0.71	0.25	0.44
Observations	508,766	586,027	412,972	465,777

Notes: Panel A presents the instrumental variable estimation of the effect of vessel tonnage in ports on air pollution, where we include the dates when there exist tropical cyclones near ports (e.g., within the 200-mile radius of ports) and two days before and after the events. Panel B presents the instrumental variable estimation of the effect of vessel tonnage in ports on air pollution, where we exclude 21 days of observations once cyclones are close to certain ports (e.g., within the 200-mile radius). Each column presents an individual regression on a local air pollutant. Log of vessel tonnage is instrumented by an indicator of seven-day lagged and 500-mile distant cyclones from ports. All regressions include weather controls, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, precipitation, wind speed, and relative wind direction between a monitor-port pair. All regressions also include county-by-year, month, day-of-week, holiday, and monitor-port pair fixed effects. Standard errors are clustered by monitor-port pair and day. The first-stage F statistics for Panel A is 21–35 and for Panel B is 21–34. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.23: Effect of air pollution on hospital visit rates in California port areas, satellite-based projected data

	Dependent variable: hospital visits/million residents					
	Respiratory			Heart	Psychiatric	
	Asthma	Upper Respiratory	All Respiratory	All Heart	Anxiety	All Psychiatric
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Overall population						
$PM_{2.5}$	1.82***	2.41***	7.05***	2.38***	0.51**	1.42***
	(0.32)	(0.51)	(1.38)	(0.50)	(0.22)	(0.52)
Adjusted R^2	0.39	0.33	0.47	0.35	0.22	0.40
Observations	1,799,639	1,799,639	1,799,639	1,799,639	1,799,639	1,799,639
Panel B: Black						
$PM_{2.5}$	5.45***	5.81***	16.72***	4.33***	0.63	−0.10
	(1.30)	(1.09)	(3.25)	(1.45)	(0.63)	(1.50)
Adjusted R^2	0.17	0.10	0.23	0.13	0.05	0.19
Observations	884,524	884,524	884,524	884,524	884,524	884,524
Panel C: White						
$PM_{2.5}$	1.40***	1.53***	5.54***	2.82***	0.10	1.77*
	(0.40)	(0.34)	(1.24)	(0.89)	(0.43)	(0.98)
Adjusted R^2	0.17	0.09	0.33	0.28	0.15	0.32
Observations	1,674,738	1,674,738	1,674,738	1,674,738	1,674,738	1,674,738

Notes: This table presents the instrumental variable estimation of the effect of $PM_{2.5}$ on hospital visit rates for the overall population, Blacks, and Whites. $PM_{2.5}$ measures are satellite-based projections, which are standardized by the sample mean and standard deviation. Each entry presents an individual regression of an air pollutant on an illness category. Pollution measures are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. The first-stage F statistics range from 32 to 45. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.24: Effect of port traffic on the number of reporting pollution monitors in US port areas

	Dependent variable: number of active monitor sites	
	(1)	(2)
Vessel Tonnage	−0.18	
	(0.27)	
Vessel Counts		−0.08
		(0.12)
1st-Stage F Stat.	14.47	9.16
Adjusted R^2	0.91	0.91
Observations	155,183	155,183

Notes: This table presents the instrumental variable estimation of the effect of vessel tonnage and counts on the number of active monitors reporting pollution readings within a 25-mile radius of ports. Each entry presents an individual regression. The endogenous variables, vessel tonnage and counts, are instrumented by an indicator of seven-day lagged cyclones that are at least 500-mile distant from ports. All regressions include weather controls, such as the quadratics of maximum, minimum, and dew point temperature, precipitation, wind speed, and wind direction. All regressions also include year, month, day-of-week, holiday, and port fixed effects. An observation is a port-day. Standard errors are clustered by port and day. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.25: Effect of air pollution on hospital visit rates in California port areas – joint estimation with zip codes within a 25-mile radius from ports

	Dependent variable: hospital visits/million residents								
	All Respiratory			All Heart			All Psychiatric		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Overall population									
CO	15.34***	9.70***	21.16***	0.59	2.05**	−0.17	−0.51	0.31	−0.08
	(5.22)	(3.03)	(5.97)	(1.59)	(1.00)	(1.80)	(1.73)	(1.08)	(1.99)
NO_2	−5.02		−22.14***	2.64*		4.30	2.44		0.75
	(4.97)		(8.49)	(1.51)		(2.84)	(1.70)		(3.23)
SO_2		0.99	18.29**		1.83	−1.53		2.70*	2.11
		(4.37)	(7.27)		(1.40)	(2.59)		(1.55)	(2.91)
1st-Stage F Stat.	23.16	9.46	5.77	23.16	9.46	5.77	23.16	9.46	5.77
AR Stat. P-val	3.99e-10	5.16e-10	5.16e-10	3.99e-10	5.16e-10	5.16e-10	3.99e-10	5.16e-10	5.16e-10
SW S Stat. P-val	5.16e-06	6.40e-06	6.40e-06	5.16e-06	6.40e-06	6.40e-06	5.16e-06	6.40e-06	6.40e-06
Observations	1,776,040	1,742,012	1,742,012	1,776,040	1,742,012	1,742,012	1,776,040	1,742,012	1,742,012
Panel B: Black									
CO	−8.67	−1.08	7.69	2.65	3.89	3.26	−4.95	−3.00	−4.53
	(13.01)	(7.08)	(14.61)	(4.95)	(2.89)	(5.31)	(5.61)	(3.16)	(6.33)
NO_2	32.05**		−16.77	3.40		1.19	5.41		2.91
	(13.72)		(21.64)	(5.20)		(8.23)	(5.90)		(10.12)
SO_2		40.46***	52.79***		3.33	2.45		5.33	3.20
		(11.54)	(17.62)		(4.64)	(7.32)		(5.20)	(8.89)
1st-Stage F Stat.	15.41	9.86	5.43	15.41	9.86	5.43	15.41	9.86	5.43
AR Stat. P-val	0	0	0	0	0	0	0	0	0
SW S Stat. P-val	0.000361	0.000292	0.000292	0.000361	0.000292	0.000292	0.000361	0.000292	0.000292
Observations	877,072	871,296	871,296	877,072	871,296	871,296	877,072	871,296	871,296
Panel C: White									
CO	17.02***	12.49***	20.30***	3.03	3.27*	1.40	0.23	0.86	−0.11
	(4.35)	(2.69)	(5.16)	(2.76)	(1.83)	(3.41)	(2.94)	(1.91)	(3.70)
NO_2	−7.48*		−14.74*	0.99		3.54	2.15		1.84
	(4.03)		(7.83)	(2.49)		(5.53)	(2.74)		(6.07)
SO_2		−4.59	6.20		1.09	−1.50		2.42	1.07
		(3.39)	(6.39)		(2.21)	(4.71)		(2.33)	(4.98)
1st-Stage F Stat.	24.35	9.62	3.89	24.35	9.62	3.89	24.35	9.62	3.89
AR Stat. P-val	8.13e-10	9.80e-10	9.80e-10	8.13e-10	9.80e-10	9.80e-10	8.13e-10	9.80e-10	9.80e-10
SW S Stat. P-val	8.72e-06	8.90e-06	8.90e-06	8.72e-06	8.90e-06	8.90e-06	8.72e-06	8.90e-06	8.90e-06
Observations	1,650,747	1,616,890	1,616,890	1,650,747	1,616,890	1,616,890	1,650,747	1,616,890	1,616,890

Notes: This table presents the instrumental variable estimation of the effect of air pollution on hospital visit rate within a 25-mile radius of CA ports, jointly estimated for multiple air pollutants. Each column in a panel presents an individual regression on a set of pollutants. Pollution concentrations are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls and their quadratic terms, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.26: Effect of air pollution on hospital visit rates in California port areas – joint estimation with zip codes within a 15-mile radius from ports

	Dependent variable: hospital visits/million residents								
	All Respiratory			All Heart			All Psychiatric		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Overall population									
CO	21.36***	14.32***	24.64***	1.72	2.27**	0.69	−0.83	0.26	−0.63
	(5.42)	(3.31)	(6.14)	(1.53)	(1.03)	(1.81)	(1.68)	(1.17)	(1.89)
NO_2	−10.97**		−23.31**	0.98		3.58	3.78**		2.01
	(5.29)		(9.29)	(1.52)		(3.27)	(1.69)		(3.46)
SO_2		−5.36	12.78*		0.33	−2.45		3.66**	2.09
		(4.25)	(7.20)		(1.30)	(2.76)		(1.45)	(2.93)
Observations	866,835	859,168	859,168	866,835	859,168	859,168	866,835	859,168	859,168
Panel B: Black									
CO	9.65	11.09	24.71	1.12	2.41	0.87	−8.60	−5.20	−4.61
	(13.19)	(7.57)	(15.60)	(5.36)	(3.28)	(5.72)	(5.77)	(3.66)	(6.63)
NO_2	17.70		−28.60	3.18		3.23	11.80**		−1.25
	(14.16)		(24.96)	(5.70)		(9.48)	(5.90)		(11.15)
SO_2		24.70**	45.54**		2.48	0.13		12.19**	13.10
		(11.01)	(18.59)		(4.68)	(7.70)		(5.05)	(9.46)
Observations	562,552	557,677	557,677	562,552	557,677	557,677	562,552	557,677	557,677
Panel C: White									
CO	23.97***	15.59***	26.54***	6.73**	5.52***	3.29	2.64	3.09	0.13
	(5.08)	(3.32)	(5.77)	(3.06)	(2.13)	(3.69)	(3.27)	(2.27)	(3.82)
NO_2	−14.92***		−23.78***	−3.45		4.83	1.06		6.43
	(4.51)		(9.01)	(2.69)		(6.43)	(3.09)		(6.99)
SO_2		−9.28**	8.92		−3.60	−7.30		0.46	−4.46
		(3.65)	(7.41)		(2.31)	(5.45)		(2.57)	(5.80)
Observations	802,910	795,414	795,414	802,910	795,414	795,414	802,910	795,414	795,414

Notes: This table presents the instrumental variable estimation of the effect of air pollution on hospital visit rate within a 15-mile radius of CA ports, jointly estimated for multiple air pollutants. Each column in a panel presents an individual regression on a set of pollutants. Pollution concentrations are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls and their quadratic terms, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.27: Effect of fitted vessel tonnage on highway congestion in California port areas

	Dependent variable: traffic delay with respect to threshold speed					
	35 mph	40 mph	45 mph	50 mph	55 mph	60 mph
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Vessel tonnage						
Fitted Vessel Tonnage	7.49	8.78	9.97	10.92	11.69	12.43
	(5.86)	(6.73)	(7.57)	(8.43)	(9.36)	(10.33)
Adjusted R^2	0.33	0.35	0.37	0.39	0.42	0.44
Observations	2,625,756	2,625,756	2,625,756	2,625,756	2,625,756	2,625,756
Panel B: Vessel counts						
Fitted Vessel Counts	4.84	5.67	6.44	7.06	7.55	8.03
	(3.79)	(4.35)	(4.89)	(5.45)	(6.04)	(6.67)
Adjusted R^2	0.33	0.35	0.37	0.39	0.42	0.44
Observations	2,625,756	2,625,756	2,625,756	2,625,756	2,625,756	2,625,756

Notes: This table presents the OLS estimation for the effect of fitted vessel tonnage and counts on highway congestion in California's port areas. The fitted values are obtained from regressing log vessel tonnage or vessel counts on the instrument of seven-day lagged and 500-mile distant cyclones from ports. The dependent variable is measured as average delays to a threshold speed. Each column presents a regression of threshold speed. All regressions include weather controls (i.e., the quadratics of maximum temperature, minimum temperature, dew point temperature, precipitation, and wind direction) and fixed effects (i.e., county-by-year, month, day-of-week, holiday, freeway, and VDS-port). An observation is a VDS-port-day. Standard errors are clustered by VDS-port and day. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.28: Effect of air pollution on hospital visit rates in California port areas, excluding strong windy days

	Dependent variable: hospital visits/million residents					
	Respiratory			Heart	Psychiatric	
	Asthma	Upper Respiratory	All Respiratory	All Heart	Anxiety	All Psychiatric
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Overall population						
CO	2.56***	2.65***	9.55***	2.95***	0.67**	1.63**
	(0.43)	(0.67)	(1.77)	(0.67)	(0.27)	(0.67)
NO_2	2.56***	2.50***	9.06***	3.13***	0.75***	1.85***
	(0.42)	(0.64)	(1.71)	(0.64)	(0.27)	(0.65)
$PM_{2.5}$	1.78***	1.90***	6.60***	1.99***	0.50**	1.17**
	(0.31)	(0.48)	(1.31)	(0.50)	(0.20)	(0.49)
SO_2	3.41***	3.67***	12.97***	4.38***	1.27***	2.97***
	(0.65)	(0.96)	(2.58)	(0.97)	(0.41)	(0.98)
Panel B: Black						
CO	7.17***	5.62***	20.05***	5.80***	0.64	0.08
	(1.64)	(1.44)	(3.98)	(1.75)	(0.78)	(1.80)
NO_2	7.52***	7.22***	22.56***	6.97***	1.34	1.09
	(1.83)	(1.56)	(4.39)	(1.93)	(0.88)	(1.99)
$PM_{2.5}$	5.37***	5.09***	16.65***	4.01***	0.33	−0.26
	(1.25)	(1.10)	(3.13)	(1.37)	(0.55)	(1.32)
SO_2	10.08***	11.63***	33.61***	10.04***	2.36*	2.29
	(2.60)	(2.25)	(6.24)	(2.82)	(1.27)	(2.81)
Panel C: White						
CO	2.51***	1.54***	9.15***	4.00***	0.39	2.49*
	(0.55)	(0.44)	(1.62)	(1.26)	(0.55)	(1.32)
NO_2	2.41***	1.25***	8.12***	3.89***	0.42	2.51**
	(0.52)	(0.42)	(1.55)	(1.20)	(0.54)	(1.27)
$PM_{2.5}$	1.77***	1.02***	6.02***	2.83***	0.33	1.87*
	(0.41)	(0.33)	(1.26)	(0.96)	(0.42)	(0.99)
SO_2	2.96***	1.58***	10.15***	5.12***	0.86	3.89**
	(0.74)	(0.57)	(2.17)	(1.67)	(0.75)	(1.78)

Notes: This table presents the instrumental variable estimation of the effect of air pollution on hospital visit rate, where the observations with wind speed greater than 3.3 meters per second are excluded. Each entry presents an individual regression of an air pollutant on an illness category. Pollution concentrations are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. The first-stage F statistics range from 25 to 72. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.29: Effect of air pollution on hospital visit rates for Black and White females in California port areas

	Dependent variable: hospital visits/million residents		
	All Respiratory	All Heart	All Psychiatric
	(1)	(2)	(3)
Panel A: Black female			
CO	22.15***	6.68***	0.19
	(4.85)	(1.96)	(2.50)
NO_2	26.06***	6.15***	0.78
	(5.10)	(2.08)	(2.62)
$PM_{2.5}$	19.67***	4.58***	0.40
	(3.91)	(1.53)	(1.90)
SO_2	44.54***	8.03**	1.89
	(7.88)	(3.20)	(4.21)
Panel B: White female			
CO	11.42***	5.27***	2.37
	(1.95)	(1.19)	(1.68)
NO_2	8.10***	4.49***	2.42
	(1.77)	(1.06)	(1.49)
$PM_{2.5}$	6.66***	3.96***	1.78
	(1.60)	(0.97)	(1.33)
SO_2	10.41***	6.19***	3.48
	(2.64)	(1.58)	(2.21)

Notes: This table presents the instrumental variable estimation of the effect of air pollution on hospital visit rates for Black and White females. Each entry presents an individual regression of an air pollutant on an illness category. Pollution concentrations are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. The first-stage F statistics range from 21 to 83. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.30: Effect of air pollution on all-cause total hospital visit rates in California port areas

	Dependent variable: hospital visits/million residents		
	Overall Population	Black	White
	(1)	(2)	(3)
Panel A: CO			
CO	19.02***	41.56***	12.29***
	(4.01)	(8.65)	(4.76)
Adjusted R^2	0.69	0.47	0.60
Observations	1,776,040	877,072	1,650,747
Panel B: NO_2			
NO_2	17.31***	41.77***	10.91**
	(3.69)	(8.92)	(4.23)
Adjusted R^2	0.69	0.47	0.60
Observations	1,805,287	887,300	1,679,994
Panel C: $PM_{2.5}$			
$PM_{2.5}$	13.41***	30.08***	9.02**
	(3.11)	(6.90)	(3.85)
Adjusted R^2	0.69	0.47	0.60
Observations	1,714,554	846,980	1,598,695
Panel D: SO_2			
SO_2	26.07***	57.42***	15.97***
	(5.69)	(13.61)	(6.05)
Adjusted R^2	0.69	0.47	0.60
Observations	1,742,012	871,296	1,616,890

Notes: This table presents the instrumental variable estimation of the effect of air pollution on all-cause total hospital visit rates for the overall population, Blacks, and Whites. Each entry presents an individual regression of an air pollutant on an illness category. Pollution concentrations are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. The first-stage F statistics range from 21 to 83. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.31: Effect of air pollution on hospital visit rates in California port areas, principal diagnoses

	Dependent variable: hospital visits/million residents		
	All Respiratory	All Heart	All Psychiatric
	(1)	(2)	(3)
Panel A: Overall population			
CO	6.05***	0.72***	0.32
	(1.24)	(0.22)	(0.20)
NO_2	4.91***	0.63***	0.40**
	(1.16)	(0.20)	(0.18)
$PM_{2.5}$	3.70***	0.51***	0.27*
	(0.97)	(0.16)	(0.15)
SO_2	7.43***	0.83**	0.64**
	(1.81)	(0.32)	(0.29)
Panel B: Black			
CO	10.83***	1.05	−0.40
	(2.47)	(0.69)	(0.81)
NO_2	13.38***	0.84	−0.15
	(2.55)	(0.71)	(0.82)
$PM_{2.5}$	10.02***	0.84	−0.38
	(1.94)	(0.53)	(0.61)
SO_2	22.65***	0.85	0.29
	(4.05)	(1.10)	(1.24)
Panel C: White			
CO	4.72***	0.85*	0.65*
	(0.97)	(0.43)	(0.36)
NO_2	3.19***	0.72*	0.72**
	(0.89)	(0.38)	(0.31)
$PM_{2.5}$	2.43***	0.66*	0.61**
	(0.80)	(0.34)	(0.28)
SO_2	4.23***	0.89	1.06**
	(1.30)	(0.57)	(0.47)

Notes: This table presents the instrumental variable estimation of the effect of air pollution on hospital visit rates for the overall population, Blacks, and Whites, where hospital visit rates are calculated only using principal diagnoses. Each entry presents an individual regression of an air pollutant on an illness category. Pollution concentrations are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. All regressions include weather controls, such as the quadratics of maximum temperature, minimum temperature, dew point temperature, and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. An observation is a zip code-port-day. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. The first-stage F statistics range from 21 to 83. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.32: Effect of California Ocean-Going Vessel At-Berth Regulation on air pollution, RDD estimation

	Dependent variable: residual of log pollution concentration			
	CO	NO_2	$PM_{2.5}$	SO_2
	(1)	(2)	(3)	(4)
CA Regulation	-0.13^{*}	-0.26^{**}	0.14	-0.23
	(0.07)	(0.11)	(0.11)	(0.21)
Date	0.005^{**}	0.01^{**}	0.003	0.01^{**}
	(0.002)	(0.002)	(0.003)	(0.004)
CA Regulation × Date	-0.01^{**}	-0.004	-0.01^{**}	-0.005
	(0.003)	(0.002)	(0.004)	(0.01)
Pre-policy Mean	620.35	18.40	14.70	1.83
Observations	4,677	5,082	2,698	2,934

Notes: This table presents the second-stage augmented local linear RDD estimation of the effect of the California at-berth regulation on air pollutant concentrations. The second-stage RDD dependent variable is taken from the residuals by regressing log pollution concentrations on weather controls (i.e., the quadratics of maximum, minimum, and dew point temperature, precipitation, wind speed, and relative wind direction between a monitor-port pair), fixed effects (i.e., county-by-year, month, day-of-week, holiday, and port-monitor pair), and log vessel tonnage (instrumented by seven-day lagged and 500-mile distant cyclones from ports). The local linear bandwidth is specified as 60 days on both sides of the policy threshold. An observation is a monitor-port-day. Standard errors are clustered by monitor-port pair and normalized day. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.33: Effect of California Ocean-Going Vessel At-Berth Regulation on annual hospital visits and medical costs

	All Respiratory (1)	All Heart (2)	All Psychiatric (3)
Panel A: Hospital visits per million residents			
Black	-4,300	-980	-170
White	-1,100	-580	-380
Overall Population	-1,400	-510	-340
Panel B: Medical costs per capita (2017 USD)			
Black	-37	-9	-2
White	-10	-6	-3
Overall Population	-12	-5	-3

Notes: Panel A presents the back-of-the-envelope calculations of the effect of the California at-berth regulation on annual hospital visits based on the estimates in Tables 3 and A.32. Panel B presents the medical costs associated with the hospital visits in Panel A based on the payment data from Centers for Medicare and Medicaid Services. The average medical costs are $8,917 for psychiatric illnesses, $8,715 for respiratory illnesses, and $9,679 for heart-related illnesses. Based on the US 2010 Decennial Census, total population residing in the zip codes within 25 miles of the major ports in California is 15.08 million, in which 1.12 million are Black and 5.07 million are White. All numbers are rounded to two significant figures.

Table A.34: Placebo tests for the effect of California Ocean-Going Vessel At-Berth Regulation on air pollution

	Dependent variable: residual of log pollution concentration			
	CO	NO_2	$PM_{2.5}$	SO_2
	(1)	(2)	(3)	(4)
Panel A: One year before the policy				
CA Regulation	0.03	0.02	0.07	−0.005
	(0.08)	(0.08)	(0.13)	(0.13)
Date	0.0001	−0.001	0.002	−0.001
	(0.002)	(0.002)	(0.003)	(0.003)
CA Regulation × Date	0.002	0.001	−0.01**	0.01
	(0.002)	(0.002)	(0.004)	(0.004)
Pre-policy Mean	642.22	18.71	15.01	1.89
Observations	4,745	5,055	1,913	3,129
Panel B: One year after the policy				
CA Regulation	0.15	0.10	0.07	−0.01
	(0.10)	(0.09)	(0.11)	(0.27)
Date	−0.003	0.0003	0.001	0.003
	(0.002)	(0.002)	(0.002)	(0.004)
CA Regulation × Date	0.001	−0.0003	−0.004	−0.002
	(0.002)	(0.003)	(0.003)	(0.01)
Pre-policy Mean	599.15	18.01	14.03	1.74
Observations	4,828	5,166	2,673	3,359
Panel C: Neighboring areas				
CA Regulation	0.27	0.13*	−0.23*	0.15*
	(0.16)	(0.06)	(0.11)	(0.06)
Date	0.001	−0.001	0.004*	0.01
	(0.003)	(0.001)	(0.002)	(0.01)
CA Regulation × Date	−0.01	−0.001	−0.01*	−0.01
	(0.004)	(0.002)	(0.004)	(0.02)
Pre-policy Mean	406.79	11.37	11.28	1.31
Observations	1,591	3,195	1,364	509

Notes: This table presents the placebo tests for RDD estimation of the effect of the California at-berth regulation on local air pollution. The second-stage RDD dependent variable is taken from the residuals by regressing log pollution concentrations on weather controls (i.e., the quadratics of maximum temperature, minimum temperature, dew point temperature, precipitation, wind speed, and relative wind direction between a monitor-port pair), fixed effects (i.e., county-by-year, month, day-of-week, holiday, and port-monitor pair), and log vessel tonnage (instrumented by seven-day lagged and 500-mile distant cyclones from ports). The local linear bandwidth is specified as 60 days on both sides of the policy threshold. Panel A shows the results of specifying placebo policy dates one year before the actual policy date. Panel B shows the results of specifying placebo policy dates one year after the actual policy date. Panel C shows the results by assigning the policy date to neighboring areas located 75 to 100 miles from ports. An observation is a monitor-port-day. Standard errors are clustered by monitor-port pair and normalized day. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table A.35: Projected energy consumption by marine vessels in the United States

	Fossil Fuel		Electricity	
	Reference	Shore Power	Reference	Shore Power
2017	0.78	0.78	0.00	0.00
2020	0.77	0.72	0.01	0.05
2025	0.81	0.64	0.01	0.18
2030	0.85	0.66	0.01	0.19
2035	0.90	0.70	0.01	0.22
2040	0.93	0.72	0.01	0.22
2045	0.97	0.74	0.01	0.24
2050	1.01	0.77	0.01	0.25

Notes: This table presents projected marine vessel energy consumption simulated in Yale-NEMS. The unit is quadrillion Btu. The data include electricity and fossil fuel consumption for the reference case and the shore power scenario.

B Supplementary Figures (For Online Publication)

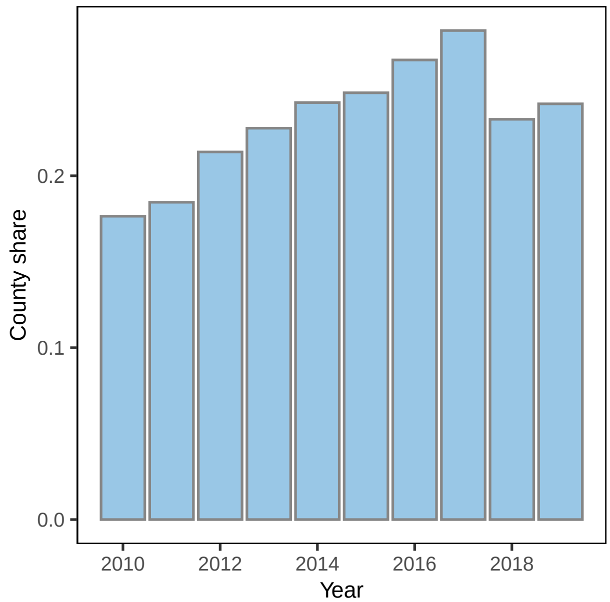

Figure B.1: Share of nonattainment counties adjacent to the major ports in the United States.

Notes: The figure plots the share of nonattainment counties that fail to meet the National Ambient Air Quality Standards and locate within a 50-mile radius of the major ports in the United States. The standards include Carbon Monoxide (1971), Nitrogen Dioxide (1971), 8-Hour Ozone (2008, 2015), PM_{10} (1987), $PM_{2.5}$ (1997, 2006, 2012), Sulfur Dioxide (1971, 2010). The data are obtained from US EPA NAAQS Greenbook.

Figure B.2: Locations of zip codes near the major California ports.

Notes: This figure plots the locations of zip codes that are within 25 miles of the major ports in California, shown in blue areas. According to the US 2010 Decennial Census, around 47 percent of the population in California resides in the blue areas.

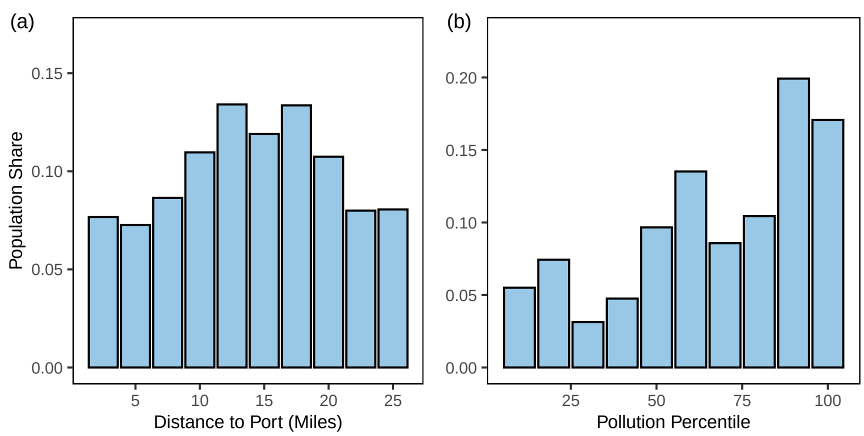

Figure B.3: (a) Distribution of Hispanic population by distance to major California ports. (b) Distribution of the Hispanic population in California port areas by percentile of $PM_{2.5}$ concentration.

Notes: Panel (a) plots population distribution in the California port areas by the distance between census tract and port for the Hispanic population. We obtain the population data at the census tract level and assign a distance between a census tract to its nearest mapped port to the population within the census tract. Panel (b) plots population distribution in the California port areas by percentile of $PM_{2.5}$ concentration. Larger pollution percentiles represent higher pollution exposures. The data are obtained from the US 2010 Decennial Census and US EPA Air Quality System.

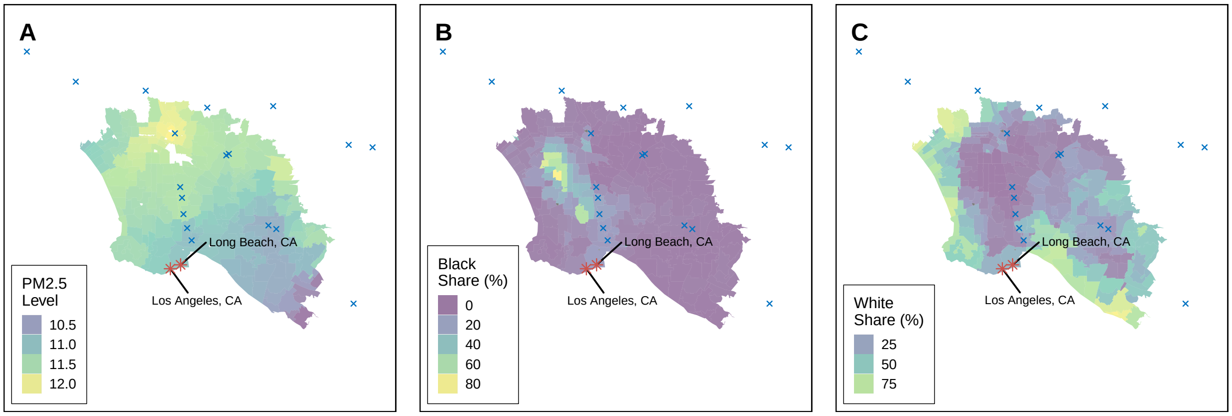

Figure B.4: Average $PM_{2.5}$ concentrations, Black population shares, and White population shares in zip codes near ports in Los Angeles, California.

Notes: Panel A presents the daily average $PM_{2.5}$ concentrations at the zip code level based on the EPA monitoring data within 25 miles from the two major ports near Los Angeles, California. Panel B shows the percentage of Black population in a zip code for the same area, while Panel C shows the percentage of White population. The blue crosses in the panels represent the location of $PM_{2.5}$ monitor sites with available data. The red stars indicate the Ports of Los Angeles and Long Beach. The pollution data are obtained from the US EPA Air Quality System. The population data are acquired from the US 2010 Decennial Census.

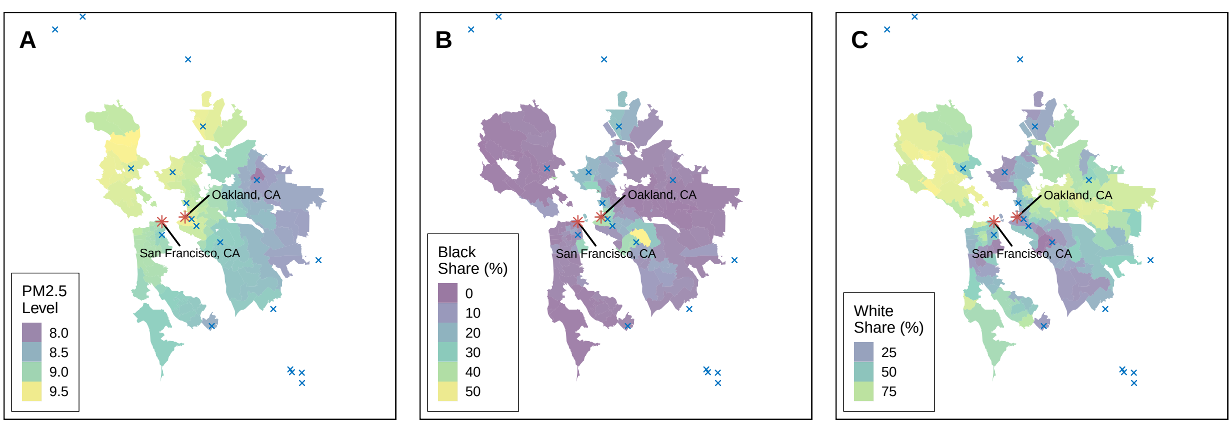

Figure B.5: Average $PM_{2.5}$ concentrations, Black population shares, and White population shares in zip codes near ports in San Francisco, California.

Notes: Panel A presents the daily average $PM_{2.5}$ concentrations at the zip code level based on the EPA monitoring data within 25 miles from the two major ports near San Francisco, California. Panel B shows the percentage of Black population in a zip code for the same area, while Panel C shows the percentage of White population. The blue crosses in the panels represent the location of $PM_{2.5}$ monitor sites with available data. The red stars indicate the Ports of San Francisco and Oakland. The pollution data are obtained from the US EPA Air Quality System. The population data are acquired from the US 2010 Decennial Census.

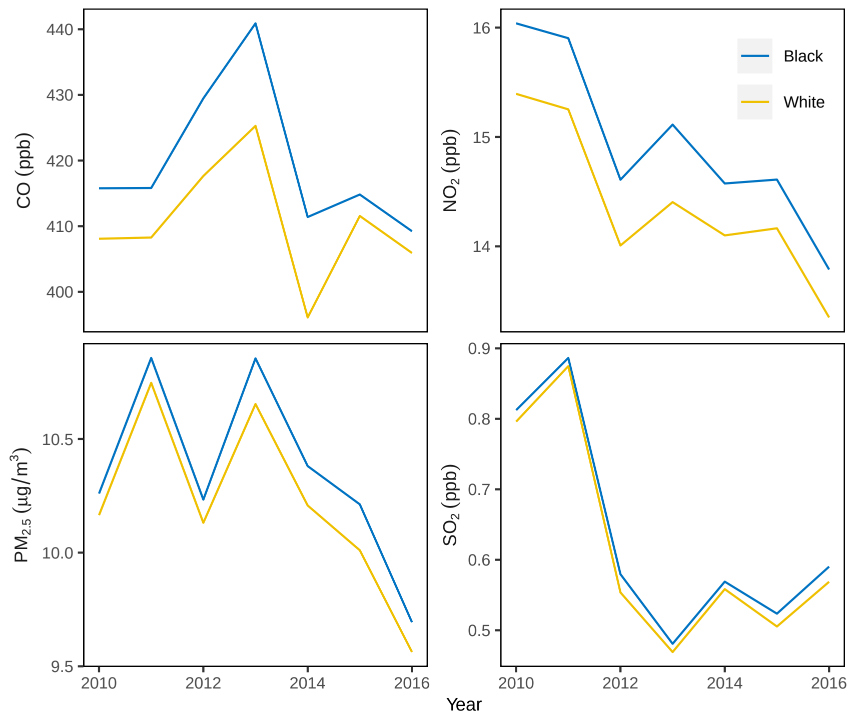

Figure B.6: Annual air pollution exposure for individuals visiting hospitals by race.

Notes: This figure plots the annual averages of baseline pollution exposure separately for non-Hispanic Black and White patients in the areas within 25 miles from ports in California. The patients visit hospitals due to psychiatric, respiratory, and heart-related illnesses during 2010–2016. The pollution data are obtained from the US EPA Air Quality System, and the hospital visit data are obtained Office of Statewide Health Planning and Development of California.

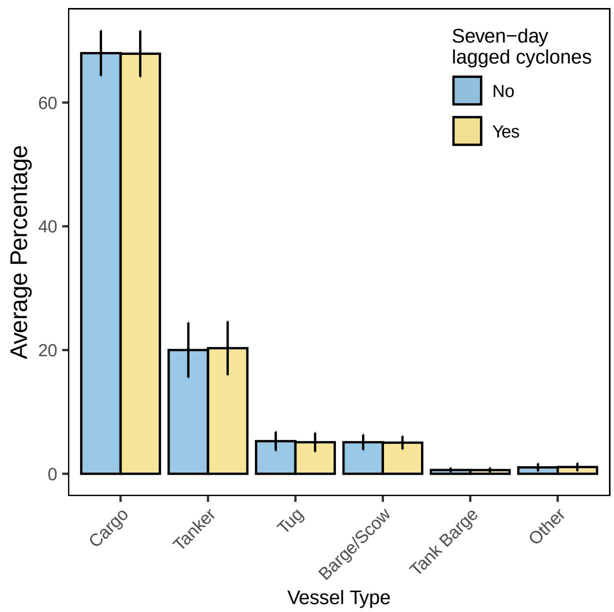

Figure B.7: Average daily share of vessel type in ports.

Notes: This figure presents the average daily share of vessel types in major 27 US ports, separately for the days when there exist seven-day lagged and 500-mile distant tropical cyclones in the ocean and the days when there are no such cyclones. The error bars indicate standard deviations. The data are obtained from the US Army Corps of Engineers.

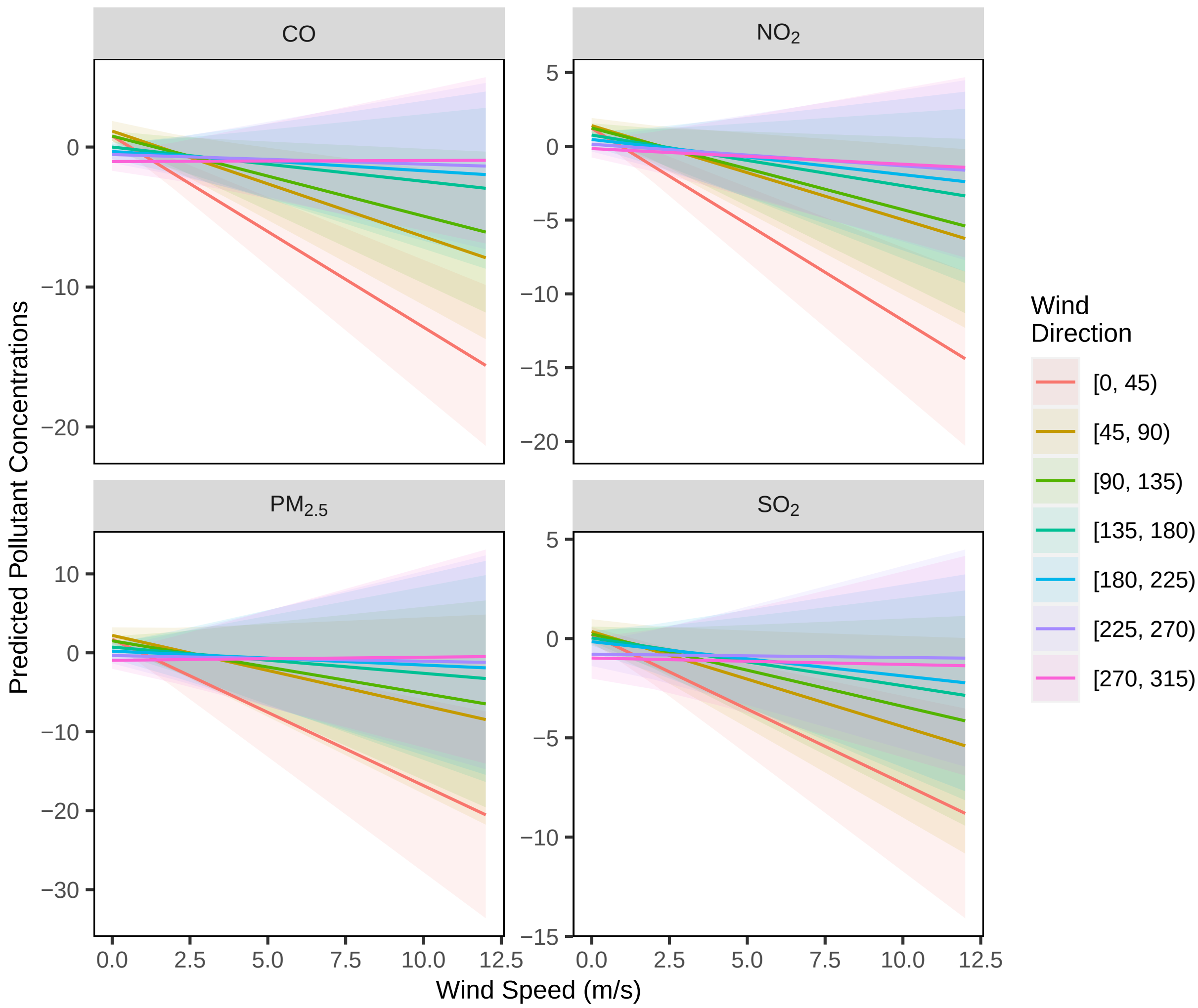

Figure B.8: First-stage results of adjusted predictions of pollutant concentrations with respect to wind direction and wind speed.

Notes: This figure presents the adjusted predictions of pollutant concentrations generated by the first-stage regressions, i.e., equation (4) of 2SLS. We allow the wind direction and wind speed variables to vary, while keeping other non-focal variables constant. Specifically, we evaluate pollutant concentrations at the location of Port of Long Beach and zip code 90062 for the year 2015, with the projected vessel tonnage as 4.56, dew point temperature as 4.56, precipitation as 0.42, maximum temperature as 21.63, minimum temperature as 12.83, month as July, day-of-week as Friday, and non-holiday days. The wind direction blowing north is normalized to zero, and it increases up to 360 degrees clockwise.

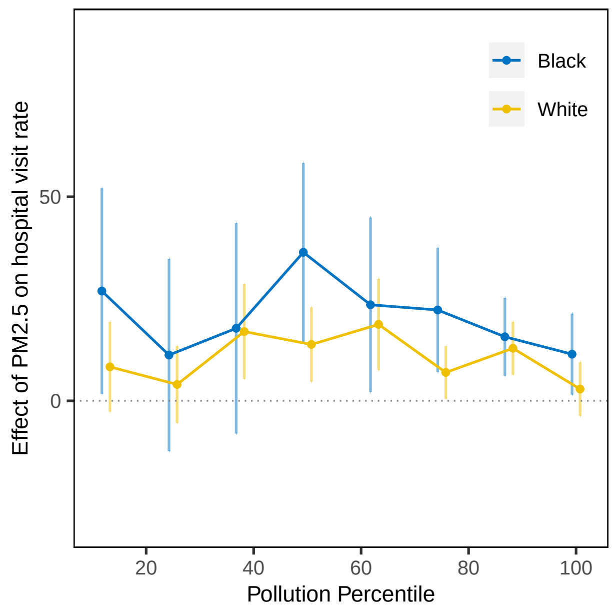

Figure B.9: Effects of $PM_{2.5}$ on hospital visit rates by pollution percentile using satellite-based pollution measures.

Notes: This figure plots the effects of $PM_{2.5}$ pollution on total hospital visit rates (related to respiratory, heart, and psychiatric illnesses) in eight pollution percentile groups. The $PM_{2.5}$ pollution measures are based on satellite-based pollution data. Pollution concentrations in regressions are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. Error bars correspond to 95% confidence intervals, where standard errors from regressions are clustered by port-zip code and day. An observation is a zip code-port-day.

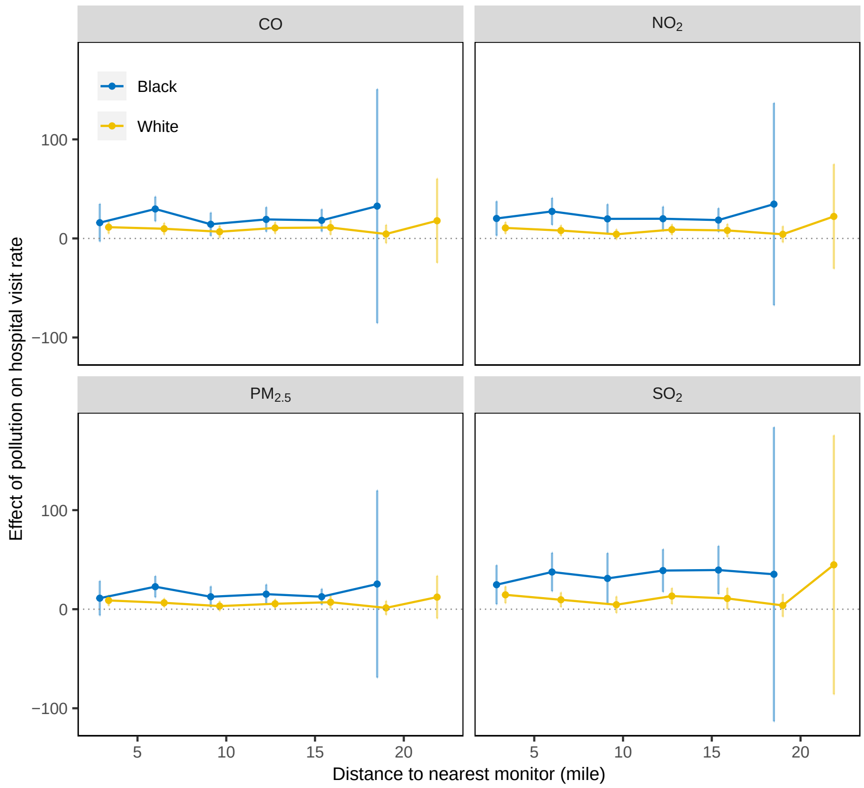

Figure B.10: Effects of pollution on hospital visit rates by distance to nearest pollution monitors.

Notes: This figure plots effects of pollution on total hospital visit rates (related to respiratory, heart, and psychiatric illnesses) for zip codes by distance to nearest pollution monitors. Pollution concentrations in regressions are standardized to their means and standard deviations, and they are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and their interactions. Error bars correspond to 95% confidence intervals, where standard errors from regressions are clustered by port-zip code and day. An observation is a zip code-port-day. Missing values indicate that there are monitors within such distance to zip codes.

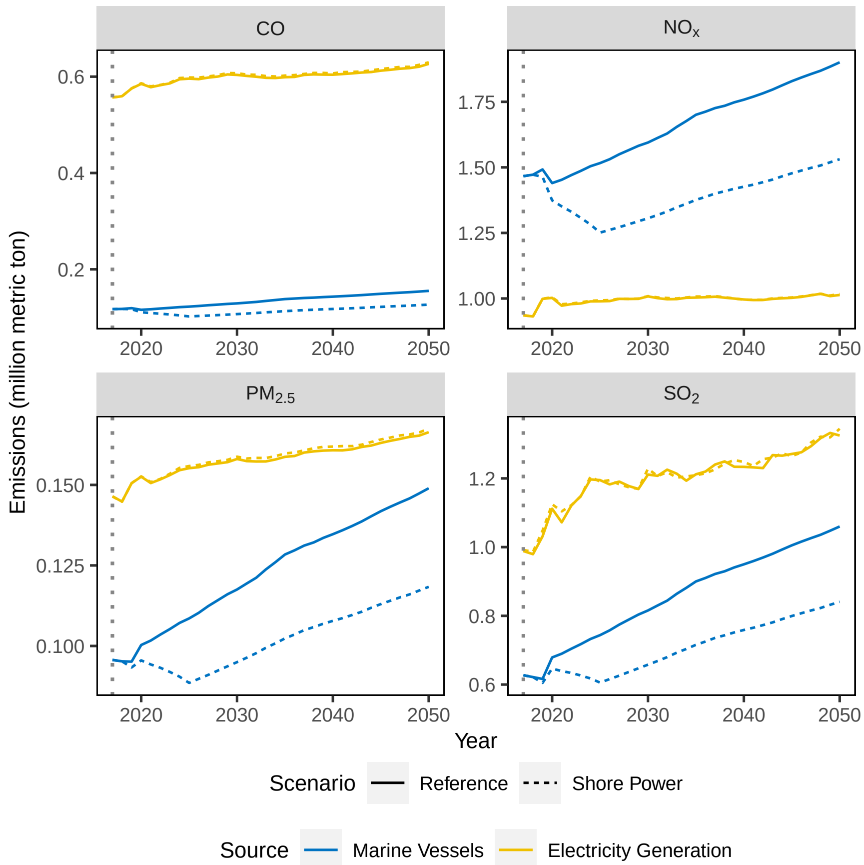

Figure B.11: Projected emissions of local air pollutants from marine vessels and electricity generation in the United States.

Notes: This figure plots local air pollutant emissions from marine vessels and power plants in the United States under the reference and shore power scenarios, projected in Yale-NEMS. The projection starts from 2017 indicated by the gray dotted lines.

C Supplementary Analysis (For Online Publication)

C.1 Results Comparison

This appendix presents supplementary analyses for the main text. We first present comparisons of our baseline estimates to the existing evidence in the literature. We then provide additional evidence on how pollution affects different unconditional quantiles of hospital visit distributions for Blacks and Whites. In the third part, we show the estimates of the reduced-form relationship between vessels in ports and human health. Lastly, we present the analysis of the relationship between Black-White health gap and socioeconomic characteristics.

Effect of vessels in ports on air pollution. We first compare our instrumented estimates (focusing on the effects of vessel tonnage) in Table 2 to the existing evidence on the contributions of seaports to local air pollution. We are not aware of any other study that explores this question in the literature; however, some government reports and online articles address the relationship between port and local air pollution. For example, US EPA estimates that ocean-going vessels contribute to 7% of NO_x emissions in Ports of Baton Rouge/New Orleans and up to 61% in the Santa Barbara areas (EPA, 2003). In addition, another evidence states that marine shipping in ports accounts for as much as half SO_x emissions in major port cities, such as Los Angeles.[1]

Our estimates show that a 100,000 Mt vessel tonnage increase in port leads to a 1.17 ppb increase in NO_2 concentrations. The summary statistics in Table 1 show that on average there is 425,000 Mt vessel tonnage in a port in a day. This tonnage results in about a 5 ppb increase in NO_2 concentrations in port areas in the US, a 36% increase of the daily mean concentration. This result is within the range of previously cited sources.

We also compare our estimates to the NAAQS to examine whether pollution from ports is likely to lead to nonattainment status.[2] The current one-hour standard for CO is that the pollution concentration cannot exceed 35,000 ppb more than once per year. Our results show that one average-sized vessel (29,000 Mt) in a port results in a 6.64 ppb increase in CO pollution.[3] Combining this 6.64 ppb increase with the average daily maximum of CO (shown in Table A.3), the estimated resulting concentration is 846.54 ppb (6.64 + 839.9), which is far below the EPA standard. Similarly, the resulting pollution concentrations

[1] See https://www.ft.com/content/31d0e224-dde8-11e8-9f04-38d397e6661c.

[2] The details of the standards for pollutants considered harmful to public health and the environment are available at https://www.epa.gov/criteria-air-pollutants/naaqs-table.

[3] The 6.64 ppb increase is calculated from 0.29×23.19 based on the estimates in Table 2 and summary statistics reported in Table 1.

for NO_2 and SO_2 due to average gross vessel tonnage in ports are also below the EPA's one-hour standards.[4]

EPA has established a 24-hour standard for $PM_{2.5}$ at 35 micrograms per cubic meter ($\mu g/m^3$). Adding the increase in $PM_{2.5}$ concentrations 0.35 $\mu g/m^3$ (0.29×1.20) (owing to an average-sized vessel in a port) to the daily 24-hour average (10.66 $\mu g/m^3$) results in a concentration of 11 $\mu g/m^3$, which is around 31% of the EPA standard. Note that the calculations presented above are based on the summary averages across all ports. Some areas on certain days may still exceed the EPA standards due to increased vessel counts in ports.

Effect of air pollution on health. Since there is a large body of economics and epidemiological literature examining the effect of air pollution on health, it is natural to compare our estimates in Panel A of Table 3 to the literature. Compared to Schlenker and Walker (2016), our estimates associated with the effect of CO on respiratory and heart hospital visits are relatively larger. For example, we find that a one ppb increase in CO concentration leads to a 0.02% increase in all respiratory hospital visits, while Schlenker and Walker (2016) find a 0.037% increase.[5] The discrepancy in results may be driven by different studied locations. Other epidemiological studies show the effect of a one ppb increase in CO pollution on respiratory hospital visits in a range of 0.001–0.008% (e.g., Hwang and Chan, 2002; Peel et al., 2005; Stieb et al., 2009), which are smaller than our estimates.

For heart-related illness, we find that a one $\mu g/m^3$ increase in $PM_{2.5}$ concentration leads to a 0.3% increase of hospital visits, which is higher than the estimates 0.13–0.15% in the epidemiology literature (e.g., Dominici et al., 2006; Bell et al., 2008). Two recent epidemiology studies find evidence that a 0.11% increase in psychiatric hospital visits is attributed to a one $\mu g/m^3$ increase in $PM_{2.5}$ concentration, which is fairly close to our estimate, 0.09%.

C.2 RIF-Quantile Effect of Air Pollution on Health

We provide additional evidence on how pollution affects different unconditional quantiles of the hospital visit distributions for Blacks and Whites using the unconditional quantile regression method introduced by Firpo et al. (2009). This method involves calculating the re-centered influence function (RIF) for the outcome variable (e.g., hospital visit rates) at a certain quantile and replace the dependent variable in equation (3) with the calculated RIF. The RIF for hospital visit y at the nth quantile q_n is calculated as $\text{RIF}(y, q_n) = q_n + \frac{n - \mathbb{1}\{y \leq q_n\}}{f_y(q_n)}$,

[4] The one-hour standards for NO_2 and SO_2 are 100 parts per billion (ppb) and 75 ppb, respectively.

[5] This calculation requires converting standardized estimates to the level before standardization.

where $f_y(q_n)$ is the density function of y at quantile q_n. In practice, we calculate 19 RIF statistics, starting from the 5th quantile to the 95th quantile of the hospital visit rate distribution for each subsample of Blacks and Whites. In total, we fit 38 RIF-quantile regressions for each of the four studied air pollutants. Because pollution is endogenous, we adopt a control-function approach, where we include the residuals from the first-stage regression equation (4) into the regression equation of interest (3). One caveat of this RIF-quantile analysis using the control-function approach is that we should interpret the standard errors carefully because there may exist sampling error in the first-stage residuals.

The regression estimates illustrate how the effect of pollution on hospital visit rates directly transforms to the unconditional distribution of hospital visit rates. Figure C.1 presents the RIF-quantile regression estimates by race and pollutant, suggesting that at the upper quantiles of the hospital visit rate distribution, air pollution has larger impacts on Blacks compared to Whites.

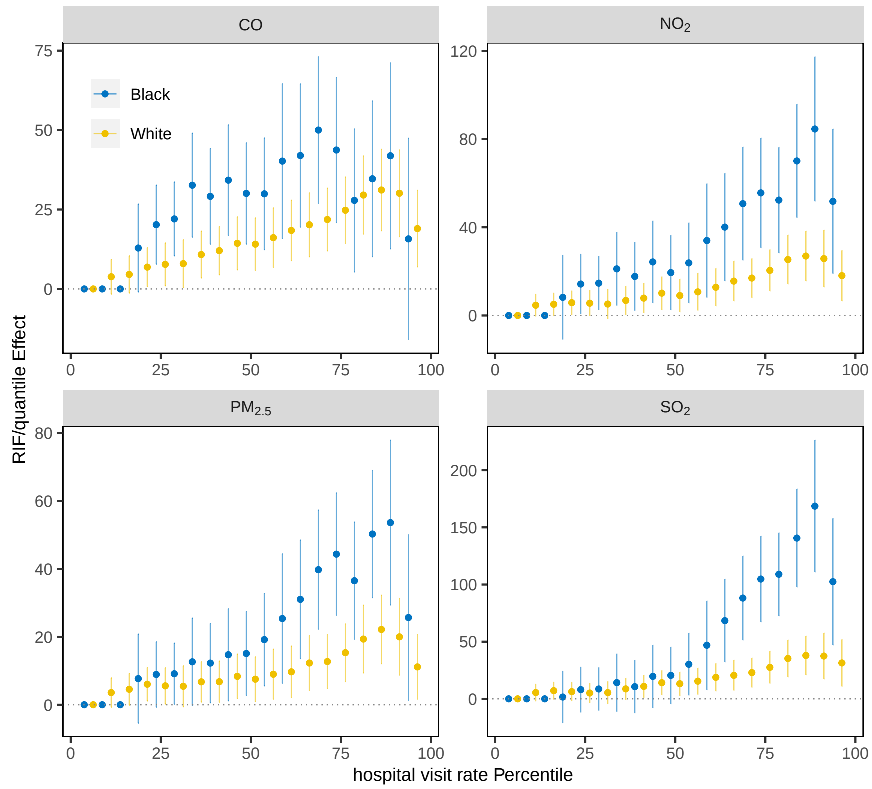

Figure C.1: RIF-quantile effects of pollution on hospital visit rates by race.

Notes: This figure plots the estimates from 38 individual regressions of equation (3) for each air pollutant, with 19 regressions for each race. The dependent variable is the RIF statistics of total hospital visit rate associated with respiratory, heart, and psychiatric ailments for a given quantile. The pollution measures are instrumented by fitted vessel tonnage in ports, wind direction, wind speed, and interactions. All regressions include a set of weather controls, such as the quadratics of maximum, minimum, and dew point temperatures and precipitation. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by zip code-specific population. The error bars represent 95% confidence intervals.

C.3 Reduced-form Relationship between Vessels in Ports and Health

This section examines the reduced-form relationship between the number of vessels in ports and human health. We estimate the regression model in equations (1) and (2) by specifying the dependent variable as hospital visit rate across illness categories. We use the ten-day lagged cyclones that are 500 miles distant from ports as the instrumental variable in our baseline specification.[6] Since the instrumental variable specification is similar to the one used in the main text, we do not present the results for instrument validity checks.

[6]We use the ten-day lagged cyclones here instead of the seven-day lagged ones in the main text because the ten-day lagged cyclones show a stronger correlation in the first stage.

Table C.1 presents the first-stage relationship between the cyclone instrument and vessel tonnage in ports across samples. The point estimate is statistically significant, suggesting the cyclone instrument leads to a 3–4% reduction in vessel tonnage in ports. The first-stage F statistics are in a range of 22–23, which are above the threshold of ten, suggesting no evidence of weak instruments.

Table C.1: First-stage results of the effect of tropical cyclones on vessel tonnage

	Dependent variable: vessel tonnage		
	Overall	Black	White
	(1)	(2)	(3)
Tropical Cyclone	−0.38***	−0.39***	−0.31***
	(0.08)	(0.08)	(0.07)
First-stage F Stat.	22.04	21.89	22.54
Adjusted R^2	0.74	0.73	0.78
Observations	1,805,287	887,300	1,679,994

Notes: This table presents the first-stage results of the instrumental variable estimation in Table C.2. The instrument is a dummy of ten-day lagged and 500-mile distant cyclones from ports. All regressions include a set of weather controls, such as the quadratics of maximum, minimum, and dew point temperatures, precipitation, wind speed, and relative wind direction between a zip code-port pair. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by zip code-specific population. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Table C.2 presents the instrumental variable estimation for the effect of vessel tonnage on hospital visits across seven illness categories. Most estimates associated with respiratory illnesses shown in columns (1)–(3) are statistically significant. They show that a 100,000 Mt increase in gross vessel tonnage in a port results in an additional 15.19 hospital visits per million residents related to all respiratory illnesses for the overall population, 35.59 hospital visits per million Black population, and 10.33 hospital visits per million White population. These results provide additional evidence that vessels in ports can contribute to racial disparities in respiratory-related health outcomes. However, the estimates associated with psychiatric and heart illnesses have surprising signs, and they are either statistically significant at the 5–10% level or insignificant. We do not see strong results related to psychiatric and heart illnesses, probably because the composition of air pollutants co-emitted from vessels together may not cause mental and heart illnesses.

Table C.2: Effect of vessel tonnage on contemporaneous hospital visit rate in California port areas, instrumental variable estimation

	Dependent variable: hospital visits/million residents					
	Respiratory			Heart	Psychiatric	
	Asthma	Upper Respiratory	All Respiratory	All Heart	Anxiety	All Psychiatric
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Overall population						
Vessel Tonnage	1.82**	5.41***	15.19***	−0.30	−1.10*	−2.91*
	(0.80)	(1.38)	(3.74)	(1.40)	(0.60)	(1.56)
Adjusted R^2	0.38	0.26	0.40	0.35	0.21	0.39
Observations	1,805,287	1,805,287	1,805,287	1,805,287	1,805,287	1,805,287
Panel B: Black						
Vessel Tonnage	7.08**	9.79***	35.59***	−0.80	−2.07	−9.34**
	(3.51)	(3.02)	(10.97)	(3.41)	(1.40)	(4.10)
Adjusted R^2	0.16	0.08	0.19	0.13	0.05	0.18
Observations	887,300	887,300	887,300	887,300	887,300	887,300
Panel C: White						
Vessel Tonnage	1.24	2.34***	10.33***	−0.61	−1.43	−4.22
	(1.12)	(0.83)	(3.41)	(2.82)	(1.22)	(3.06)
Adjusted R^2	0.17	0.09	0.32	0.28	0.15	0.32
Observations	1,679,994	1,679,994	1,679,994	1,679,994	1,679,994	1,679,994

Notes: This table presents the instrumental variable estimation of the effect of vessel tonnage on the contemporaneous hospital visit rate. Each column presents an individual regression on an illness category. The endogenous variable, log of vessel tonnage, is instrumented by the dummy of ten-day lagged and 500-mile distant cyclones from ports. All regressions include a set of weather controls, such as the quadratics of maximum, minimum, and dew point temperatures, precipitation, wind speed, and relative wind direction between a zip code-port pair. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

Tables C.3 shows the OLS estimates for the effect of vessel tonnage on hospital visits. The estimates for respiratory illnesses become insignificant for the Black population. They are also much smaller than the corresponding instrumental variable estimates, suggesting potential bias. The OLS estimates associated with psychiatric and heart illnesses are positive, but they are with small magnitudes.

Table C.3: Effect of vessel tonnage on contemporaneous hospitalizaton rate in California port areas, OLS estimation

	Dependent variable: hospital visits/million residents					
	Respiratory			Heart	Psychiatric	
	Asthma	Upper Respiratory	All Respiratory	All Heart	Anxiety	All Psychiatric
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Overall population						
Vessel Tonnage	0.06	0.06	0.38***	0.21***	0.08***	0.19***
	(0.03)	(0.05)	(0.14)	(0.06)	(0.02)	(0.06)
Adjusted R^2	0.39	0.34	0.47	0.35	0.22	0.40
Observations	1,805,287	1,805,287	1,805,287	1,805,287	1,805,287	1,805,287
Panel B: Black						
Vessel Tonnage	0.03	0.18	0.49	0.67***	0.04	0.11
	(0.14)	(0.12)	(0.36)	(0.17)	(0.07)	(0.17)
Adjusted R^2	0.17	0.10	0.23	0.13	0.05	0.19
Observations	887,300	887,300	887,300	887,300	887,300	887,300
Panel C: White						
Vessel Tonnage	0.18***	0.01	0.71***	0.81***	0.31***	0.78***
	(0.05)	(0.03)	(0.14)	(0.12)	(0.05)	(0.13)
Adjusted R^2	0.17	0.09	0.34	0.28	0.15	0.32
Observations	1,679,994	1,679,994	1,679,994	1,679,994	1,679,994	1,679,994

Notes: This table presents the OLS estimation of the effect of vessel tonnage on the contemporaneous hospital visit rate. Each column presents an individual regression on an illness category. All regressions include a set of weather controls, such as the quadratics of maximum, minimum, and dew point temperatures, precipitation, wind speed, and relative wind direction between a zip code-port pair. All regressions also include county-by-year, month, day-of-week, holiday, and zip code-port pair fixed effects. Standard errors are clustered by zip code-port pair and day. Estimates are weighted by the zip code-specific population. The first-stage F statistics range from 22 to 23. Significance levels are indicated by *** 1%, ** 5%, and * 10%.

C.4 Relationship between Racial Health Gap and Health and Economic Characteristics

To explore the correlates of racial health disparities, we collect local public health and economic characteristics by race at the zip code or county level from multiple sources.

Health characteristics The county-level health characteristics are obtained from the Annual Survey Data of the Behavioral Risk Factor Surveillance System (BRFSS) from the

Centers for Disease Control and Prevention.[7] BRFSS is a survey that collects information on chronic health conditions and health behaviors, conducted every year via telephone across the US We collect data for the period 2003–2012, where county-level responses are available. We focus on the counties where the zip codes within 25 miles of the major California ports are located. An observation in the final dataset is county-year.

We calculate the race-specific smoking rate in each county as the share of survey respondents who report smoking “every day” or “some days” to the total number of respondents in the race group. We calculate the poor or fair health status rate as the percent of respondents who report their general health as “poor” or “fair.” We also calculate the obesity rate in each county as the share of survey respondents who have a body mass index 30 or above. Lastly, we calculate the no exercise rate in each county as the share of respondents who did not participate in exercises other than regular jobs during the past month. We then plot the distributions of each calculated health characteristic separately for Blacks and Whites, as shown in Figure C.2(a). The results demonstrate that Blacks tend to have worse health conditions than Whites, implying worse baseline health for Blacks.

Economic characteristics We obtain zip code-level economic characteristics data from the American Community Survey (ACS) 5-Year Data from US Census Bureau for the period 2012–2016.[8] An observation in the final dataset is zip code-year.

The race-specific poverty rate characteristic in each zip code is calculated as the percent of the population who have income in the past 12 months below the poverty level to the total population of the race group. We calculate the no health insurance rate as the share of the population who do not have health insurance coverage. We measure income as per capita inflation-adjusted to the data year dollar. We calculate the bachelor’s degree rate as the percent of the population who have a bachelor’s degree or above.

Similarly, we plot the distributions of each calculated economic characteristic separately for Blacks and Whites. Figure C.2(b) shows that Blacks have worse socioeconomic status than Whites, which may make them more vulnerable to deal with health risks from pollution exposure.

We also estimate the correlations between the Black-White health gap and the considered economic characteristics by running the following regression:

$$y_{it} = Xb_{it} + Xw_{it} + e_{it},$$

[7] Data were downloaded from https://www.cdc.gov/brfss/annual_data/annual_data.htm (December 26, 2021).

[8] We use the R package “tidycensus” to get access to the data.

where y_{it} is the difference of average daily hospital visit rate between Blacks and Whites for zip code i in year t. Xb_{ip} is an economic characteristic for Blacks, standardized to its mean and standard deviation, while Xw_{ip} is the corresponding standardized economic characteristic for Whites. We run the regression separately for each economic characteristic. Figure C.2(c) presents the estimated coefficients and 95% confidence intervals, showing correlations between the Black-White health gap in port areas and the economic characteristics.

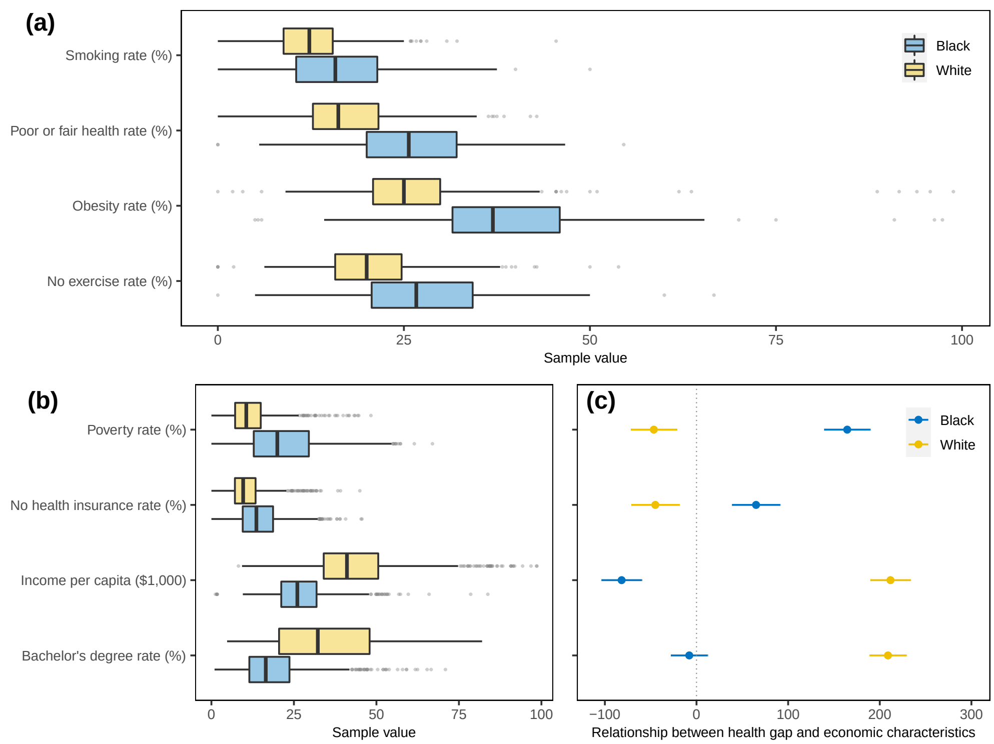

Figure C.2: (a) Distributions of local health characteristics by race. (b) Distributions of local economic characteristics by race. (c) Relationship between Black-White health gap and standardized economic characteristics.

Notes: Panel (a) presents the distributions of county-level health characteristics. Panel (b) shows the distributions of zip code-level economic characteristics. Panel (c) demonstrates the relationship between the Black-White health gap and economic characteristics. The Black-White health gap is measured as the difference of annual average daily hospital visit rates between Blacks and Whites. The economic characteristics in Panel (c) are standardized to their means and standard deviations. Error bars in Panel (c) correspond to 95% confidence intervals. The health characteristics data are from the Annual Survey Data of the Behavioral Risk Factor Surveillance System from the Centers for Disease Control and Prevention. The economic characteristics data are obtained from the American Community Survey (ACS) 5-Year Data from US Census Bureau. The hospital visit rates are calculated based on data from the Office of Statewide Health Planning and Development of California.

D National Energy Modeling System (For Online Publication)

The National Energy Modeling System (NEMS) is an integrated energy-economy modeling system developed by EIA. A 2017 version of NEMS is currently hosted on a server at Yale University, and we call it Yale-NEMS at EIA's request. Yale-NEMS comprises 13 modules comprehensively modeling major energy supply sectors, conversion sectors, demand markets, macroeconomics, and international energy markets. The model simulates energy markets out to 2050 subject to a comprehensive set of constraints, such as economics, technological advancement, demographics, resource availability, and behavior assumptions. The model also includes current energy and environmental policies at the state and federal levels, while it does not consider any proposed rule-makings. Model projections include energy consumption, production, trade, prices, and emissions.

Since we are particularly interested in the effects of shore-side energy consumption and its interaction with the power sector, this appendix discusses how Yale-NEMS models marine fuel consumption and electricity generation. The description of other modules is available at EIA (2009). We first introduce the reference case of Yale-NEMS, which we use as the baseline for our analysis.

D.1 Annual Energy Outlook

We take Annual Energy Outlook (AEO) 2017 as the reference case. AEO 2017 is a regular update of the US energy market outlook, released in early 2017 by EIA. The series of AEOs have been widely referenced for decision makings by government agencies, academia, and private sectors for decades. AEO 2017 projects a time path of key US energy market indicators from present to 2050 EIA (2017a). Comparing to previous annual outlooks, AEO 2017 includes two reference projections, one including the Clean Power Plan (CPP) and the other excluding it. Because the CPP is much less stringent than its original form, in this study, we use AEO 2017 without the Clean Power Plan as the reference case.

While AEO 2017 is a few years old, electricity generation in the United States has only become cleaner since 2017. Thus, if our simulation results are biased in any direction, they would be biased towards *overestimating* the air pollution from electricity consumption. This suggests that using AEO 2021 would only strengthen our results that the California port electrification regulation reduced air pollution emissions on net.

D.2 Marine Energy Consumption

In Yale-NEMS, the transportation demand module projects transit and auxiliary fuel consumption by marine vessels, within the US Emission Control Area—the areas within 200 nautical miles of the US coast and outside ECA EIA (2016).

Yale-NEMS models the marine fuel consumption by vessel type (tanker, container, gas (LPG/LNG), roll-on/roll-off, bulk, and general cargo) within the ECA in three steps, as is discussed in great detail in EIA (2016). First, the model estimates the total energy consumption in a base year (2013) based on historical data. From the base year, the model then determines the projections of energy demand in future years by several factors: fleet turnover rate—representing the rate of new vessels entering a fleet moving through ECA, marine fuel efficiency improvement, and industrial output—accounting for economic growth. Third, the model splits total energy consumption into four fuel types, including distillate oil, residual oil, CNG, and LNG, based on fuel price changes using a logit model specification.

EIA's NEMS does not explicitly model port-side electricity consumption and we add this feature to Yale-NEMS. First, we obtain historical data on vessel visits connected to onshore electricity and compare them to the total number of visits, which provides us the approximate percentage of energy consumption from electricity by year and region. For future years, we assume the same proportion of using electricity from 2016. We also incorporate the California Ocean-Going Vessel At-Berth Regulation (see Section 6.1 for details). Second, since we know the total fossil fuel consumption in ECA, we calculate the total electricity consumption based on the calculated percentages, constituting the reference shore-side electricity consumption in the model. Third, we subtract the newly added marine electricity demand from the total commercial electricity demand. Thus the total electricity demand across sectors is still comparable to the AEO 2017 base projections. Fourth, we calculate the reference emissions from vessels by applying the emission factors by engine type (transit and auxiliary) and fuel type to total fuel consumption.

D.3 Electricity Generation

The Electricity Market Module (EMM) in Yale-NEMS explicitly models the US electricity market and its interaction with other energy markets EIA (2017b). The module is at the North American Electric Reliability Corporation (NERC) region level. In each modeling year, other interrelated modules pass critical parameters to the EMM, including electricity demand from the four end-use demand modules (commercial, industrial, residential, and transportation demand), input fuel prices from the fuel supply modules (coal, natural gas, and fuel oils), and macroeconomic expectations from the macroeconomic module. The EMM then makes production decisions by choosing a fuel mix to generate electricity to meet demand cost-efficiently with perfect foresight.

The outputs from the EMM include electricity quantities and prices, input fuel consumption, emissions, and capital investment for additional capacity, which are then all returned to the related modules. Several factors determine the total emissions from generating electricity, including emission factors across energy types and mitigation technologies. The model iterates until market equilibrium achieves. The electricity consumption from ports is linked to EMM. When there is electricity incurred by vessels, the demand is received by the EMM, and then the EMM generates electricity to meet such demand most economically.

Yale-NEMS only reports emissions of SO_2 and NO_x from the power sector. To evaluate $PM_{2.5}$, we use an approximation approach similar to Gillingham and Huang (2019, 2020). First, we calculate the base year (2014) $PM_{2.5}$ emissions from power plants based on the EPA 2014 National Emissions Inventory (NEI) data and obtain the energy consumption from Yale-NEMS in the same year. Second, we extrapolate the emissions after 2014 as a constant proportion of energy consumption.

D.4 Shore Power Scenario

We construct a shore power scenario, in which all US ports implement shore power for auxiliary engines of vessels. Specifically, we allow auxiliary fuels (e.g., distillate oil, residual oil, and natural gas) consumed by vessels to be gradually replaced by electricity generated by power plants from 2020 to 2025, and after 2025 all auxiliary engines are powered by electricity. The fuel switch follows the following linear adjustment:

$$
\begin{aligned}
q_{f,t} &= \left(1 - \frac{t - 2019}{2025 - 2019}\right) q^0_{f,t}, \\
q_{e,t} &= \frac{t - 2019}{2025 - 2019} \sum_f q^0_{f,t},
\end{aligned}
$$

where $q^0_{f,t}$ represents the consumption of auxiliary fuel f by vessels in ports in year t ($t < 2025$) in the reference case and $q_{f,t}$ is the adjusted fuel consumption in the Shore Power scenario. $q_{e,t}$ is electricity consumption by vessels in ports switched from fossil fuels. From the year 2025 onwards, fossil fuels consumed by auxiliary engines are entirely replaced with electricity, as represented in the following:

$$q_{f,t} = 0,$$
$$q_{e,t} = \sum_f q^0_{f,t}.$$

We run the reference case and the Shore Power scenario individually in Yale-NEMS. We then compare the emissions results between the two cases, and the differences indicate the effect of implementing shore power in ports.

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