When Growth Stumbles, Pollute? Trade War, Environmental Enforcement, and Pollution

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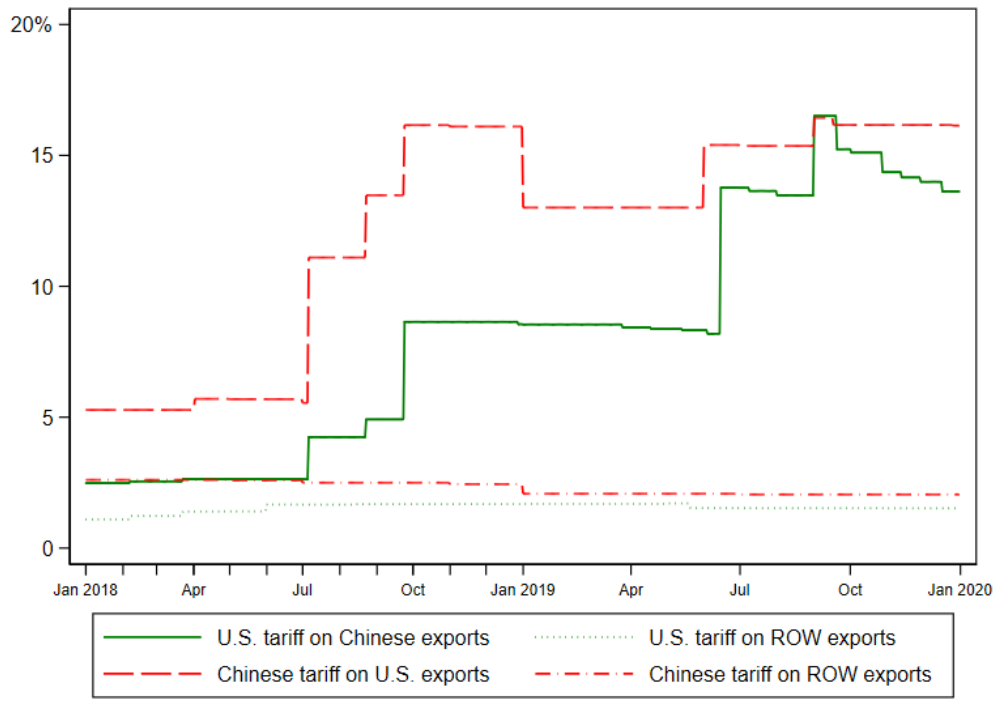
Motivation

- Politicians face a trade-off between economic growth and environmental protection.
- Under the pressure of economic downturn risk, local governments tend to sacrifice long-term sustainable development and give firms tacit permission to excess pollutant emissions to offset the negative impacts of adverse economic shocks.

Trade war provides a natural experiment

- China has experienced remarkable economic growth since 1978. Recently, there are concerns about the slowdown in economic growth.
- The trade war heightens the risk of an economic downturn. It has a sudden and substantial increase in U.S. tariffs and intensifies the risk of economic disruption.



Notes: The figure presents the import-weighted average Chinese tariff rates on US products (red line) and U.S. tariffs on Chinese products (green line). Chinese tariffs are weighted by China's HS-8 imports from the U.S. in 2017. U.S. tariffs are weighted by the U.S. HS-10 imports from China in 2017.

Timeline text

This paper

Effects of the 2018 U.S.-China trade war on China's air pollution

- less export, less production ($\downarrow$)
- lenient environmental policy ($\uparrow$)

Findings:

1) U.S. tariffs' effects on Chinese total exports: zero
   The less export less production ($\downarrow$) channel does not exist.
2) Citywide air pollution: increase
   A 1% increase in U.S. tariffs leads to a 0.9% increase in SO_2 and a 0.7% increase in $PM_{2.5}$.
3) Firms' emissions: increase

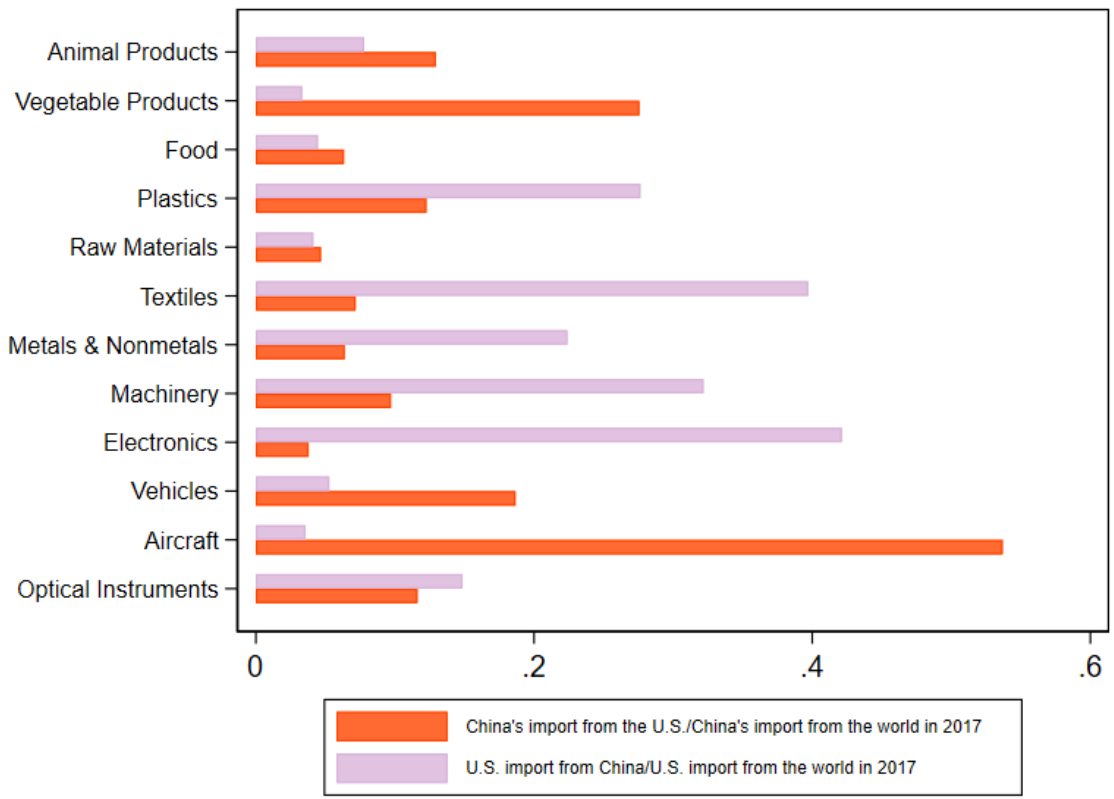
Mechanisms: lenient environmental policy

- More severe pollution increases after sunsets.
- Lower environmental fine.
- Pollution is mentioned less in government reports and media.

Outline

U.S.-China import structure

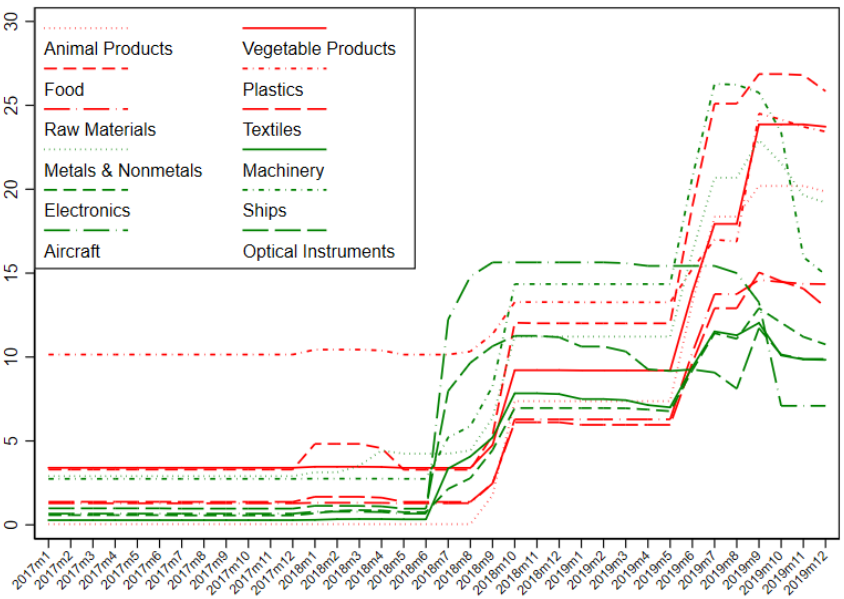
- Major products China imports from the U.S.:
  - Agricultural products, optical instruments, aircraft, motor vehicles, nuclear reactors and machinery, electronic integrated circuits
- Major products the U.S. imports from China:
  - Shoes, clothes, mobile phones, and toys

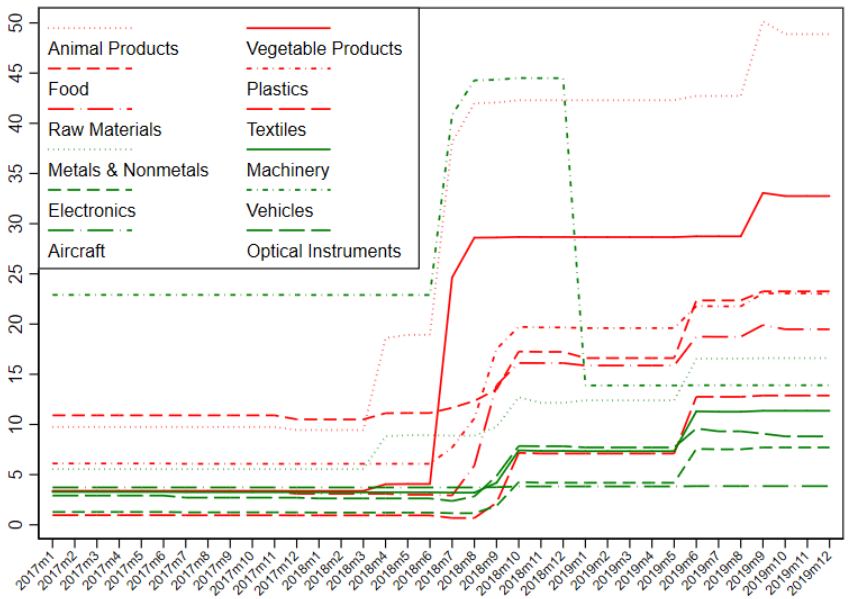


Tariff policy

- United States: high-end manufactured products (wave 1 & 2)
  - Prelude 1 & prelude 1: solar panel, washing machine, and steel
  - Wave 1-5 (China): wave 1-2 (specific sectors) vs. wave 3-5
- China: agricultural products (prelude 1 & wave 1)
  - Prelude 1 & wave 1-2 (specific sectors) vs. wave 3-5 (general)

U.S. punitive tariffs vs. China's retaliatory tariffs





Timeline text

Was China affected by the 2018 Trade War?

- "We [The U.S.] are taking in tens of billions of dollars. China is paying for it [tariffs]."
- The impact of U.S. tariffs on the U.S. economy
  - nearly complete pass through of tariffs to the U.S. (Amiti et al., 2019; Fajgelbaum et al., 2020; Cavallo et al., 2021).
  - U.S. real income decreased by $1.4 billion per month. Each household lost $831 per year (Amiti et al., 2019; Fajgelbaum et al., 2020).
- The impact of the U.S. tariffs on the Chinese economy
  - U.S. tariffs had no effect on the export price (Jiao et al., 2022).
  - U.S. tariffs decreased Chinese total exports to the U.S. but also increased export to other countries (Jiang et al., 2023).
  - U.S. tariffs reduced nightlight (Chor and Li, 2021).

Related literature: impact of 2018 trade war

- Reduce bilateral trade flows Amiti et al. (2019); Fajgelbaum et al. (2020); Cavallo et al. (2021); Fajgelbaum et al. (2021); Jiao et al. (2021); Jiang et al. (2023); Feng et al. (2023)
- Higher import prices: tariff pass-through in the U.S. (93-100%) vs. China (68%) Amiti et al. (2019); Fajgelbaum et al. (2020); Cavallo et al. (2021); Fajgelbaum et al. (2021); Jiao et al. (2021); Jiang et al. (2023); Feng et al. (2023)
- Reduce employment Flaaen and Pierce (2019); Beck et al. (2023)
- Lower economic growth Chor and Li (2021); Han et al. (2023)
- Political elections Blanchard et al. (2019)
- Lower stock returns Amiti et al. (2021); Li et al. (2023); Han et al. (2023)
- This paper: the first on environmental consequences of the trade war

Related literature: trade and pollution in China

- The global economic crisis during the late 2000s and its trade shock decreased $PM_{2.5}$ in China (Gong et al., 2023)
- Export expansion 1990-2010 increased SO_2 levels (Bombardini and Li, 2020)
- Mechanisms lie in production effects rather than lenient environmental policy

Outline

Air pollution data

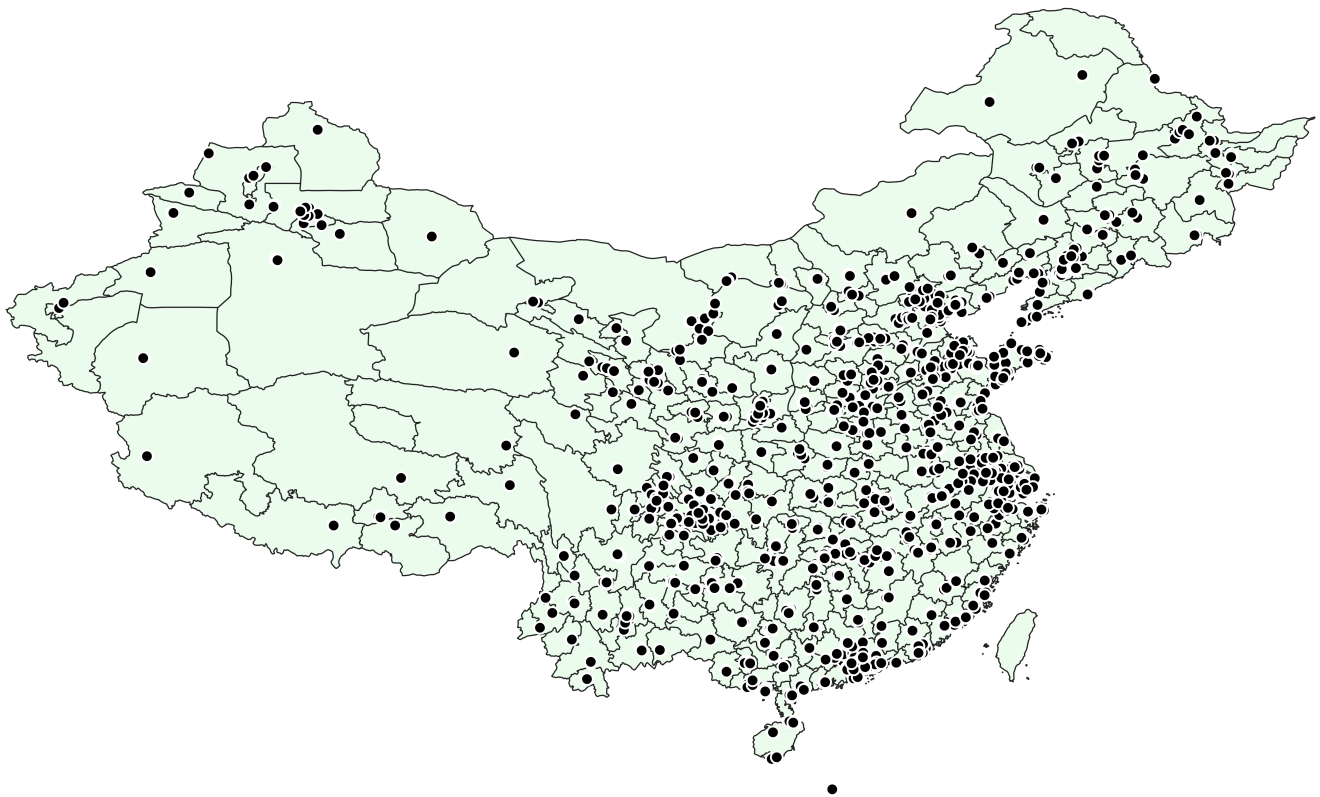
Citywide air quality (AQI, SO_2, NO_2, $PM_{2.5}$, PM_{10}) City-level pollution

- monitor-hourly, 2016 monitors, 2017-2019 (official air quality monitor)

Firm-level emissions (SO_2, NO_X, Particles)

- firm-hourly, 7639 firms, 2017-2019 (Continuous Emission Monitoring System)

2016 monitors in 341 cities



Tariff data

- Tariff escalation (2017-2019)
  - China's State Council and the U.S. International Trade Commission
  - HS 8-digit (10-digit product), trade partner, and date
  - Considers tariff exemption
- Baseline tariffs
  - Common practice: HS 6-digit annual MFN tariffs
  - Chinese MFN tariffs vary by HS 10-digit product and month considering monthly adjustments (e.g. July/December 2017, May/July/November 2018, and January/July 2019)
  - Chinese preferential tariffs (HS 10-digit, trade partner, and month), 42% of imports in 2017 (e.g., ASEAN, Korea, Australia)
  - U.S. MFN/preferential/specific/compound tariffs from USITC (HS 8-digit product, trade partner, and year)

Trade data

- Product-level export and import data: 2017-2019
  - HS 8-digit product
  - Export value and quantity, by destination country, monthly
- Firm-level trade data: 2015
  - Import and export value
  - Firm-level info, HS-8-digit product, and trade partner
  - Available only pre- trade war

U.S. tariff

$$\Delta USTariff_{it} = \sum_k \frac{X_{ik0}^{US}}{X_{i0}} \Delta USTariff_{kt}$$

- $\frac{X_{ik0}^{US}}{X_{i0}}$ denotes the export share of product k from prefecture i to the U.S., relative to total prefecture-level exports, in 2015 prior to the U.S.-China trade war
- The variation in $\Delta USTariff_{it}$ stems from: differences in initial export variety (product-country) composition at the prefecture level; and differences in the U.S. tariff changes over time at the product level, $\Delta USTariff_{kt}$

Map

Chinese tariff

$$\Delta CHNTariff_{it} = \sum_{k \in \mathcal{K}, j} \frac{M_{ikj0}}{M_{i0}} \Delta CHNTariff_{kjt}$$

- K is the set of products k which are defined as intermediate inputs using Broad Economic Codes (BEC)
- $\frac{M_{ikj0}}{M_{i0}}$ denotes the import share of product k of prefecture i from country j, relative to total prefecture-level imports in 2015
- The variation in $\Delta CHNTariff_{it}$ stems from differences in initial import variety (product-country) composition at prefecture-level; and differences in China's import tariff changes over time at variety-level, $\Delta CHNTariff_{kt}$

Map

Outline

Empirical strategy

$$\ln P_{it} = \beta \text{ Post}_t \times \text{Treated}_i + City_i + YearMonth_{it} + \eta_t + \epsilon_{it}$$

- Sample: Jan 2017 - Dec 2019, all prefecture-level cities in China.
- P_{it}: air pollution in city i in month t.
- $Post_t$ is 1 if month t is between Jul 2018 and Dec 2019.
- $Treated_i$ is 1 if city i is a high-exposure city and 0 otherwise.

  We calculate the sum of tariff escalation at the city level and assign cities into quartiles. Cities in the top quartile are high-exposure cities. The other three quartiles are low-exposure cities.
- β: high exposure cities' pollution responses to the trade war relative to low exposure cities.

Results

Compared with low-exposure cities, monitors in high-exposure cities observe $1.997\mu g/m^3$ (10.3%) increase in SO_2 and $3.107\mu g/m^3$ (7.1%) increase in $PM_{2.5}$ in the post period (Jul 2018 to Dec 2019).

	AQI	SO_2	NO_2	$PM_{2.5}$	PM_{10}
High exposure × Post	4.294***	1.997***	1.322***	3.107***	5.192***
	(1.334)	(0.488)	(0.485)	(1.065)	(1.687)
Observations	39970	39970	39970	39970	39970
R-square	0.857	0.816	0.844	0.846	0.845
Y-mean	71.453	19.366	30.366	43.792	79.553
Y-sd	31.606	16.885	15.268	25.758	41.623
Monitor FEs	Y	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y	Y
Prov-Month FEs	Y	Y	Y	Y	Y

Notes: Variable *High exposure* is absorbed by monitor fixed effects. Standard errors are clustered at the station-month level.

Empirical strategy: dynamic tariff exposure

$$\Delta ln(P_{it}) = \beta \Delta USTariff_{it} + \alpha \Delta CHNTariff_{it} + \gamma_t + \eta_i + \varepsilon_{it}$$

- $\Delta ln(P_{it})$: year-on-year change in pollution
  $= ln(P_{it}) - ln(P_{i,t-12})$
- $\Delta ln(USTariff_{it})$: year-on-year change in U.S. tariff
  $= ln(USTariff_{it}) - ln(USTariff_{i,t-12})$
- $\Delta ln(CHNTariff_{it})$: year-on-year change in China tariff
  $= ln(CHNTariff_{it}) - ln(CHNTariff_{i,t-12})$
- β: effect of U.S. tariff changes on pollution changes

Results

A 1% increase in U.S. tariff (at the city-month level) leads to a 0.95% increase in SO_2 and 0.71% increase in $PM_{2.5}$ at the monitor-month level:

	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)	0.596^{***}	0.951^{**}	0.914^{***}	0.711^{**}	0.662^{***}
	(0.184)	(0.436)	(0.261)	(0.279)	(0.237)
Δln(CHNTariff)	-0.096	-0.115	0.430^{***}	-0.633^{***}	-0.031
	(0.134)	(0.272)	(0.149)	(0.182)	(0.158)
Observations	48868	48868	48868	48868	48868
R-square	0.228	0.169	0.178	0.192	0.239
Y-mean	-0.048	-0.193	-0.027	-0.075	-0.064
Y-sd	0.221	0.402	0.271	0.296	0.275
Monitor FEs	Y	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y	Y

Notes: Standard errors are clustered at the monitor-month level.

Robustness

- Drop 2017 Link1
- Month-on-month change Link2
- City-month pollution as outcomes Link3
- Weighted regression using city GDP Link4
- Placebo effects on last year's pollution Link5
- Dynamic effects Link6

Heterogeneity across hours

Pollution increases are stronger at night than that before sunsets:

	Effects at 2pm				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)	0.036	0.650	0.097	0.306	-0.248
	(0.217)	(0.447)	(0.365)	(0.327)	(0.285)
Δln(CHNTariff)	0.063	-0.498*	-0.205	-0.355*	0.048
	(0.159)	(0.298)	(0.216)	(0.212)	(0.200)
Observations	48811	48811	48811	48811	48811
R-square	0.226	0.149	0.109	0.177	0.214
Y-mean	-0.037	-0.188	-0.049	-0.076	-0.065
Y-sd	0.243	0.423	0.347	0.331	0.310
	Effects at 10pm				
Δln(USTariff)	0.742***	1.118**	1.177***	0.575*	0.834***
	(0.209)	(0.492)	(0.313)	(0.301)	(0.265)
Δln(CHNTariff)	-0.298**	-0.134	0.759***	-0.839***	-0.377**
	(0.144)	(0.297)	(0.165)	(0.192)	(0.167)
Observations	48813	48813	48813	48813	48813
R-square	0.201	0.152	0.171	0.180	0.209
Y-mean	-0.054	-0.192	-0.024	-0.077	-0.068
Y-sd	0.237	0.442	0.293	0.313	0.295

Other hours

Night time emissions

Notes: Steel mill pollution during the night in Guangxi, June 2019

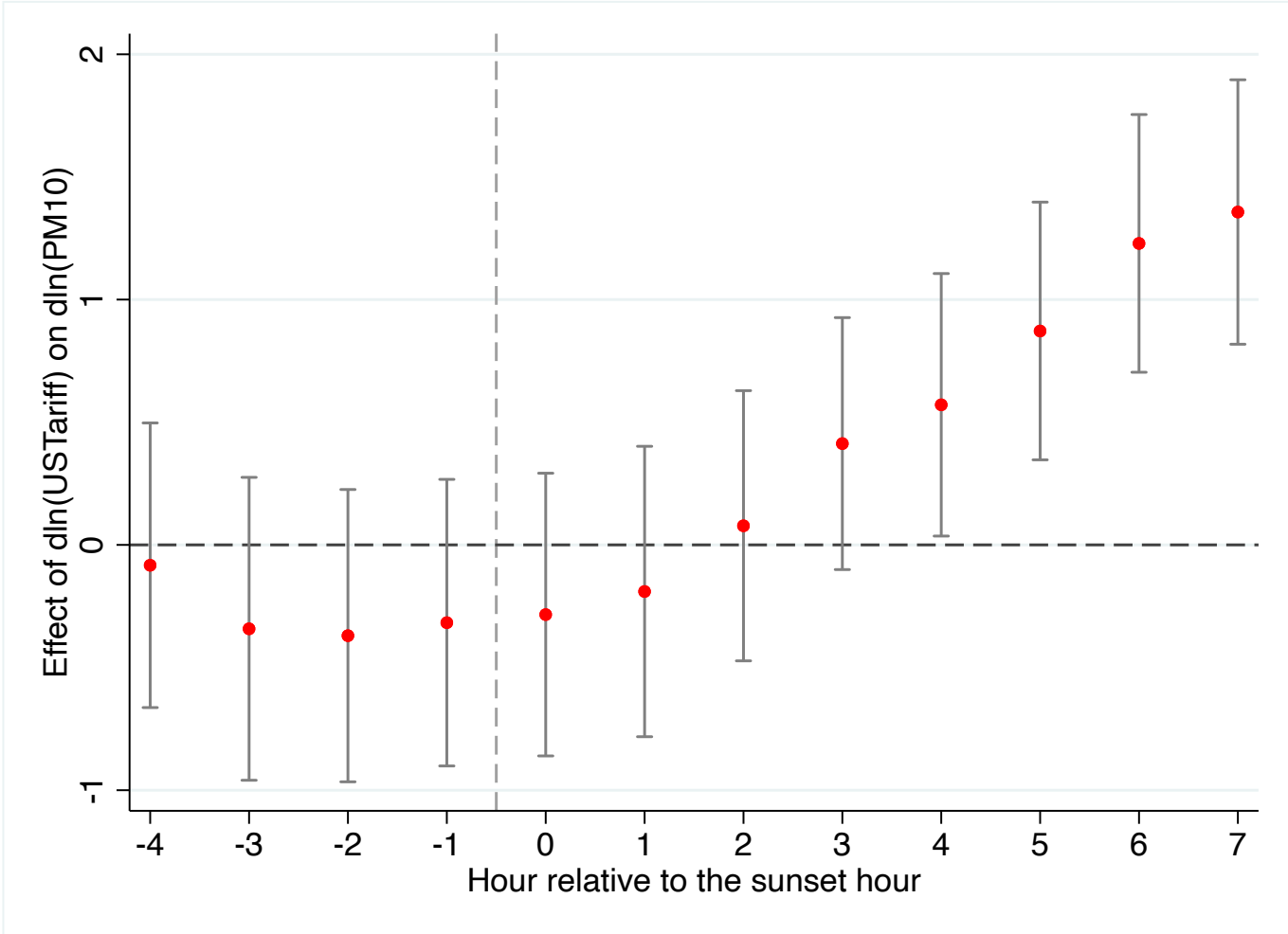
Before vs. after sunset

We use the actual sunset hour and re-calculate the same-day pollution differences. A 1% increase in U.S. tariff leads to a 6.4% increase in same-day dark hour $PM_{2.5}$ pollution. The sunset effect is stronger than off hour effect.

	Dark hour - daytime hour				
	ΔAQI diff	ΔSO_2 diff	ΔNO_2 diff	$\Delta PM_{2.5}$ diff	ΔPM_{10} diff
Δln(USTariff)	11.058***	3.173**	1.250	6.404***	15.003***
	(2.260)	(1.352)	(0.935)	(1.918)	(2.503)
Δln(CHNTariff)	-4.959***	0.738	0.912*	-2.809**	-5.264***
	(1.380)	(0.892)	(0.466)	(1.103)	(1.771)
Observations	48847	48847	48847	48847	48847
R-square	0.048	0.066	0.088	0.051	0.048
Y-mean	-0.105	0.119	0.054	0.012	-0.033
Y-sd	2.032	1.213	0.915	1.717	2.345
Monitor FEs	Y	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y	Y

Notes: Standard errors are clustered at the monitor-month level.

Tariff effect at each hour relative to sunset



Notes: These figures display coefficients on ΔU.S. Tariff. We separately estimate coefficients at each sunset hour.

Other pollutants

Outline

Firms' emission effects of city-level tariff

End-of-pipe measures show firms' emissions increase by 16-23% as U.S. tariff increases by 1%. The magnitude is greater than that of citywide air quality.

	ΔParticles	ΔSO_2	ΔNO_x
Δ US Tariff	16.158*	22.830**	-9.710
	(8.854)	(8.268)	(7.900)
Δ China Tariff	2.572	-10.210	-0.619
	(3.302)	(7.846)	(2.686)
Observations	3965	3689	3705
R-square	0.515	0.522	0.514
Y-mean	-0.271	-0.276	-0.155
Y-sd	1.111	1.300	1.035
Firm FEs	Y	Y	Y
Year-Month FEs	Y	Y	Y

Notes: Standard errors are clustered at the province-month level.

Firm-level evidence: who pollute more?

Citywide tariff escalation plays a bigger role than industry-level tariffs.

	ΔParticles	ΔSO_2	ΔNO_x
Δ US Tariff_City	15.501*	23.022**	-9.852
	(8.818)	(8.399)	(7.857)
Δ US Tariff_Industry	13.519*	7.878	-7.764
	(7.046)	(9.125)	(11.218)
Δ China Tariff	2.741	-8.850	-0.754
	(3.145)	(7.165)	(2.430)
Observations	3829	3561	3554
R-square	0.514	0.528	0.515
Y-mean	-0.274	-0.269	-0.160
Y-sd	1.106	1.295	1.042
Firm FEs	Y	Y	Y
Year-Month FEs	Y	Y	Y

Notes: Standard errors are clustered at the province-month level.

Firms with scrubbers pollute more

Merging our CEMS firms with scrubber dummies in Karplus and Wu (2023), firms with scrubbers have higher increases in emission intensities.

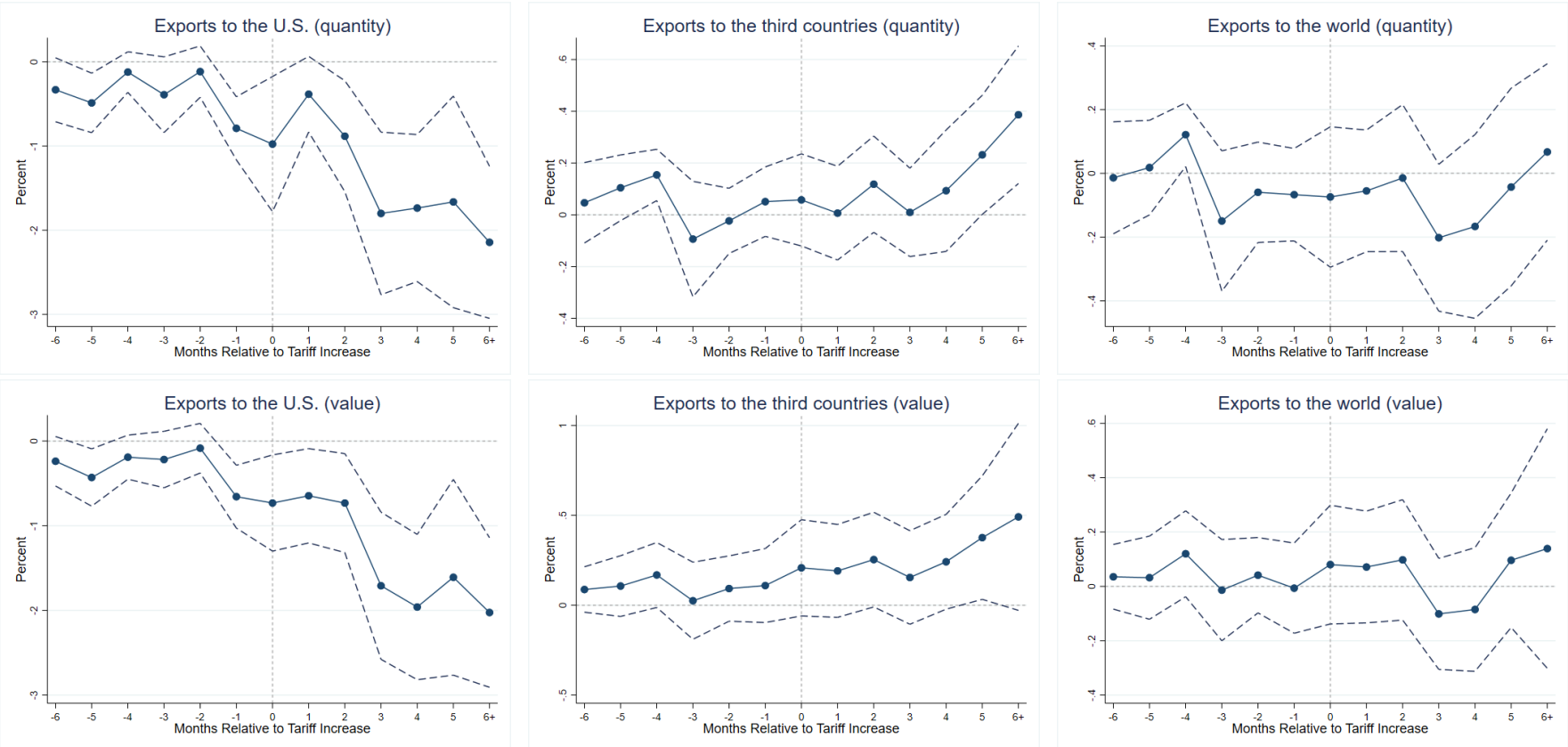
	ΔParticles	ΔSO_2	ΔNO_x
Δln(USTariff)	21.660	-8.399	-18.725*
	(16.854)	(21.583)	(11.113)
Δln(USTariff)$\times$ SO2 scrubber	14.494	33.278*	-0.744
	(16.429)	(18.152)	(9.943)
Δln(CHNTariff)	9.715**	-12.550**	-4.960
	(4.747)	(5.797)	(3.276)
Observations	1363	1241	1317
R-square	0.425	0.526	0.407
Y-mean	-0.391	-0.339	-0.134
Y-sd	1.186	1.179	0.897
Firm FEs	Y	Y	Y
Year-Month FEs	Y	Y	Y

Notes: Standard errors are clustered at the province-month level.

Outline

Rule out the export channel

The dynamic effects of tariffs on exports



Notes: Sample for the first/middle/last two figures: China's monthly HS-8-product-level export to the U.S./export to third countries/total export to all trade partners from 2017:1 to 2019:12.

Empirical strategy

$$\Delta X_{Ipct} = \alpha_0 + \beta_1 \Delta USTariff_{pt} + \beta_2 \Delta Tariff_{pct} + D_{p'I} + D_{p'c} + D_{ct} + \mu_{Ipct}$$

- $\Delta USTariff_{pt}$ denotes the log change in tariffs imposed by the U.S. on product p compared to last year
- $\Delta Tariff_{Ipct}$ denotes the log change in tariffs imposed by country c on product p
- $\Delta \ln X_{pct}$ denotes the log of Chinese exports of product p from province I to country c in month t between January 2017 and December 2019.
- HS6 product-province fixed effects ($D_{p'I}$)
- HS6 product-country fixed effects ($D_{p'c}$)
- country-year-month fixed effects (D_{ct})

Tariff and export

Tariffs and exports

	(1)	(2)	(3)	(4)	(5)	(6)
	Export to the U.S.		to third countries		to the world	
	$\Delta ln(V)$	$\Delta ln(Q)$	$\Delta ln(V)$	$\Delta ln(Q)$	$\Delta ln(V)$	$\Delta ln(Q)$
$\Delta \ln\left(1+\tau\_us_{pt}\right)$	-0.60***	-0.58***	0.14**	0.10**	0.10	0.06
	(0.12)	(0.12)	(0.06)	(0.05)	(0.07)	(0.05)
$\Delta \ln\left(1+\tau_{pct}\right)$			-0.22	-0.07	-0.53***	-0.44**
			(0.29)	(0.28)	(0.20)	(0.20)
Observations	109,340	108,968	4,479,791	4,434,843	4,589,131	4,543,811
R-squared	0.31	0.29	0.19	0.18	0.20	0.19
HS-6 FE	YES	YES	NO	NO	NO	NO
HS-6 $\times$ Country FE	NO	NO	YES	YES	YES	YES
Country $\times$ Year-month FE	NO	NO	YES	YES	YES	YES
Year-month FE	YES	YES	NO	NO	NO	NO

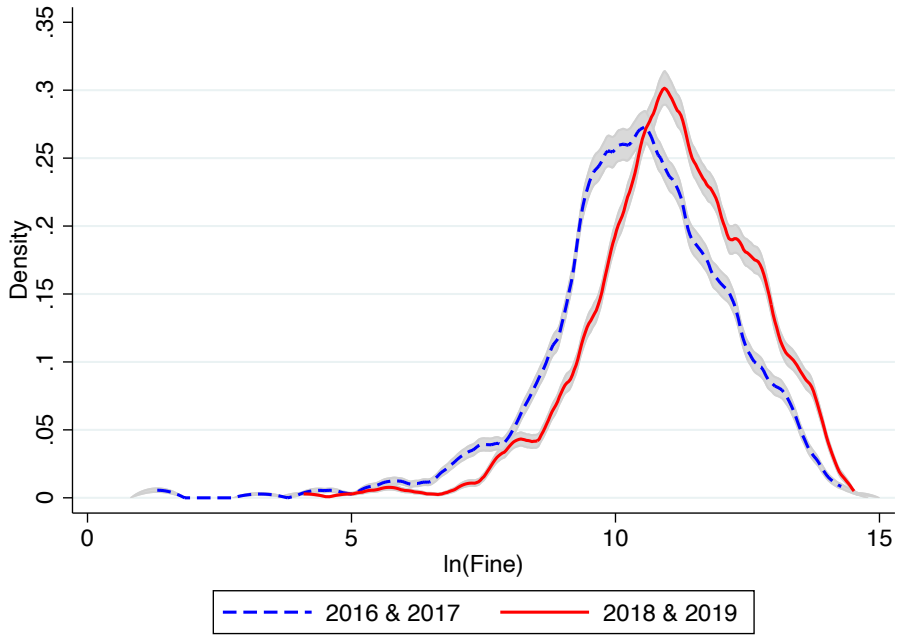
Notes: Columns (1) - (6) report export values and export quantities regressed on the export tariff rates. Columns (1) and (2) include HS-6 product fixed effects and time fixed effects. Columns (3) - (6) include HS-6-product-country fixed effects and country-time fixed effects. Sample in Columns (1) - (2): China's monthly HS-8-product-level export data to the U.S. from 2017:1 to 2019:12. Sample in Columns (3) - (4): China's monthly HS-8-product-country-level export data to third countries from 2017:1 to 2019:12. Sample in Columns (5) - (6): China's monthly HS-8-product-country-level export data to all countries from 2017:1 to 2019:12. Variables are in twelve-month log change. Regressions in Columns (1) and (2) are weighted by HS-8 product-level export value last year. Regressions in Columns (3) - (6) are weighted by HS-8 product-country-level export value last year. Standard errors in Columns (1) and (2) are clustered by HS-6 product. Standard errors in Columns (3) - (6) are clustered by HS-6 product and country. Significance: * 0.10, ** 0.05, *** 0.01.

Outline

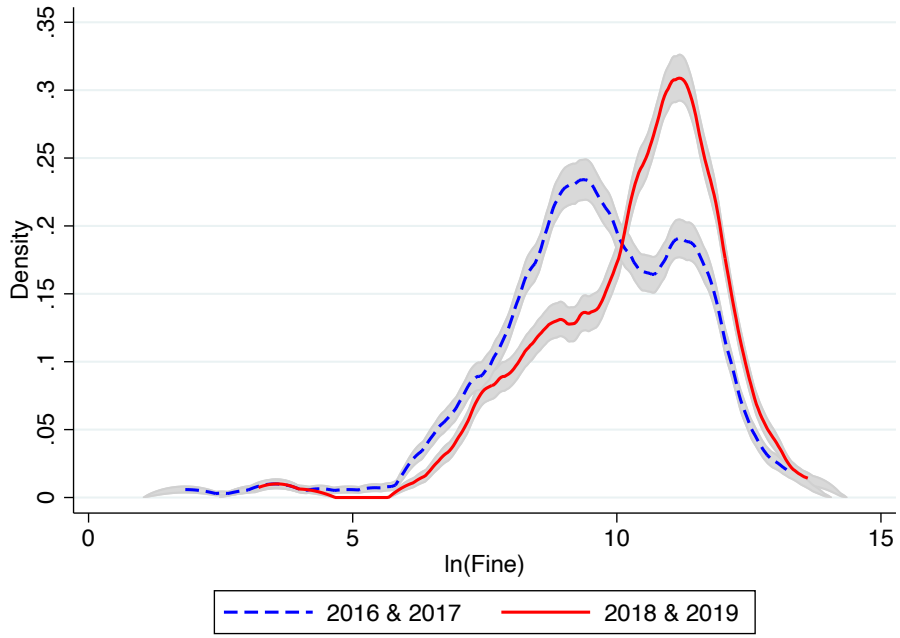
#1: Environmental fine

- Local environmental agencies conduct inspections on illegal acts and impose penalties on firms found to violate environmental regulations.
- These penalties are documented and made available through annual releases on government websites.
- Each ticket includes the culpable firm's name, industry affiliation, location, details on illegal acts, fine amount, and environmental agency involved.
- We aggregate the event-level data at the firm-month level.

Distribution before and after the trade war



(a) High-exposure cities



(b) Low-exposure cities

Note: We calculate total environmental fine at the city-year level, and plot kernel density curves for high-exposure and low-exposure cities in Panel (a) and (b). Gray areas denote the 95% confidence intervals.

Results on environmental fine

	Δ#Events	Δ#Events with fine	ΔTotal fine	ΔFine per event
Δ US Tariff	0.311	0.785	-6.912**	-8.530**
	(0.769)	(0.800)	(3.130)	(3.815)
Δ China Tariff	-3.590***	-4.094***	-9.622**	-2.729
	(0.639)	(0.591)	(4.483)	(4.581)
Observations	11880	11880	11880	11880
R-square	0.435	0.326	0.301	0.263
Y-mean	0.199	0.080	0.285	0.171
Y-sd	0.611	0.564	1.671	1.595
City FEs	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y

Notes: The sample period is from 2017:1 to 2019:12. We stack our sample 12 times to merge the city-year level fine with the city-month level tariff. *#Events*, *#Events with fine*, and *Total fine* is divided by 12, i.e. we assume fine events are equally distributed across the year. All columns include year-month and city fixed effects. Standard errors are clustered at the province-year level.

#2: Text-based environmental stringency index

We use the environmental stringency index from Chen et al. (2018) to measure environmental phrases in official planning documents:

$$ESI_{pcy} = \frac{\#\text{words in phrase } p\text{-related sentences in city } c \text{ year } t\text{'s work report}}{\#\text{words in city } c \text{ year } t\text{'s work report}}$$

$$ESI_{cy} = \sum_{p} \frac{\#\text{words in phrase } p\text{-related sentences in city } c \text{ year } t\text{'s work report}}{\#\text{words in city } c \text{ year } t\text{'s work report}}$$

Trade war and environmental stringency index

	Stringency index	
Δ US Tariff	-0.770**	-0.074***
	(0.331)	(0.017)
Δ China Tariff	0.255	0.019
	(0.189)	(0.012)
Observations	10008	150120
R-square	0.701	0.714
Y-mean	0.652	0.043
Y-sd	0.239	0.087
Phrase FEs		Y
City FEs	Y	Y
Year-Month FEs	Y	Y

Notes: The sample period is from 2017:1 to 2019:12. We stack our sample 12 times to merge the city-year level stringency index with the city-month level tariff. Column (1) sums all 15 environmental phrases together. Column (2) uses separate *ESI* for each phrase and adds phrase fixed effects. Both columns include year-month and city fixed effects. Column (2) also adds phrase fixed effects.

#3: Media index and public attention

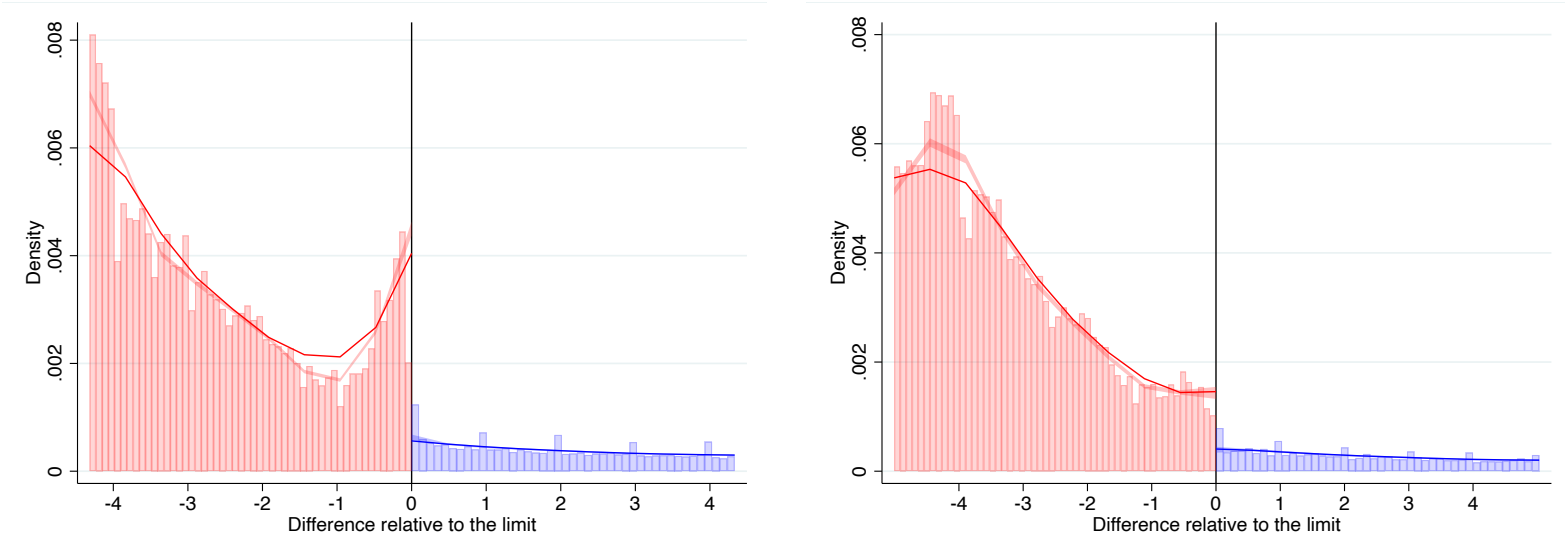
We use the Baidu media index on "smog" as the dependent variable, derived from the number of news articles reported by major internet media and included in Baidu News. We also use the search index as a proxy of public interest in "smog".

A 1% increase in U.S. tariffs leads to a 2.1% decrease in the media index, while has little effect on search indexes.

	Media index	Search index		
		Overall	PC	Mobile
Δln(USTariff)	-2.128***	-0.334	-0.001	-0.177
	(0.591)	(1.541)	(1.661)	(1.384)
Δln(CHNTariff)	1.090***	-0.224	-0.622	-0.555
	(0.245)	(0.681)	(0.952)	(0.763)
Observations	10656	10656	10656	10656
R-square	0.917	0.863	0.788	0.833
Y-mean	2.434	3.812	2.658	3.358
Y-sd	1.849	1.422	1.427	1.476
County FEs	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y

Notes: Standard errors are clustered at the province-month level.

#4: Emission data bunching



(c) January 2017 - June 2018

(d) July 2018 - December 2019

Figure 1: **Bunching of CEMS data before and after the trade war**

Note: We use firm-hour level reports of CEMS emissions for SO_2, NO_x, and Particles 2017-2019, and calculate emission concentrations relative to the limits. We test if there are discontinuities around $0\mu g/m^3$. McCrary test shows t-statistics are -52.4778 and -15.682 in the pre- and post-period respectively.

#5: Heterogeneity across local government budgets

	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)	0.581***	0.586	0.929***	0.823***	0.530**
	(0.191)	(0.455)	(0.273)	(0.293)	(0.243)
Δln(USTariff)$\times$ Budget	-0.004	-0.088***	0.003	0.027**	-0.032***
	(0.009)	(0.019)	(0.010)	(0.011)	(0.010)
Δln(CHNTariff)	-0.096	-0.114	0.430***	-0.633***	-0.031
	(0.134)	(0.272)	(0.149)	(0.182)	(0.158)
Observations	48868	48868	48868	48868	48868
R-square	0.228	0.170	0.178	0.192	0.239
Y-mean	-0.048	-0.193	-0.027	-0.075	-0.064
Y-sd	0.221	0.402	0.271	0.296	0.275
Monitor FEs	Y	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y	Y

Notes: Standard errors are clustered at the monitor-month level.

#6: Heterogeneity across locations

Pollution increase is more striking for monitors close to provincial boundaries:

	AQI	SO_2	NO_2	$PM_{2.5}$	PM_{10}
Δln(USTariff)	1.018^{***}	1.496^{**}	1.417^{***}	1.701^{***}	0.893^{**}
	(0.279)	(0.606)	(0.382)	(0.422)	(0.349)
Δln(USTariff)$\times$ Dist	-0.006^{**}	-0.008	-0.007	-0.014^{***}	-0.003
	(0.003)	(0.006)	(0.005)	(0.004)	(0.004)
Δln(CHNTariff)	-0.095	-0.113	0.432^{***}	-0.629^{***}	-0.031
	(0.134)	(0.272)	(0.149)	(0.182)	(0.158)
Observations	48868	48868	48868	48868	48868
R-square	0.228	0.169	0.178	0.192	0.239
Y-mean	-0.048	-0.193	-0.027	-0.075	-0.064
Y-sd	0.221	0.402	0.271	0.296	0.275
Monitor FEs	Y	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y	Y

Notes: Standard errors are clustered at the monitor-month level.

Outline

Conclusion

- Pollution ↑
  - Monitor-level and firm-level ↑
- Export: to the US ↓; to the ROW ↑
- Lenient environmental policy → pollution intensity ↑
  - Direct evidence: environmental fine↓; stringency↓; media exposure↓
  - Indirect evidence: excess pollution at night and near provincial boundaries
  - Indirect evidence: city-level tariffs have a larger impact than industry-level tariffs
- Driving force: political incentive
  - Pollution increases are more striking in cities whose leaders have lower long-term promotion incentives
  - Cities with native and older officials had less pollution increases

Appendix

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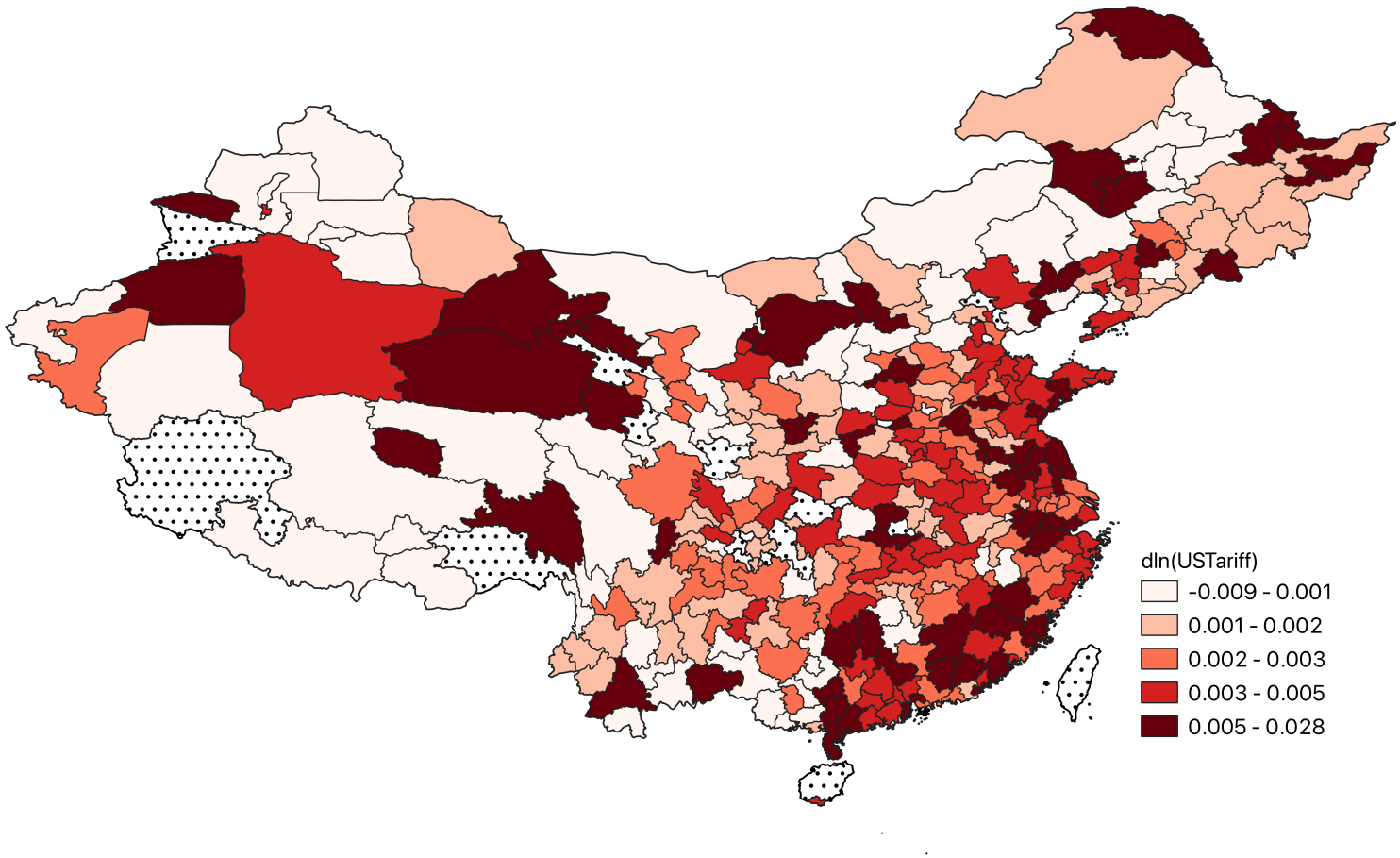
Trade war timeline

Wave	Date of implementation	Event
Panel A. United States		
Prelude 1	2018-02-07	The U.S. imposes 30% tariffs on solar panels and 20% on washing machines under two Section 201 cases.
Prelude 2	2018-03-23	The U.S. imposes 25 % Section 232 tariffs on steel and 10 % Section 232 tariffs on aluminum imported from China and other countries, temporarily exempting Argentina, Australia, Brazil, Canada, Mexico, the U.S., and South Korea.
Wave 1	2018-07-06	The U.S. imposes 25% Section 301 tariffs on $34 billion of imports from China.
Wave 2	2018-08-23	The U.S. imposes 25% Section 301 tariffs on $16 billion of imports from China.
Wave 3	2018-09-24	The U.S. imposes 10% Section 301 tariffs on $200 billion of imports from China.
Wave 4	2019-06-15	The U.S. raises Section 301 tariffs from 10% to 25% on $200 billion of imports from China.
Wave 5	2019-09-01	The U.S. imposes 15% tariffs on $101 billion of imports from China.
Panel B. China		
Prelude 1	2018-04-02	China imposes 15% or 25% retaliatory tariffs on $2.4 billion of imports from the U.S. in response to U.S. Section 232 tariffs on steel and aluminum tariffs.
Wave 1	2018-07-06	China imposes 25% retaliatory tariffs on $34 billion of imports from the U.S. in response to U.S. Section 301 tariffs imposed on July 6, 2018.
Wave 2	2018-08-23	China imposes 25% retaliatory tariffs on $16 billion of imports from the U.S. in response to U.S. Section 301 tariffs imposed on August 23, 2018.
Wave 3	2018-09-24	China imposes 5% or 10% retaliatory tariffs on $60 billion of imports from the U.S. in response to U.S. Section 301 tariffs imposed on September 24, 2018.
Wave 4	2019-06-01	China imposes an additional 5%, 10%, or 15% tariffs on a subset of the existing product list implemented on September 24, 2018, in response to the U.S. Section 301 tariff increase imposed on June 15, 2019.
Wave 5	2019-09-01	China imposes an additional 5% or 10% tariffs on $75 billion of imports from the U.S. in response to the U.S. Section 301 tariff increase imposed on September 1, 2019.

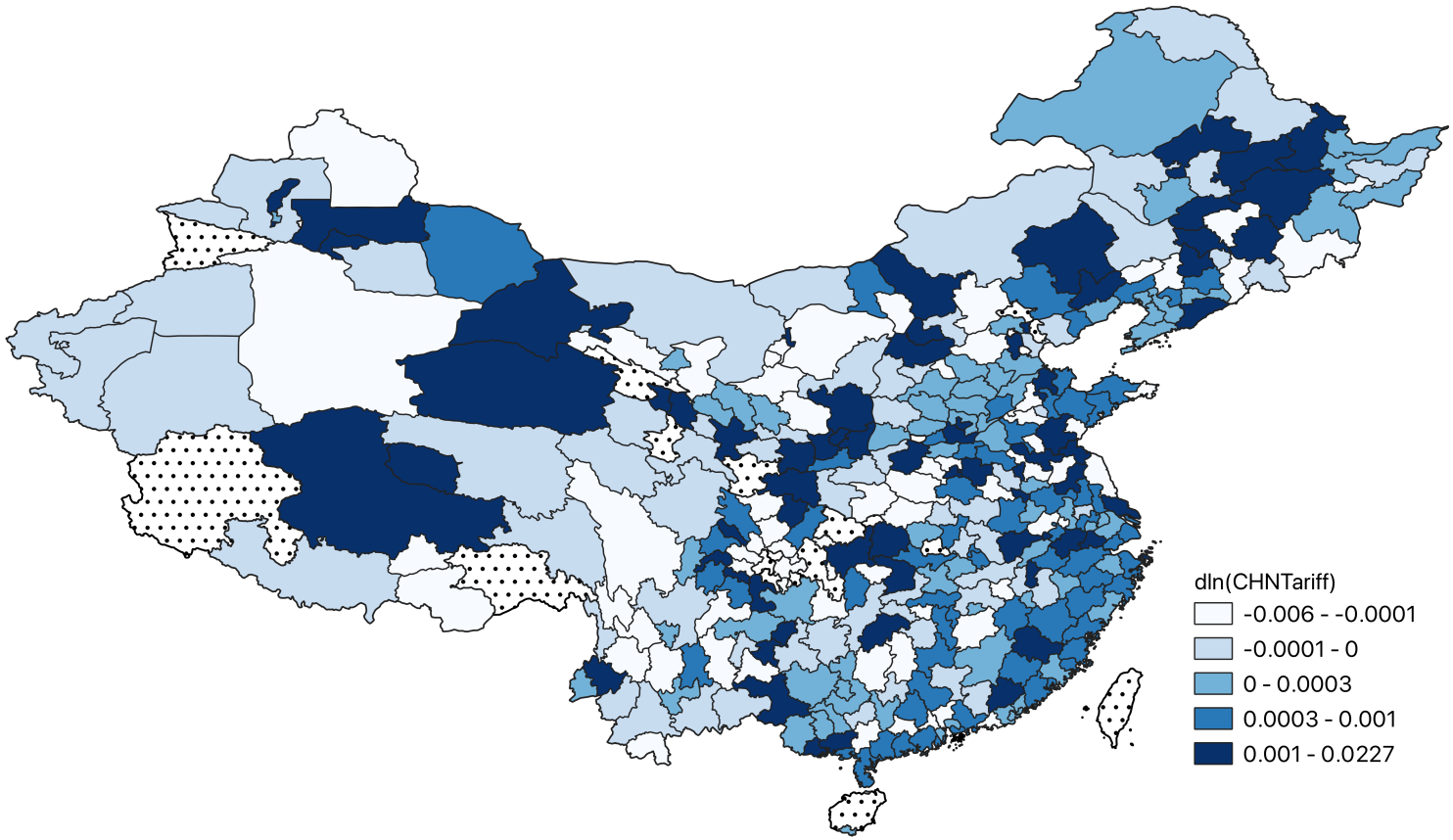
Back

$\Delta ln(USTariff_{it})$, average July 2018 - December 2019



◂ Return

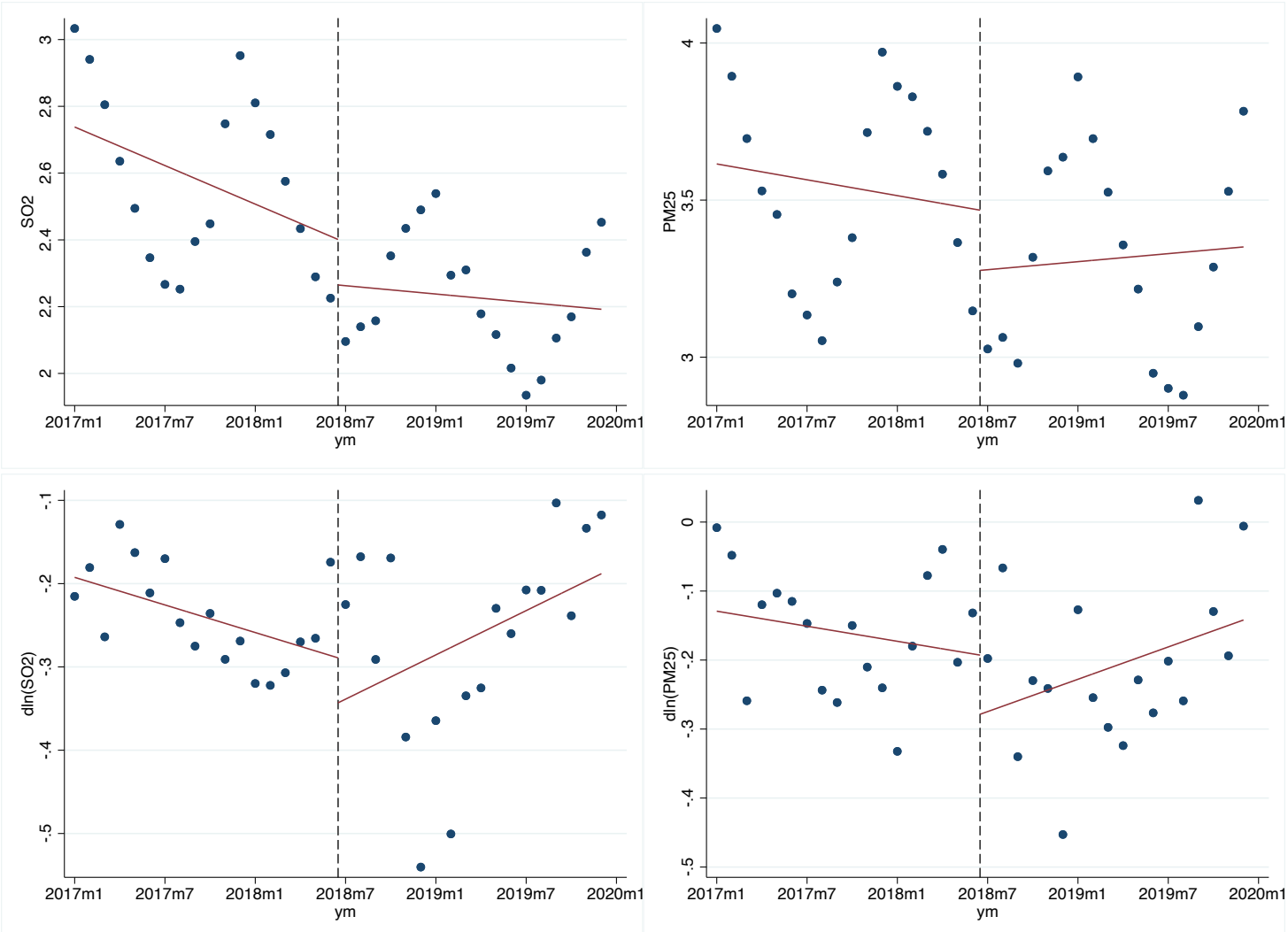
$\Delta ln(CHNTariff_{it})$, average July 2018 - December 2019



◂ Return

P_{it} and $\Delta ln(P_{it})$ in each month

Recent trends of air pollution reduction are flipped after the trade shock:

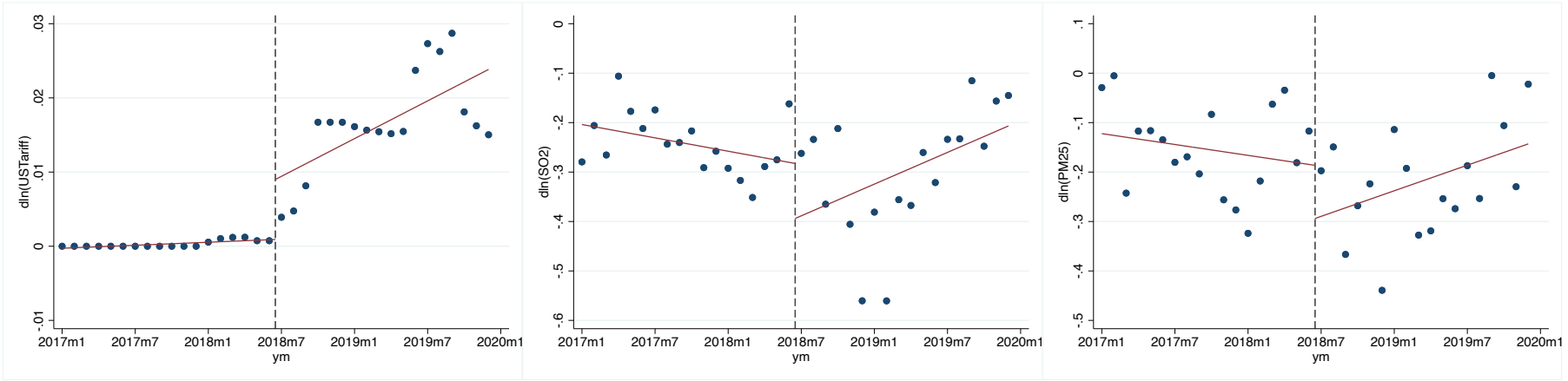


Notes: These figures display binscatter plots for pollution in each month (top), pollution changes relative to last year (bottom).

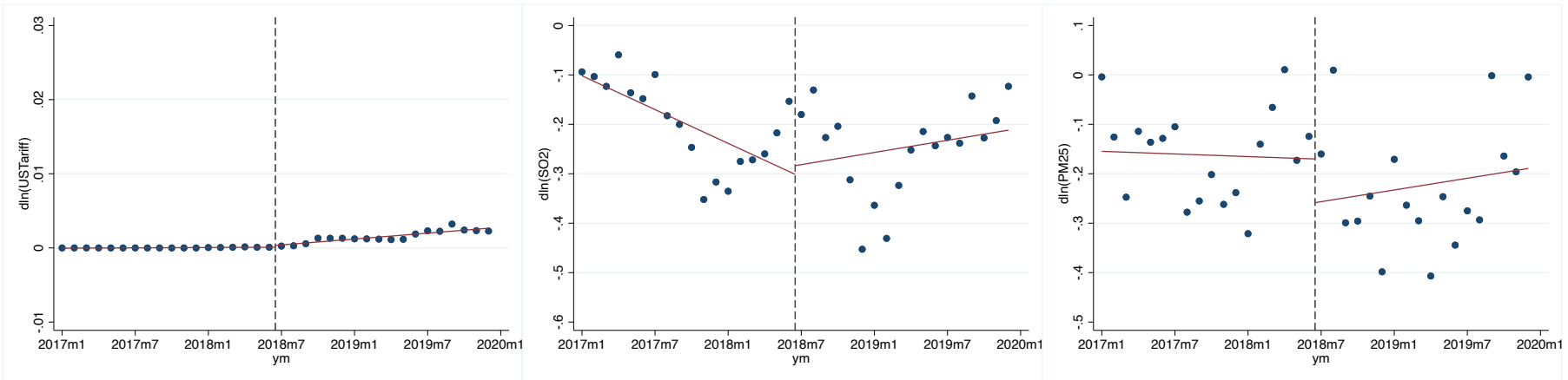
◂ Return

Top and bottom quartile, US tariff

High exposure cities, US tariff:



Low exposure cities, US tariff:

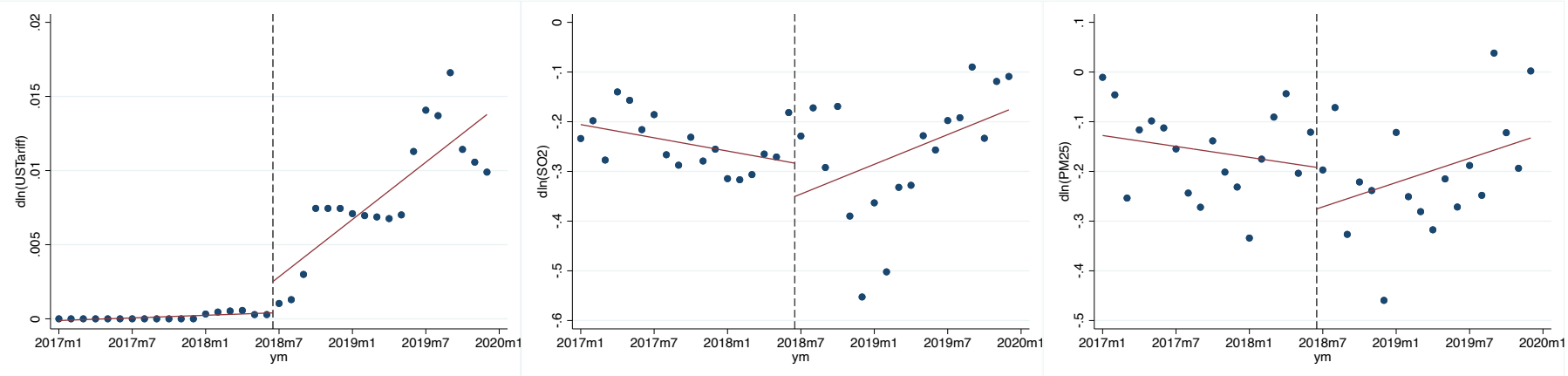


Notes: These figures display binscatter plots for the year-to-year monthly changes of U.S. tariffs, SO2, and PM2.5, where city-level tariffs are weighted by exports. Cities are classified into two groups based on their US tariff exposure.

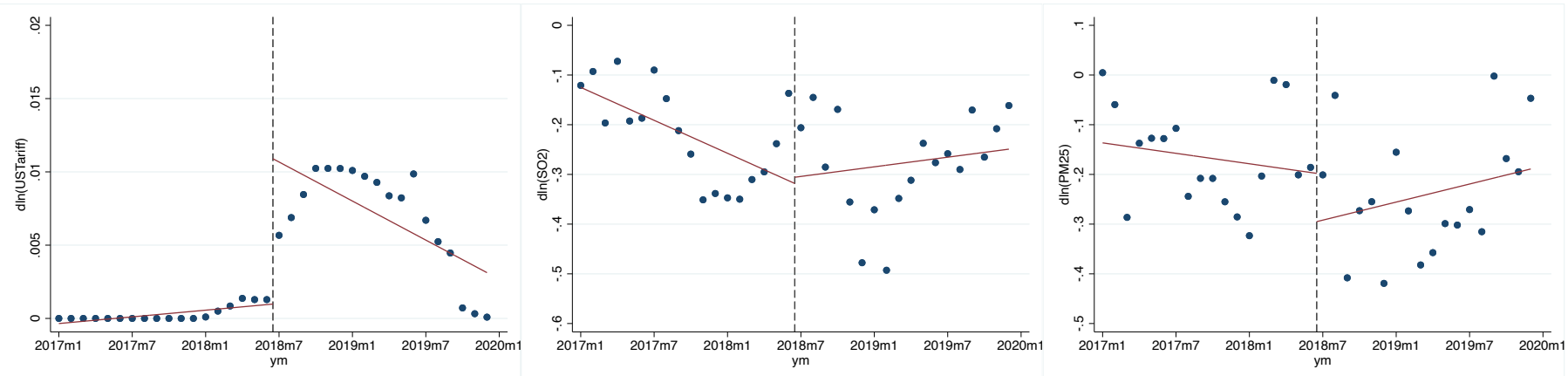
◂ Return

Cities with increasing US tariff

Cities with increasing US tariff:



Other cities:

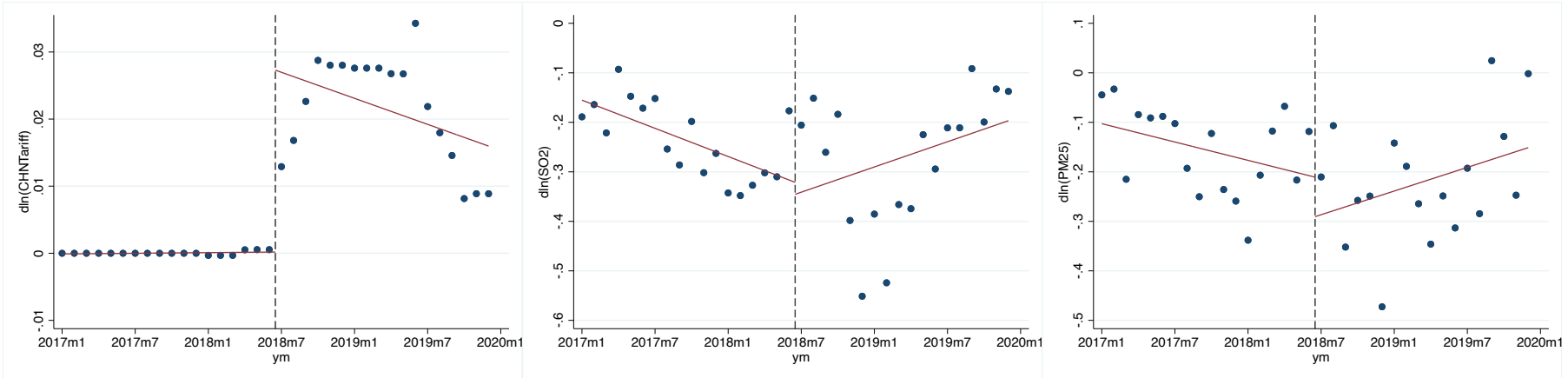


Notes: These figures display binscatter plots for the year-to-year monthly changes of U.S. tariffs, SO2, and PM2.5, where city-level tariffs are weighted by exports. Cities are classified into two groups based on their US tariff exposure's change in the post-period.

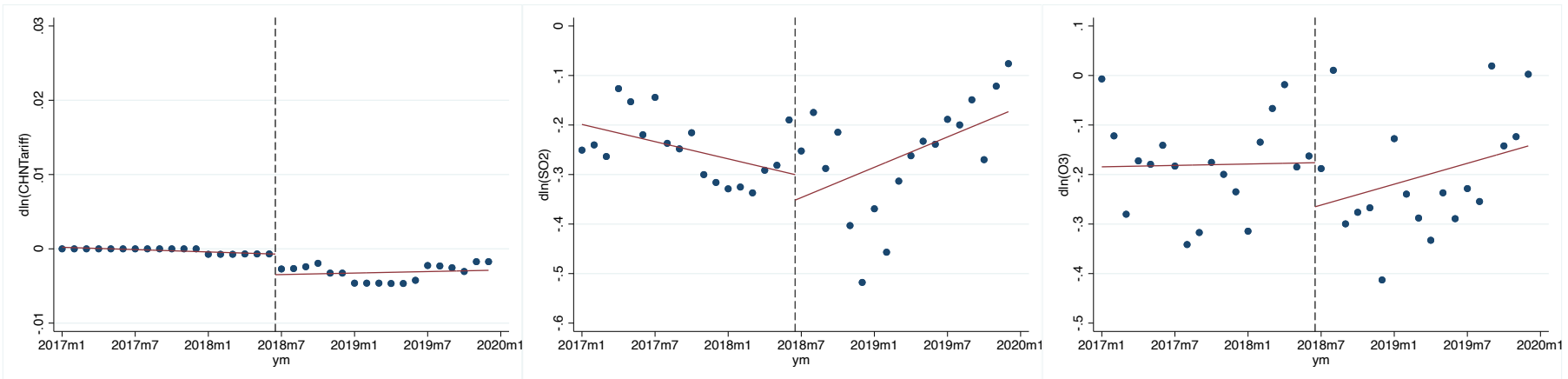
◂ Return

Top and bottom quartile, China tariff

High exposure cities, China tariff:



Low exposure cities, China tariff:



Notes: These figures display binscatter plots for the year-to-year monthly changes of China tariffs, SO2, and PM2.5, where city-level tariffs are weighted by exports. Cities are classified into two groups based on their China tariff exposure.

Return

Was China affected by the 2018 Trade War?

- "We will be taking in Tens of Billions of Dollars in Tariffs from China."
- The impact of U.S. tariffs on the U.S. economy
  - nearly complete pass through of tariffs to the U.S. (Amiti et al., 2019; Fajgelbaum et al., 2020; Cavallo et al., 2021).
  - U.S. real income decreased by $1.4 billion per month. Each household lost $831 per year (Amiti et al., 2019; Fajgelbaum et al., 2020).
- The impact of the U.S. tariffs on the Chinese economy
  - U.S. tariffs had no effect on the export price (Jiao et al., 2022).
  - U.S. tariffs decreased Chinese total exports to the U.S. but also increased export to other countries (Jiang et al., 2023).
  - U.S. tariffs reduced nightlight (Chor and Li, 2021).

Robustness: drop 2017

	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)	0.733***	1.845***	0.900***	1.053***	0.696***
	(0.202)	(0.459)	(0.299)	(0.309)	(0.268)
Δln(CHNTariff)	0.324**	0.330	0.794***	-0.158	0.477**
	(0.159)	(0.289)	(0.171)	(0.208)	(0.190)
Observations	32334	32334	32334	32334	32334
R-square	0.265	0.230	0.209	0.236	0.282
Y-mean	-0.065	-0.215	-0.061	-0.089	-0.089
Y-sd	0.217	0.383	0.251	0.291	0.271
Monitor FEs	Y	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y	Y

Notes: Standard errors are clustered at the monitor-month level.

◂ Return

Robustness: month-on-month change

	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)	3.402***	0.980	0.149	5.030***	1.920
	(0.978)	(1.176)	(0.973)	(1.277)	(1.176)
Δln(CHNTariff)	-1.612***	-1.017**	-0.183	-1.777***	-2.103***
	(0.354)	(0.472)	(0.459)	(0.567)	(0.463)
Observations	49044	49044	49044	49044	49044
R-square	0.400	0.211	0.444	0.409	0.438
Y-mean	-0.008	-0.021	-0.004	-0.009	-0.010
Y-sd	0.227	0.301	0.250	0.309	0.275
Monitor FEs	Y	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y	Y

Notes: Standard errors are clustered at the monitor-month level.

◂ Return

Empirical strategy: event study

$$\ln P_{it} = \beta \text{ Post}_t \times \text{Treated}_i + City_i + YearMonth_{it} + \eta_t + \epsilon_{it}$$

- Sample: Jan 2017 - Dec 2019, all prefecture-level cities in China.
- P_{it}: air pollution in city i in month t.
- $Post_t$ is 1 if month t is between Jul 2018 and Dec 2019.
- $Treated_i$ is 1 if city i is a high-exposure city and 0 otherwise.

  We calculate the sum of tariff escalation at the city level and assign cities into quartiles. Cities in the top quartile are high-exposure cities. The other three quartiles are low-exposure cities.
- β: high exposure cities' pollution responses to the trade war relative to low exposure cities.

◂ Return

Robustness: results on city-month pollution

A 1% increase in U.S. tariff leads to 1.6% increase in SO_2 and 0.9% increase in $PM_{2.5}$ at the city-month level:

	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)	0.629^{**}	1.649^{**}	0.482	0.853^{*}	0.571
	(0.309)	(0.683)	(0.337)	(0.437)	(0.393)
Δln(CHNTariff)	-0.084	-0.077	0.669^{***}	-0.658^{**}	-0.140
	(0.229)	(0.432)	(0.207)	(0.295)	(0.265)
Observations	11844	11844	11844	11844	11844
R-square	0.241	0.209	0.239	0.206	0.257
Y-mean	-0.052	-0.193	-0.034	-0.081	-0.069
Y-sd	0.213	0.333	0.223	0.278	0.266
City FEs	Y	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y	Y

Notes: Standard errors are clustered at the city-month level.

Return

Weighted regression using city GDP

Estimates are smaller in weighted regression, suggesting smaller cities have larger pollution increases in response to U.S. tariffs.

	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)	1.102**	0.289	0.600	1.529**	0.966
	(0.558)	(0.905)	(0.490)	(0.739)	(0.649)
Δln(CHNTariff)	-0.107	-0.910*	-0.244	-0.577	0.032
	(0.354)	(0.476)	(0.268)	(0.498)	(0.392)
Observations	10332	10332	10332	10332	10332
R-square	0.251	0.254	0.288	0.220	0.268
Y-mean	-0.050	-0.211	-0.035	-0.078	-0.065
Y-sd	0.202	0.283	0.186	0.257	0.240
City FEs	Y	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y	Y

Notes: Standard errors are clustered at the city-month level.

Return

Placebo: effect of current tariffs on last year's pollution

	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)	-0.788*	-0.314	-0.338	-1.028*	-0.772
	(0.420)	(0.627)	(0.451)	(0.580)	(0.501)
Δln(CHNTariff)	-0.048	-0.003	0.036	-0.205	0.053
	(0.238)	(0.381)	(0.215)	(0.304)	(0.266)
Observations	48630	48630	48630	48630	48630
R-square	0.232	0.161	0.158	0.194	0.232
Y-mean	-0.051	-0.172	-0.010	-0.082	-0.057
Y-sd	0.233	0.433	0.306	0.308	0.287
Monitor FEs	Y	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y	Y

Notes: Standard errors are clustered at the monitor-month level.

◂ Return

Dynamic effects in each quarter

Pollution increases are mainly driven by winter quarters: Return

	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)× 2018q3	-2.851***	-4.270***	-1.955**	-4.981***	-3.573***
	(0.588)	(1.646)	(0.936)	(1.083)	(0.728)
Δln(USTariff)× 2018q4	1.959***	0.135	3.924***	2.611***	2.018***
	(0.627)	(0.988)	(0.623)	(0.861)	(0.743)
Δln(USTariff)× 2019q1	1.507**	-0.687	2.486***	0.986	2.713***
	(0.590)	(0.929)	(0.623)	(0.830)	(0.651)
Δln(USTariff)× 2019q2	0.267	-2.643***	1.048*	1.278**	0.226
	(0.342)	(0.869)	(0.545)	(0.619)	(0.481)
Δln(USTariff)× 2019q3	.124	1.61***	.538	.0703	.124
	(.226)	(.612)	(.421)	(.363)	(.306)
Δln(USTariff)× 2019q4	.689**	2.81***	-.454	.976**	.724*
	(.311)	(.716)	(.426)	(.432)	(.416)
Δln(CHNTariff)	-.124	-.0974	.35**	-.673***	-.0633
	(.135)	(.275)	(.15)	(.183)	(.158)
Observations	48868	48868	48868	48868	48868
R-square	0.277	0.187	0.195	0.234	0.280
Y-mean	-0.048	-0.193	-0.027	-0.075	-0.064
Y-sd	0.221	0.402	0.271	0.296	0.275
FEs	Monitor, Prov-Month, Year-Month; Δ US Tariff × 2017q1 to 2018q2				

Notes: Standard errors are clustered at the monitor-month level.

Effects at each hour (1/12)

	Effects 12-1am				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δ US Tariff	1.032***	0.838*	1.188***	1.092***	1.216***
	(0.209)	(0.489)	(0.311)	(0.303)	(0.267)
Δ China Tariff	-0.224	-0.172	0.792***	-0.791***	-0.153
	(0.140)	(0.309)	(0.169)	(0.200)	(0.167)
Observations	48807	48807	48807	48807	48807
R-square	0.188	0.151	0.170	0.168	0.201
Y-mean	-0.054	-0.186	-0.017	-0.077	-0.067
Y-sd	0.238	0.447	0.305	0.312	0.298
	Effects 1-2am				
Δ US Tariff	1.166***	0.739	1.312***	1.135***	1.336***
	(0.212)	(0.492)	(0.305)	(0.296)	(0.271)
Δ China Tariff	-0.254*	-0.090	0.735***	-0.804***	-0.125
	(0.144)	(0.308)	(0.173)	(0.211)	(0.173)
Observations	48809	48809	48809	48809	48809
R-square	0.184	0.152	0.169	0.166	0.201
Y-mean	-0.055	-0.185	-0.015	-0.076	-0.069
Y-sd	0.241	0.458	0.312	0.316	0.300

◂ Return

Effects at each hour (2/12)

	Effects 2-3am				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δ US Tariff	1.114***	0.454	1.151***	1.069***	1.367***
	(0.211)	(0.497)	(0.303)	(0.296)	(0.280)
Δ China Tariff	-0.263*	-0.110	0.733***	-0.717***	-0.091
	(0.148)	(0.303)	(0.175)	(0.217)	(0.179)
Observations	48786	48786	48786	48786	48786
R-square	0.189	0.153	0.174	0.171	0.203
Y-mean	-0.054	-0.179	-0.013	-0.074	-0.068
Y-sd	0.244	0.457	0.318	0.322	0.306
	Effects 3-4am				
Δ US Tariff	1.024***	0.282	1.154***	0.980***	1.215***
	(0.213)	(0.500)	(0.310)	(0.299)	(0.277)
Δ China Tariff	-0.145	-0.020	0.737***	-0.572***	-0.084
	(0.153)	(0.304)	(0.179)	(0.214)	(0.189)
Observations	48801	48801	48801	48801	48801
R-square	0.191	0.152	0.175	0.173	0.205
Y-mean	-0.051	-0.178	-0.012	-0.071	-0.064
Y-sd	0.246	0.458	0.319	0.323	0.306

Return

Effects at each hour (3/12)

	Effects 4-5am				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δ US Tariff	0.860***	0.180	1.087***	0.740**	1.004***
	(0.234)	(0.519)	(0.353)	(0.329)	(0.303)
Δ China Tariff	0.071	0.314	1.043***	-0.434*	0.231
	(0.162)	(0.303)	(0.194)	(0.225)	(0.199)
Observations	48771	48771	48771	48771	48771
R-square	0.174	0.147	0.163	0.162	0.183
Y-mean	-0.050	-0.176	-0.010	-0.070	-0.063
Y-sd	0.255	0.467	0.336	0.335	0.316
	Effects 5-6am				
Δ US Tariff	0.842***	0.549	1.039***	0.748**	0.961***
	(0.236)	(0.514)	(0.357)	(0.339)	(0.297)
Δ China Tariff	0.097	0.326	1.027***	-0.494**	0.246
	(0.163)	(0.301)	(0.190)	(0.223)	(0.198)
Observations	48781	48781	48781	48781	48781
R-square	0.174	0.147	0.162	0.162	0.180
Y-mean	-0.050	-0.178	-0.010	-0.070	-0.062
Y-sd	0.256	0.468	0.332	0.336	0.317

◂ Return

Effects at each hour (4/12)

	Effects 6-7am				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δ US Tariff	0.892***	0.806	0.965***	0.740**	1.110***
	(0.239)	(0.511)	(0.363)	(0.338)	(0.303)
Δ China Tariff	0.318*	0.341	1.022***	-0.431**	0.486**
	(0.165)	(0.293)	(0.188)	(0.219)	(0.201)
Observations	48767	48767	48767	48767	48767
R-square	0.179	0.148	0.174	0.168	0.182
Y-mean	-0.051	-0.182	-0.011	-0.071	-0.063
Y-sd	0.257	0.470	0.324	0.336	0.318
	Effects 7-8am				
Δ US Tariff	0.911***	1.048**	0.943***	1.137***	0.937***
	(0.215)	(0.490)	(0.306)	(0.310)	(0.270)
Δ China Tariff	0.190	0.273	0.572***	-0.529***	0.337*
	(0.157)	(0.286)	(0.163)	(0.199)	(0.195)
Observations	48799	48799	48799	48799	48799
R-square	0.188	0.156	0.189	0.176	0.197
Y-mean	-0.052	-0.187	-0.015	-0.071	-0.064
Y-sd	0.247	0.457	0.295	0.322	0.304

◂ Return

Effects at each hour (5/12)

	Effects 8-9am				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δ US Tariff	0.691***	0.815*	0.934***	1.071***	0.692***
	(0.209)	(0.474)	(0.273)	(0.298)	(0.266)
Δ China Tariff	0.187	0.318	0.489***	-0.591***	0.415**
	(0.157)	(0.283)	(0.153)	(0.196)	(0.193)
Observations	48794	48794	48794	48794	48794
R-square	0.191	0.162	0.191	0.177	0.197
Y-mean	-0.052	-0.191	-0.022	-0.072	-0.064
Y-sd	0.243	0.447	0.281	0.317	0.300
	Effects 9-10am				
Δ US Tariff	0.732***	0.937**	1.022***	1.207***	0.872***
	(0.205)	(0.467)	(0.265)	(0.297)	(0.264)
Δ China Tariff	0.179	0.291	0.506***	-0.547***	0.444**
	(0.152)	(0.275)	(0.153)	(0.193)	(0.188)
Observations	48800	48800	48800	48800	48800
R-square	0.191	0.162	0.179	0.175	0.198
Y-mean	-0.054	-0.196	-0.029	-0.076	-0.066
Y-sd	0.238	0.439	0.277	0.314	0.297

Return

Effects at each hour (6/12)

	Effects 10-11am				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δ US Tariff	0.495**	1.355***	1.185***	1.243***	0.627**
	(0.209)	(0.442)	(0.274)	(0.302)	(0.274)
Δ China Tariff	0.144	0.111	0.355**	-0.557***	0.358**
	(0.146)	(0.283)	(0.166)	(0.190)	(0.175)
Observations	48801	48801	48801	48801	48801
R-square	0.192	0.163	0.164	0.173	0.199
Y-mean	-0.053	-0.200	-0.034	-0.077	-0.063
Y-sd	0.236	0.431	0.286	0.314	0.297
	Effects 11am-12pm				
Δ US Tariff	0.371*	1.074**	0.967***	0.954***	0.482*
	(0.218)	(0.435)	(0.299)	(0.317)	(0.282)
Δ China Tariff	0.063	-0.270	0.260	-0.572***	0.206
	(0.148)	(0.290)	(0.181)	(0.197)	(0.179)
Observations	48795	48795	48795	48795	48795
R-square	0.201	0.160	0.144	0.176	0.205
Y-mean	-0.052	-0.205	-0.041	-0.079	-0.065
Y-sd	0.236	0.427	0.299	0.318	0.297

Return

Effects at each hour (7/12)

	Effects 12-1pm				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δ US Tariff	0.333	0.902**	0.679**	0.858***	0.346
	(0.215)	(0.429)	(0.313)	(0.321)	(0.275)
Δ China Tariff	-0.017	-0.304	0.221	-0.488**	0.028
	(0.152)	(0.288)	(0.191)	(0.203)	(0.190)
Observations	48804	48804	48804	48804	48804
R-square	0.216	0.158	0.130	0.180	0.210
Y-mean	-0.048	-0.200	-0.046	-0.079	-0.065
Y-sd	0.240	0.423	0.316	0.325	0.304
	Effects 1-2pm				
Δ US Tariff	0.221	0.879**	0.401	0.775**	0.029
	(0.219)	(0.446)	(0.343)	(0.325)	(0.282)
Δ China Tariff	0.069	-0.461	0.022	-0.344*	0.072
	(0.156)	(0.287)	(0.205)	(0.206)	(0.197)
Observations	48807	48807	48807	48807	48807
R-square	0.217	0.153	0.116	0.174	0.210
Y-mean	-0.043	-0.194	-0.050	-0.078	-0.066
Y-sd	0.241	0.420	0.335	0.327	0.308

Return

Effects at each hour (8/12)

	Effects 2-3pm				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)	0.036	0.650	0.097	0.306	-0.248
	(0.217)	(0.447)	(0.365)	(0.327)	(0.285)
Δln(CHNTariff)	0.063	-0.498*	-0.205	-0.355*	0.048
	(0.159)	(0.298)	(0.216)	(0.212)	(0.200)
Observations	48811	48811	48811	48811	48811
R-square	0.226	0.149	0.109	0.177	0.214
Y-mean	-0.037	-0.188	-0.049	-0.076	-0.065
Y-sd	0.243	0.423	0.347	0.331	0.310
	Effects 3-4pm				
Δ US Tariff	-0.055	0.565	-0.031	-0.141	-0.495
	(0.224)	(0.469)	(0.367)	(0.333)	(0.311)
Δ China Tariff	-0.089	-0.529*	-0.296	-0.425*	-0.186
	(0.162)	(0.303)	(0.218)	(0.217)	(0.210)
Observations	48815	48815	48815	48815	48815
R-square	0.231	0.146	0.107	0.177	0.215
Y-mean	-0.035	-0.188	-0.049	-0.076	-0.065
Y-sd	0.244	0.430	0.345	0.334	0.312

Return

Effects at each hour (9/12)

	Effects 4-5pm				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δ US Tariff	0.042	0.854*	-0.129	-0.297	-0.389
	(0.231)	(0.475)	(0.364)	(0.343)	(0.312)
Δ China Tariff	-0.144	-0.478	-0.346	-0.490**	-0.258
	(0.158)	(0.302)	(0.214)	(0.215)	(0.204)
Observations	48816	48816	48816	48816	48816
R-square	0.223	0.139	0.107	0.168	0.211
Y-mean	-0.036	-0.190	-0.049	-0.076	-0.065
Y-sd	0.241	0.432	0.338	0.332	0.310
	Effects 5-6pm				
Δ US Tariff	-0.026	1.029**	-0.312	-0.254	-0.492
	(0.224)	(0.464)	(0.348)	(0.325)	(0.308)
Δ China Tariff	-0.179	-0.460	-0.336	-0.587***	-0.211
	(0.159)	(0.298)	(0.205)	(0.210)	(0.205)
Observations	48828	48828	48828	48828	48828
R-square	0.221	0.140	0.112	0.170	0.210
Y-mean	-0.037	-0.191	-0.049	-0.076	-0.065
Y-sd	0.240	0.431	0.324	0.330	0.307

Return

Effects at each hour (10/12)

	Effects 6-7pm				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δ US Tariff	0.005	1.148**	0.054	-0.085	-0.312
	(0.223)	(0.469)	(0.314)	(0.320)	(0.304)
Δ China Tariff	-0.210	-0.431	-0.325*	-0.641***	-0.222
	(0.153)	(0.303)	(0.187)	(0.202)	(0.191)
Observations	48820	48820	48820	48820	48820
R-square	0.215	0.143	0.123	0.170	0.210
Y-mean	-0.040	-0.191	-0.046	-0.075	-0.066
Y-sd	0.235	0.431	0.304	0.322	0.302
	Effects 7-8pm				
Δ US Tariff	0.140	1.239***	0.454	0.113	-0.253
	(0.225)	(0.454)	(0.301)	(0.303)	(0.301)
Δ China Tariff	-0.233	-0.432	-0.006	-0.534***	-0.195
	(0.150)	(0.294)	(0.168)	(0.200)	(0.187)
Observations	48822	48822	48822	48822	48822
R-square	0.210	0.148	0.150	0.176	0.215
Y-mean	-0.046	-0.194	-0.043	-0.076	-0.068
Y-sd	0.232	0.433	0.292	0.316	0.296

◂ Return

Effects at each hour (11/12)

	Effects 8-9pm				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δ US Tariff	0.236	1.029**	0.526*	0.148	0.008
	(0.215)	(0.471)	(0.301)	(0.301)	(0.287)
Δ China Tariff	-0.209	-0.341	0.293*	-0.649***	-0.213
	(0.152)	(0.294)	(0.170)	(0.198)	(0.186)
Observations	48822	48822	48822	48822	48822
R-square	0.206	0.152	0.165	0.179	0.214
Y-mean	-0.052	-0.196	-0.037	-0.077	-0.070
Y-sd	0.231	0.435	0.289	0.312	0.293
	Effects 9-10pm				
Δ US Tariff	0.692***	1.234***	0.827***	0.497*	0.583**
	(0.203)	(0.478)	(0.313)	(0.296)	(0.263)
Δ China Tariff	-0.286**	-0.375	0.514***	-0.815***	-0.227
	(0.145)	(0.293)	(0.169)	(0.192)	(0.172)
Observations	48811	48811	48811	48811	48811
R-square	0.203	0.151	0.168	0.181	0.209
Y-mean	-0.055	-0.195	-0.031	-0.077	-0.069
Y-sd	0.234	0.437	0.290	0.311	0.292

Return

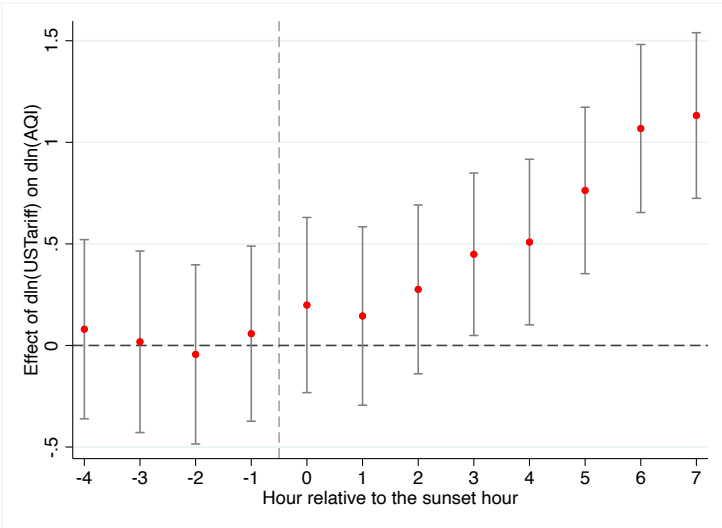
Effects at each hour (12/12)

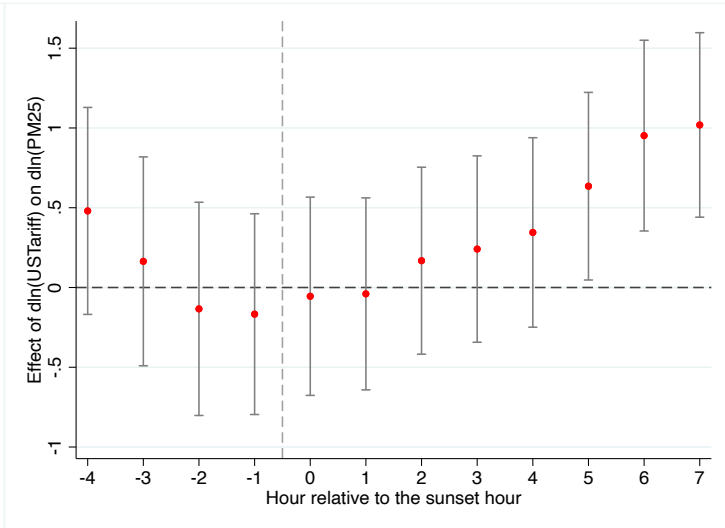
	Effects 10-11pm				
	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)	0.742***	1.118**	1.177***	0.575*	0.834***
	(0.209)	(0.492)	(0.313)	(0.301)	(0.265)
Δln(CHNTariff)	-0.298**	-0.134	0.759***	-0.839***	-0.377**
	(0.144)	(0.297)	(0.165)	(0.192)	(0.167)
Observations	48813	48813	48813	48813	48813
R-square	0.201	0.152	0.171	0.180	0.209
Y-mean	-0.054	-0.192	-0.024	-0.077	-0.068
Y-sd	0.237	0.442	0.293	0.313	0.295
	Effects 11pm-12am				
Δ US Tariff	0.910***	0.966**	1.149***	0.826***	0.998***
	(0.207)	(0.492)	(0.313)	(0.304)	(0.265)
Δ China Tariff	-0.265*	-0.187	0.706***	-0.842***	-0.159
	(0.142)	(0.302)	(0.168)	(0.195)	(0.168)
Observations	48821	48821	48821	48821	48821
R-square	0.197	0.152	0.170	0.178	0.204
Y-mean	-0.055	-0.190	-0.021	-0.078	-0.068
Y-sd	0.238	0.444	0.300	0.312	0.296

Return

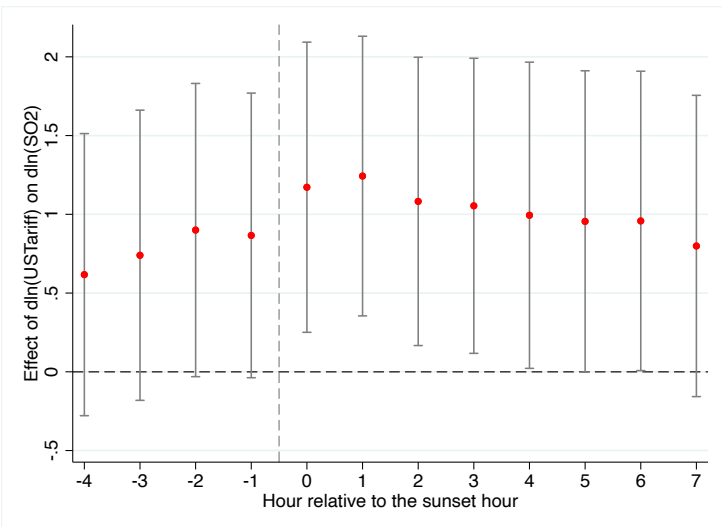
Tariff effect at each hour relative to sunset

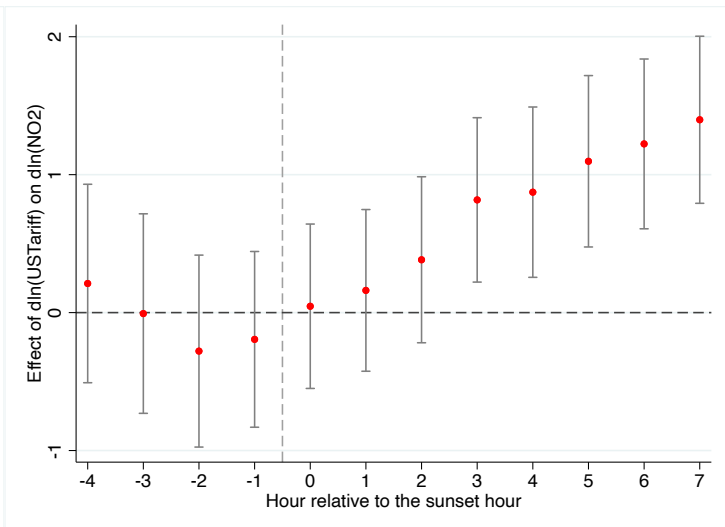
Effects on AQI and $PM_{2.5}$:





Effects on SO_2 and NO_2:





◂ Return

Private firms pollute more

	Panel A: Private firms		
	ΔParticles	ΔSO_2	ΔNO_x
Δln(USTariff)	16.171*	25.612*	-9.124
	(9.069)	(13.015)	(9.376)
Δln(CHNTariff)	2.784	-9.347*	0.284
	(2.988)	(5.073)	(2.520)
Observations	3851	3595	3614
R-square	0.514	0.523	0.515
	Panel B: State owned enterprises		
Δln(USTariff)	9.021	19.075	-7.951
	(26.543)	(43.362)	(19.098)
Δln(CHNTariff)	30.038*	4.327	-10.686
	(16.087)	(30.051)	(35.472)
Observations	319	266	253
R-square	0.679	0.706	0.808
Firm FEs	Y	Y	Y
Year-Month FEs	Y	Y	Y

Notes: Sample period is 2018-2019. Firms are required to report data every quarter. Standard errors are clustered at the province level.

Nightlight as a proxy of economic outputs

- Apart from export, we also rule out production changes since domestic production may be affected by tariff burdens.
- We check if firms in custom or CEMS have different production using nightlight as a proxy.
- Data is from VIIRS Stray Light Corrected Nighttime Day/Night Band Composites.
  Resolution: 30 arc seconds, monthly
- We calculate the average nightlight at the firm-month level using 1km and 5km buffers around firms.

Effects on nightlight around custom firms

	Average light within 1km	Average light within 5km
Δ US Tariff	1.054	1.025
	(0.714)	(0.628)
Δ China Tariff	0.917***	0.719**
	(0.340)	(0.297)
Observations	2222112	2222112
R-square	0.143	0.183
Y-mean	0.092	0.100
Y-sd	0.411	0.310
Firm FEs	Y	Y
Year-Month FEs	Y	Y

Notes: Sample period is 2017-2019. Standard errors are clustered at the city level.

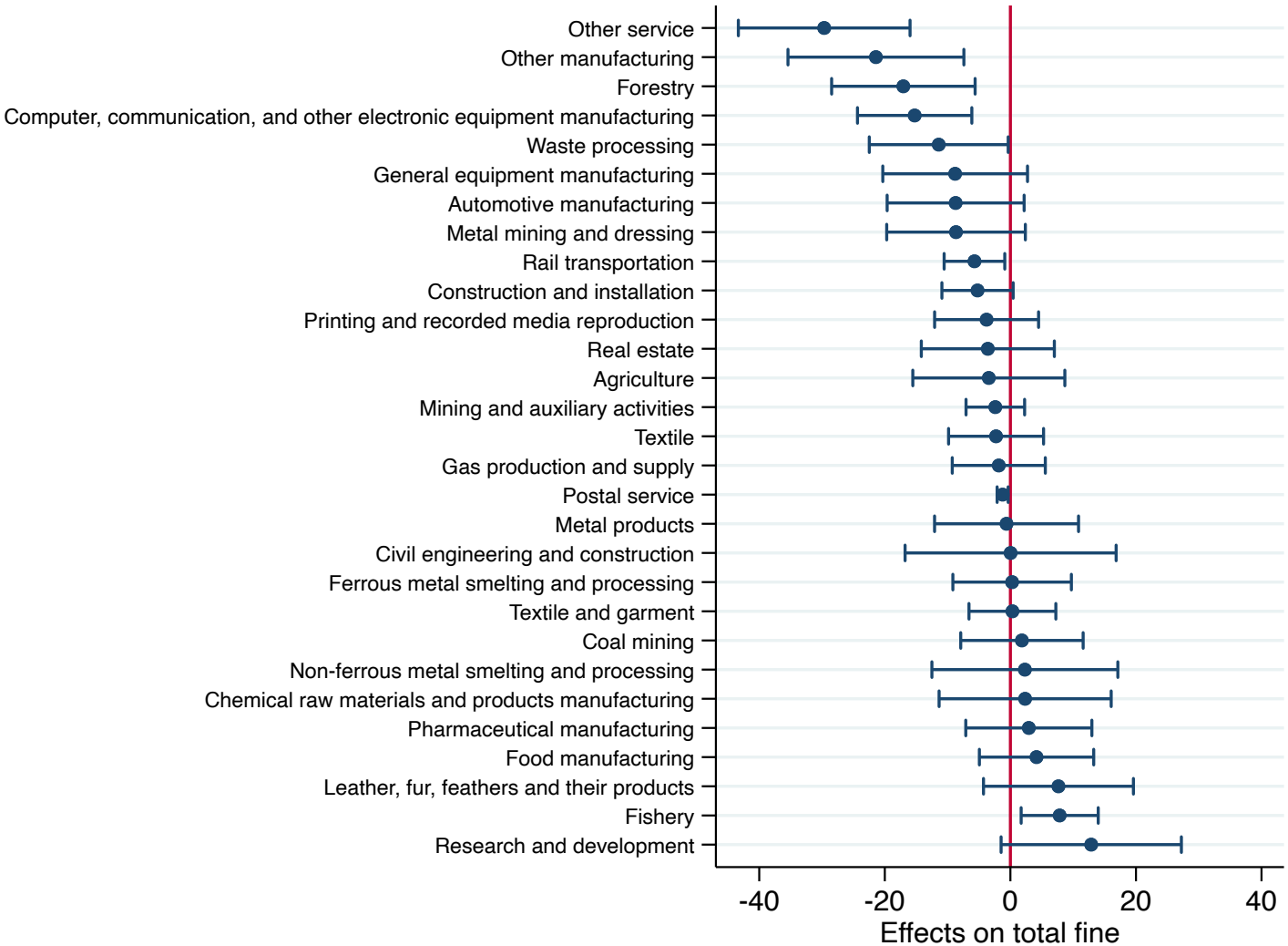
Effects on nightlight around CEMS firms

	Average light within 1km	Average light within 5km
Δ US Tariff	1.392	0.999
	(0.977)	(0.927)
Δ China Tariff	0.641	0.747*
	(0.436)	(0.388)
Observations	259416	259416
R-square	0.131	0.176
Y-mean	0.092	0.093
Y-sd	0.456	0.337
Firm FEs	Y	Y
Year-Month FEs	Y	Y

Notes: Sample period is 2017-2019. Standard errors are clustered at the city level.

Heterogeneity across industries

Reductions in environmental fines are higher in manufacturing sectors.



Note: This figure plots the estimated coefficients on $\Delta USTariff_{it}$ and 95% confidence intervals. We use the total fine of different industries as dependent variables.

Benchmark CEMS using satellite and city monitor

We test potential data manipulation in CEMS:

$$AOD_{it} = \beta_1 CEMS_{it} + \beta_2 CEMS_{it} \times Post_t + Firm_i + YearMonth_t + \varepsilon_{it}$$

- AOD_{it}: satellite data, aerosol optical depth (AOD) near CEMS firm i on day t.

  We also use the closest city monitor's PM_{10} and $PM_{2.5}$ as dependent variables.
- $CEMS_{it}$: CEMS data, particle emissions from firm i on day t
- $Post_t$: if t is between Jul 2018 and Dec 2019.
- β_1: if positive, CEMS and satellite data are correlated.
- β_2: if positive, more underreporting efforts after the trade war.

Benchmark CEMS using satellite and city monitor (con't)

Negative estimates on interaction terms suggest slightly lower underreporting efforts in CEMS data before the trade war:

	Satellite AOD	Citywide PM_{10}	Citywide $PM_{2.5}$
CEMS	0.070^{*}	0.029^{***}	0.014^{***}
	(0.037)	(0.007)	(0.005)
CEMS $\times$ Post	-0.139	-0.028^{*}	-0.014
	(0.090)	(0.015)	(0.011)
Observations	27983	26481	26406
R-square	0.662	0.750	0.745
Y-mean	626.941	72.864	40.816
Y-sd	208.329	32.779	20.668
Firm FEs	Y	Y	Y
Year-Month FEs	Y	Y	Y

Notes: Sample period is 2017-2019. Standard errors are clustered at the province-month level.

#7: Local officials' background

	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)	1.033***	3.107***	3.347***	0.466	1.265***
	(0.275)	(0.619)	(0.405)	(0.416)	(0.354)
Δln(USTariff)× Native Party	-0.475*	-3.492***	-3.252***	0.129	-0.760**
	(0.288)	(0.636)	(0.416)	(0.425)	(0.362)
Δln(USTariff)× Native Mayor	-1.672*	-0.715	2.432*	-1.599	-1.188
	(0.941)	(1.817)	(1.283)	(1.350)	(1.368)
Δln(CHNTariff)	-0.018	-0.380	0.323**	-0.578***	0.156
	(0.138)	(0.257)	(0.147)	(0.188)	(0.159)
Observations	44375	44375	44375	44375	44375
R-square	0.231	0.170	0.173	0.192	0.243
Y-mean	-0.047	-0.195	-0.027	-0.073	-0.062
Y-sd	0.218	0.403	0.269	0.293	0.270
Monitor FEs	Y	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y	Y

Notes: Standard errors are clustered at the monitor-month level.

Local officials' tenure length

	ΔAQI	ΔSO_2	ΔNO_2	$\Delta PM_{2.5}$	ΔPM_{10}
Δln(USTariff)	1.169***	0.103	2.450***	3.391***	0.572
	(0.448)	(1.051)	(0.675)	(0.655)	(0.566)
Δln(USTariff)$\times$ Tenure Party	-0.132	0.068	-0.471**	-0.896***	0.086
	(0.131)	(0.298)	(0.207)	(0.193)	(0.165)
Δln(CHNTariff)	-0.112	0.033	0.440***	-0.620***	-0.056
	(0.136)	(0.274)	(0.152)	(0.183)	(0.160)
Observations	45182	45182	45182	45182	45182
R-square	0.230	0.172	0.175	0.193	0.241
Y-mean	-0.047	-0.196	-0.027	-0.073	-0.063
Y-sd	0.218	0.404	0.270	0.292	0.270
Monitor FEs	Y	Y	Y	Y	Y
Year-Month FEs	Y	Y	Y	Y	Y

Notes: Standard errors are clustered at the monitor-month level.