Trade Policy Uncertainty, Offshoring, and the Environment: Evidence from US Manufacturing Establishments

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Trade and Global Value Chains in Times of Insecurity

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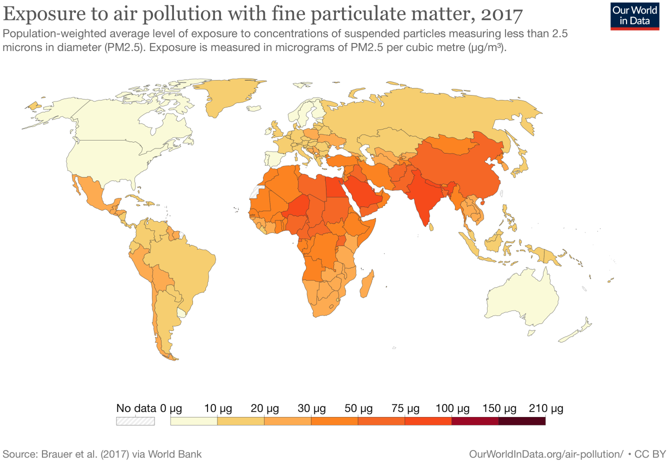
Introduction

Global divergence in pollution emissions in the 21st century (Copeland et al., 2021)

- Stark cross-sectional differences b/w high- vs. low- & middle-income countries



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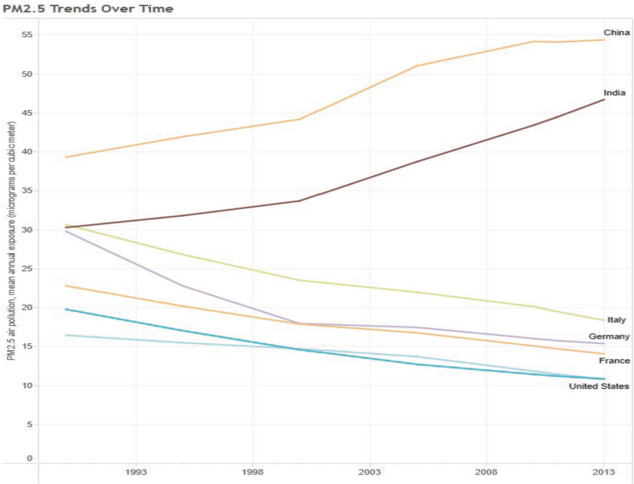
- Growth in global emissions over time driven by low- & middle-income countries



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Contemporaneously, a remarkable movement toward global integration

- Easier access to imported intermediate goods & better offshoring opportunities (Feenstra, 1998, Hummels et al., 2001)
- China's entry to the global trade

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Pollution haven/offshoring hypothesis provides a compelling explanation

- *Progress toward trade liberalization leads to relocation of high-polluting activities from developed to developing countries with laxer environmental regulations* (Copeland and Taylor, 2004, Copeland et al, 2022)
- Ample discussion in policy and media; Limited ***causal*** evidence

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Important aspect that has been often overlooked in empirical research on PHH/POH

- Offshoring is an *investment* decision (Bloom et al., 2007; Handley and Limao, 2015), influenced by institutional factors
- Possible cost advantages (factor price, tax, abatement cost) of offshoring become ambiguous under uncertainty in trading relationships

→ A *shock* generating variations in trade policy uncertainty (TPU) is needed

This Paper

We study long-run environmental consequences of trade liberalization ($\Downarrow$ TPU) in US manufacturing and explore mechanisms through which firms adjust

$\Rightarrow$ *A priori*, ambiguous impact on pollution emissions

- Increase in import competition in final goods market $\Rightarrow$ Emissions $\Uparrow$ & $\Downarrow$
- Easier access to purchase intermediate goods (or offshoring) $\Rightarrow$ Emissions $\Downarrow$

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1. Significant and persistent within-establishment declines in pollution emissions

2. More pronounced effects for establishments that,
   - face tough environmental regulations
   - operate in upstream industries
   - have within-firm global sourcing networks

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1. Significant and persistent within-establishment declines in pollution emissions
2. More pronounced effects for establishments that,
   - face tough environmental regulations
   - operate in upstream industries
   - have within-firm global sourcing networks
3. Strong evidence supporting the pollution offshoring hypothesis
   - Significant increase in relocation of high-polluting production to China;
   - Increase in imports of high-polluting products from China

Related Literature

Clean-up of US manufacturing

Copeland and Taylor 1994; Grossman and Krueger 1995; Levinson 2009; Shapiro and Walker 2018; Holladay and LaPlue III 2021

⇒ Use establishment-level data to examine the importance of international trade as adjustment channel

International trade and environmental outcomes

Holladay 2016; Cherniwchan 2017; Martin 2011; Gutiérrez and Teshima 2018; Bombardini and Li 2020; Rodrigue et al. 2020

Pollution haven/offshoring hypothesis

Greenstone 2002; List et al 2003; Levinson & Taylor 2008; Tanaka et al 2022; Bartram et al 2022 Eskeland & Harrison 03; Hanna 2010

⇒ Provide comprehensive & causal evidence of POH by leveraging rich data on establishment-level measures of offshoring and a trade policy uncertainty shock

Impact of the China trade shock on US economy

Autor et al. 2013; Pierce and Schott 2016; Choi and Xu 2020; Hyun et al. 2022; Kim 2022; Bloom et al. 2016; Autor et al. 2020; Che et al. 2016; Autor et al. 2020, Pierce and Schott 2020

⇒ First to establish causality on the environmental consequences

Outline

Data Sources

Toxics Release Inventory (TRI), 1987-2020

Initiated in 1986 after disastrous toxic chemical leaks (India and US)

US facilities required to report (EPCRA, Section 313)

1. TRI-listed-chemical-specific production waste ▸ Institutional Change
   - List of TRI-covered chemicals expand;
   - Reporting threshold criteria change
2. Descriptions on pollution prevention measures

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Establishment-chemical-year-level data on,

- ✓ $\text{Production Waste} = \text{Released} + \underbrace{\text{Recycled} + \text{Treated} + \text{Energy Recovery}}_{\text{Waste Managed}}$
- ✓ Measures to reduce pollutants at the source
  (e.g., substituting materials, modifying production methods)

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Our selection of chemicals (after extensive checks on institutional changes over 20 yrs)

(i) covered by the TRI program

(ii) with constant reporting criteria during 1997-2017

⇒ Primarily focus on PM_{10} Summary statistics

Data Sources

National Establishment Time Series (NETS)

- Establishment identifiers matched to TRI facilities
- Establishment Characteristics (employment, sales, industry, location, trade)

⇒ TRI-NETS matched establishments in manufacturing (1997-2017)

(i) top industries in pollution emissions: SIC 28, 33 ▸ shares ▸ trends

(ii) substantial variation in pollution emissions

Wharton Research Data Services (WRDS)

- Companies filing with the US SEC
- Subsidiary Data: Global parent and subsidiary information

International Trade Data

- Historical Tariff Rates of U.S. trading partners (Pierce and Schott, 2016)
- UNComtrade (US Imports from China and other countries)

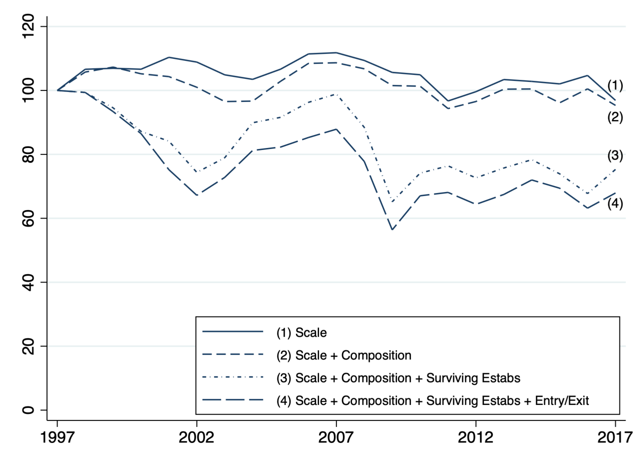
Stylized Facts

Decomposition Exercise

Fact 1

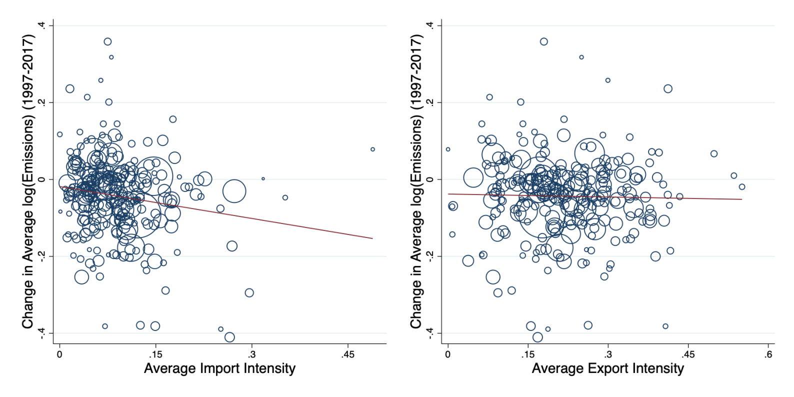
Scale + Composition + Surviving Establishments + Entry/Exit

Fact 2. Aggregate decline in emissions driven by surviving establishments



Stylized Facts

Fact 3. Within-establishment decreases pronounced in import-intensive industries



▸ Trade status divided by value added

Outline

Identification: Pierce and Schott (2016)

The US granted the Permanent Normal Trade Relations (PNTR) to China in 2001
$\rightarrow$ China's access to low NTR tariff rates applied to WTO members with certainty

- US set non-NTR rates to imports from non-market economies
- China gained access to NTR rates based on annual renewals by Congress

Magnitude of the shock,

$$NTR\ Gap_i = Non\ NTR\ Rate_i - NTR\ Rate_i$$

- $NTR\ Rate_i$: MFN tariff rate in industry i (average 4% in 1999)
- $Non\ NTR\ Rate_i$: Potential non-NTR rate in industry i (average 37% in 1999)

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✓ Higher $NTR\ Gap$ $\Longleftrightarrow$
Greater ⇓ of Trade Policy Uncertainty $\Longleftrightarrow$
Easier access to Chinese intermediate goods; Greater import competition from China

Variation in $NTR\ Gap$ is mainly driven by rates set in 1930 (Smoot-Hawley Tariff Act)
⇒ Good for identification

Research Design

Difference-in-Differences

- First difference: establishments in high versus low-NTR Gap industries
- Second difference: years before and after 2001 (post-PNTR of China)

Empirical Specification

Baseline

$$\mathrm{y}_{p,t} = \beta_0 + \beta_1 NTR\ Gap_i \times Post_t + \delta Z_i \times Post_t + \gamma X_{i,t} + \eta_p + \eta_{c,t} + \varepsilon_{p,t}$$

- $\mathrm{y}_{p,t}$: log of emissions from establishment p in industry i in year t
- $NTR\ Gap_i$: $Non\ NTR\ Rate_i - NTR\ Rate_i$
- $Post_t$: indicator for post-PNTR

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- $NTR\ Gap_i$: $Non\ NTR\ Rate_i - NTR\ Rate_i$
- $Post_t$: indicator for post-PNTR
- Controls: industry-specific time-invariant (Z_i) and time-varying ($X_{i,t}$) characteristics
  - Industry characteristics (capital-, skill-intensities, NTR rate)
  - Chinese trade policy (import tariffs, production subsidies)
- Establishment fixed effects, county-by-year fixed effects
- Standard errors two-way clustered at the industry and the county level

Empirical Specification

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Identifying assumption

Industries do not show differential trends in emissions in the pre-shock period
→ Assess parallel trends

Outline

Results: Baseline

✓ PNTR caused a within-establishment decrease in pollution emissions

	(1)	(2)	(3)	(4)
	Log(PM Emissions)			
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-1.161***	-1.049**	-1.031**	-1.191***
	(0.428)	(0.422)	(0.425)	(0.387)
$\text{NTR}_{i,t}$			-0.019	-0.008
			(0.034)	(0.036)
$\text{MFA Exposure}_{i,t}$			-0.011	-0.009
			(0.016)	(0.016)
$\text{Post}_t \times \text{Log}(\text{NP}_{i,95}/\text{Emp}_{i,95})$				0.305**
				(0.118)
$\text{Post}_t \times \text{Log}(\text{K}_{i,95}/\text{Emp}_{i,95})$				0.050
				(0.054)
$\text{Post}_t \times \Delta\text{Chinese Tariff}_i$				-0.740
				(0.459)
$\text{Post}_t \times \Delta\text{Chinese Subsidies}_i$				-33.097
				(27.109)
Establishment FE	✓	✓	✓	✓
Year FE	✓	-	-	-
County x Year FE	-	✓	✓	✓
Observations	46753	46753	46753	46753

▸ Results: Other Chemicals

Results: Dynamic Treatment Effects

$$y_{p,t} = \beta_0 + \sum_t \beta_t \mathbb{1}\{year = t\} \times NTR\,Gap_i + \sum_t \delta_t \mathbb{1}\{year = t\} \times Z_i + \gamma X_{i,t} + \eta_p + \eta_{c,t} + \varepsilon_{i,t}$$

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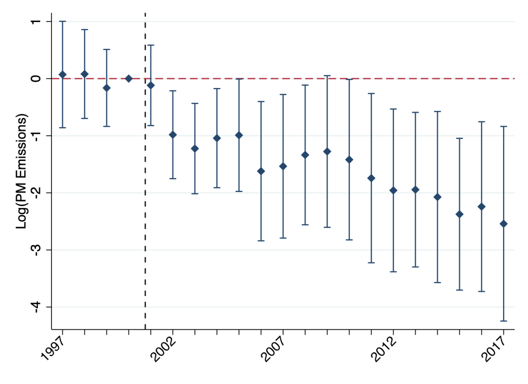
✓ PNTR caused a within-establishment decrease in pollution emissions

- No evidence of pre-existing trends; Persistent and increasingly negative effects



Robustness Exercises

- Control for NAFTA ▸ Results: DID ▸ Results: Dynamic
- Focus on different sample periods
▸ Results: DID ▸ Results: 1995-2017 ▸ Results: 1995-2006 ▸ Results: 1997-2006
- Exclude outliers ▸ Results: DID
- Exclude dominant industries (SIC 28, 33) ▸ Results: DID ▸ Trends ▸ Shares
- Apply various weighting schemes ▸ Results: DID
- and many others. ◂ Results

Results: Emission Intensity

✓ PNTR caused a within-establishment decrease in pollution emissions

- Is this driven by the extensive margin of establishment exits? No
  - (a) Continuing establishments ▸ Results
  - (b) Probability of establishment survivals doesn't respond to PNTR ▸ Results
- Is this driven by the intensive margin of establishments reducing production scale, or by a reduction in pollution emission intensity? Emission intensity!
  - (a) Emission Intensity ▸ Results

⇒ PNTR caused a within-establishment decrease in pollution emissions mainly through a decline in pollution emission intensity

▸ Employment Responses

Results: Heterogeneous Treatment Effects

✓ PNTR caused a within-establishment decrease in pollution emissions

- Any differential responses by establishment type? (⇒ Triple Diff-in-Diffs)
- Larger decline: (i) have higher import-intensity; (ii) face tough environmental regulations; (iii) operate in upstream industries; (iv) belong to multi-sector firms

	(1)	(2)	(3)	(4)	(5)	(6)
	Log(PM Emissions)					
$Post_t \times NTR\ Gap_{i,99}$	-0.221	-1.090***	0.350	-2.392	-1.252**	4.611
	(0.969)	(0.393)	(0.887)	(1.751)	(0.629)	(5.360)
$Post_t \times NTR\ Gap_{i,99} \times Import\ Intensity_{f,97}$	-4.452*					-10.944***
	(2.365)					(3.081)
$Post_t \times NTR\ Gap_{i,99} \times Nonattainment_{c,95-97}$		-2.316***				-3.995***
		(0.772)				(0.986)
$Post_t \times NTR\ Gap_{i,99} \times Upstream_{i,97}$			-2.187**			-3.172**
			(0.959)			(1.596)
$Post_t \times NTR\ Gap_{i,99} \times Log(Num.\ 4\text{-}digit\ Sectors_{f,97})$				-0.105		-2.934**
				(0.486)		(1.355)
$Post_t \times NTR\ Gap_{i,99} \times Export\ Intensity_{f,97}$					-0.454	-5.922
					(1.358)	(4.367)
Establishment FE	✓	✓	✓	✓	✓	✓
County x Year FE	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓
Observations	17373	37763	37701	37763	28347	15611

▸ Full Results ▸ Results: Emission Intensity ▸ Results: Environment Friendly Practices

Summary and Discussion

Main Results

PNTR caused a within-establishment decrease in pollution emissions

Disproportionately larger effects for establishments that,

(a) have within-firm global sourcing networks;
(b) operate in upstream industries;
(c) face tough environmental regulations;
(d) belong to multi-sector firms

Potential Mechanism

PNTR $\Longrightarrow$ Relocation (or offshoring) of high-polluting production to China?

✓ *Pollution Offshoring Hypothesis*

Outline

Mechanisms

Testing the Pollution Offshoring Hypothesis (POH)

Trade-induced *relocation of high-polluting production* from developed to developing countries with laxer environmental regulations (Copeland and Taylor, 2004, Copeland et al., 2022)

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Measurements

Challenges in constructing a comprehensive measure of relocating (or offshoring) production (Monarch et al. 2011)

✓ Relocation of Tasks

- Source task outputs from China
- Perform tasks through subsidiaries in China

✓ Relocation of *Dirty* Tasks

- Inferred from pre-shock pollution intensities of establishments/industries

Mechanisms: Sourcing from China

- ✓ PNTR caused a within-establishment increase in import activities
- ✓ Larger effects on establishments that initially
  - faced tough environmental regulations
  - engaged in dirty production (high emission intensity)

	(1) Import	(2) Import	(3) Import
$Post_t \times NTR\ Gap_{i,99}$	0.288**	0.154	1.183***
	(0.119)	(0.115)	(0.444)
$Post_t \times NTR\ Gap_{i,99} \times Nonattainment_{c,95-97}$		0.731***	
		(0.278)	
$Post_t \times NTR\ Gap_{i,99} \times Log(PM\ Emissions/Sales_{p,97})$			0.090**
			(0.040)
Establishment FE	✓	✓	✓
County x Year FE	✓	✓	✓
Controls	✓	✓	✓
Margin	Intensive	Intensive	Intensive
Observations	13760	13760	9164

▸ Results: Extensive Margin

Mechanisms: Subsidiaries (China)

✓ PNTR caused an increase in the number of subsidiaries in China

▸ China vs. Other Countries

✓ Larger effects on establishments that initially
- faced tough environmental regulations
- engaged in dirty production (high emission intensity)

	(1)	(2)
	Z = Num. Subsid. in China	
	I(Z> 0)	Log(Z)
$Post_t \times NTR\ Gap_{i,99}$	0.161	0.735
	(0.200)	(0.871)
$Post_t \times NTR\ Gap_{i,99} \times Nonattainment_{c,95-97}$	0.440	5.169***
	(0.461)	(1.102)
Establishment FE	✓	✓
County x Year FE	✓	✓
Controls	✓	✓
Observations	8346	3067
	(3)	(4)
	I(Z> 0)	Log(Z)
$Post_t \times NTR\ Gap_{i,99}$	0.872	12.871***
	(0.940)	(3.946)
$Post_t \times NTR\ Gap_{i,99} \times Log(PM\ Emissions/Sales_{p,97})$	0.057	0.938***
	(0.080)	(0.323)
Establishment FE	✓	✓
County x Year FE	✓	✓
Controls	✓	✓
Observations	4399	1372

Mechanisms

Testing the Pollution Offshoring Hypothesis (POH)

Trade-induced *relocation of high-polluting production* from developed to developing countries with laxer environmental regulations (Copeland and Taylor, 2004, Copeland et al., 2022)

✓ PNTR $\Longrightarrow$ Relocation (or offshoring) of high-polluting production to China!

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Do we observe consistent patterns at the aggregate level?

✓ PNTR $\Longrightarrow$ Increase in imports of high-polluting production from China?

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Measurements

✓ Imports

Product-level US imports from China and other trading partners

✓ Imports of *Dirty* Goods

Inferred from pre-shock pollution intensities of industries

Mechanisms: High-Polluting Product Imports (China)

✓ PNTR caused an increase in the share of imports from China

✓ Larger effects on products with initially high-pollution intensities

	(1)	(2)	(3)
	Share of US Imports from China		
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	0.092**	0.090**	0.048
	(0.043)	(0.040)	(0.052)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Log(PM EmissionsPM/Sales}_{i,97})$		0.074**	
		(0.036)	
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Upstream}_{i,97}$			0.078
			(0.069)
Product FE	✓	✓	✓
Year FE	✓	✓	✓
Controls	✓	✓	✓
Observations	198716	170020	197905

Other Mechanisms

Clean Technology Adoption

Clean-up of manufacturing (1987-2001) explained by technology adoption (Levinson, 2009)
Trade-induced technology adoption or innovation (Bloom et al. 2016)

✓ PNTR $\Longrightarrow$ Clean technology adoption?

Measurements

✓ Implementation of Pollution Prevention efforts More on P2

- material substitutions and modifications
- product modifications, process and equipment modifications

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Measurements

✓ Implementation of Pollution Prevention efforts ▸ More on P2

- material substitutions and modifications
- product modifications, process and equipment modifications

Results

✓ No significant effect on the PNTR-induced clean tech adoption ▸ Results

Outline

Conclusion

We study long-run environmental consequences of trade shocks in US manufacturing and explore mechanisms through which firms adjust

Using the US granting PNTR to China in early 2000s as a shock,

1. Significant and persistent within-establishment declines in pollution emissions

2. Strong evidence supporting the pollution offshoring hypothesis

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Implications of our work

- What happens to emissions in China? Can go either way.

- Concerning if improvements in environment in the US through the trade channel are at the expense of increasing pollution in other countries

- New waves of MFNs implementing ESG policies to subsidiaries, sourcing partners
⇒ Trade can contribute to bridging the cross-country gaps in emissions

Thank you!

Appendix

Changes in TRI Program

Time	Changes
Dec 1993	21 Chemicals and 2 Chemical Categories added
Nov 1994	286 Chemicals added
May 1997	Seven Industry Sectors (metal and coal mining facilities, electric power generators, commercial hazardous waste treatment operations, solvent recovery facilities, petroleum bulk terminals, and wholesale chemical distributors) added
Oct 1999	7 PBT Chemicals and 2 chemical categories added
Jan 2001	Lead and Lead Compounds designated as PBT chemicals
Dec 2006	TRI Burden Reduction Rule allowed the expansion of eligibility for using Form A
May 2007	TRI Dioxin Toxic Equivalency Rule
April 2009	Omnibus Appropriations Act restored the TRI reporting requirements that were effective before 2006
Nov 2010	National Toxicology Program Chemicals added
April 2012	Increasing Tribal Participation in the TRI Program
Nov 2015	1-Bromopropane added
Nov 2016	Hexabromocyclododecane (HBCD) Category added

Back

Summary Statistics

Establishment-Year Level						
Variable	Obs.	Mean	Std. Dev.	P10	P50	P90
PM $\text{Emissions}_{p,t}$ (lb)	46753	50838	450609	10	719	36605
NTR $\text{Gap}_{i,99}$	46753	0.294	0.119	0.138	0.304	0.424
$\text{NTR}_{i,t}$	46753	2.480	2.037	0.000	2.342	5.162
MFA $\text{Exposure}_{i,t}$	46753	0.098	1.493	0.000	0.000	0.000
$\text{NP}_{i,95}/\text{Emp}_{i,95}$	46753	0.281	0.096	0.176	0.259	0.435
$\text{K}_{i,95}/\text{Emp}_{i,95}$	46753	137	150	37	81	324
ΔChinese Tariff_i	46753	-0.097	0.083	-0.175	-0.077	-0.029
ΔChinese Subsidies_i	46753	-0.000	0.002	-0.002	-0.000	0.001
Import Intensity $(\text{Unconditional})_{f,97}$	37763	0.135	0.203	0.000	0.028	0.404
Import $\text{Intensity}_{f,97}$	17373	0.250	0.218	0.034	0.196	0.514
Export Intensity $(\text{Unconditional})_{f,97}$	37763	0.276	0.331	0.000	0.132	0.965
Export $\text{Intensity}_{f,97}$	28347	0.346	0.337	0.033	0.202	1.000
Firm $\text{Employment}_{f,97}$	37763	21655	76745	82	1870	41640
Num. $\text{Establishment}_{f,97}$	37763	164	472	1	19	402
Num. 4-digit $\text{Sectors}_{f,97}$	37763	24	37	1	8	73
$\text{Age}_{p,97}$	37763	57	42	9	52	110
PM $\text{Emissions}_{p,97}$	37763	59213	514114	0	254	38195
PM $\text{Emissions}_{p,97}/\text{Sales}_{p,97}$ (lb/million dollar)	37763	3145.4	38071.1	0.0	5.1	960.4
I(Num. $\text{P2}_{p,95-97}>0$)	37763	0.282	0.450	0	0	1
I(Num. P2 $\text{Clean-Tech}_{p,95-97}>0$)	37763	0.146	0.353	0	0	1
Establishment $\text{Employment}_{p,97}$	37763	477	1050	34	185	1000
Establishment $\text{Sales}_{p,97}$ (million dollar)	37763	113	286	4	29	239
CAA $\text{Nonattainment}_{c,95-97}$	37763	0.118	0.323	0	0	1

Back

Additional Summary Statistics

(A) Industry-Year Level						
Variable	Obs.	Mean	Std. Dev.	P10	P50	P90
NTR Gap$_{i,99}$	5008	0.319	0.131	0.138	0.336	0.450
NTR$_{i,t}$	5008	2.457	2.658	0.000	2.122	5.067
MFA Exposure$_{i,t}$	5008	0.432	3.349	0.000	0.000	0.000
(B) Industry Level						
Variable	Obs.	Mean	Std. Dev.	P10	P50	P90
NTR Gap$_{i,99}$	287	0.329	0.142	0.135	0.339	0.473
NP$_{i,95}$/Emp$_{i,95}$	287	0.295	0.115	0.173	0.266	0.452
K$_{i,95}$/Emp$_{i,95}$	287	94	102	27	60	218
ΔChinese Tariff$_i$	287	-0.122	0.105	-0.264	-0.092	-0.020
ΔChinese Subsidies$_i$	287	-0.000	0.002	-0.002	-0.000	0.001
(C) Firm Level: A Total of 3666 Unbalanced Firms						
Variable	Obs.	Mean	Std. Dev.	P10	P50	P90
Import Intensity (Unconditional)$_{f,97}$	2294	0.096	0.211	0.000	0.000	0.346
Import Intensity$_{f,97}$	703	0.289	0.275	0.029	0.200	0.762
Export Intensity (Unconditional)$_{f,97}$	2294	0.337	0.387	0.000	0.144	1.000
Export Intensity$_{f,97}$	1485	0.501	0.374	0.049	0.422	1.000
Firm Employment$_{f,97}$	2294	5566	70366	40	388	8636
Num. Establishment$_{f,97}$	2294	50	407	1	4	84
Num. 4-digit Sectors$_{f,97}$	2294	9	17	1	2	24
(D) Establishment Level: A Total of 4946 Unbalanced Establishments						
Variable	Obs.	Mean	Std. Dev.	P10	P50	P90
PM Emissions$_{p,97}$	3858	41262	472714	0	15	17422
PM Emissions$_{p,97}$/Sales$_{p,97}$ (lb/million dollar)	3858	2354.7	33172.9	0.0	0.6	577.9
I(Num. P2$_{p,95-97}$>0)	3858	0.260	0.439	0	0	1
I(Num. P2 Clean-Tech$_{p,95-97}$>0)	3858	0.130	0.336	0	0	1
Establishment Employment$_{p,97}$	3858	410	916	28	160	900
Establishment Sales$_{p,97}$	3858	91	245	4	25	189
Age$_{p,97}$	3858	55	42	9	50	109
(E) County Level						
Variable	Obs.	Mean	Std. Dev.	P10	P50	P90
CAA Nonattainment$_{c,95-97}$	841	0.045	0.208	0	0	0

Back

Additional Summary Statistics

Compare Final Sample with NETS Manufacturing

(A) Establishment Level (1997)								
	1. Final Sample				2. NETS (Manufacturing)			
Variable	Obs.	Mean	Std. Dev.	P50	Obs.	Mean	Std. Dev.	P50
Establishment Employment$_{p,97}$	3858	410	916	160	748519	31	174	5
Establishment Sales$_{p,97}$	3858	91	245	25	748519	5	47	0.4

(B) Firm Level (1997)								
	1. Final Sample				2. NETS (Manufacturing)			
Variable	Obs.	Mean	Std. Dev.	P50	Obs.	Mean	Std. Dev.	P50
Import Intensity (Unconditional)$_{f,97}$	2294	0.096	0.211	0.000	649439	0.008	0.086	0.000
Import Intensity$_{f,97}$	703	0.289	0.275	0.200	8496	0.648	0.387	0.857
Export Intensity (Unconditional)$_{f,97}$	2294	0.337	0.387	0.144	649439	0.079	0.262	0.000
Export Intensity$_{f,97}$	1485	0.501	0.374	0.422	58484	0.874	0.261	1.000
Firm Employment$_{f,97}$	2294	5566	70366	388	649439	74	4551	5
Num. Establishment$_{f,97}$	2294	50	407	4	649439	2	47	1
Num. 4-digit Sectors$_{f,97}$	2294	9	17	2	649439	1	2	1

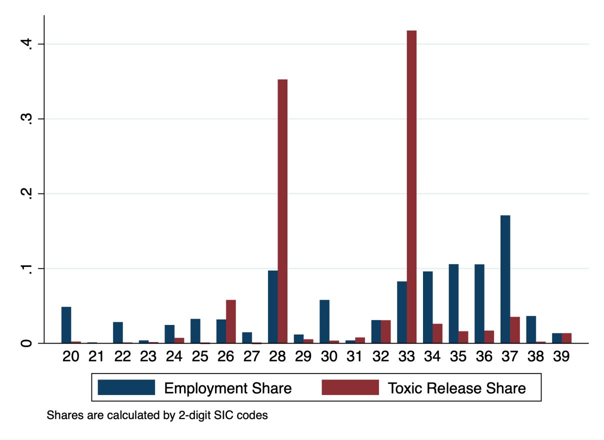
Back

Top and Bottom 5 Industries in PM_{10} Emissions

Top 5 Industries in PM_{10} Emissions		Bottom 5 Industries in PM_{10} Emissions	
3313	Electrometallurgical Products, except Steel	2254	Knit Underwear and Nightwear Mills
3321	Gray and Ductile Iron Foundries	2591	Household Furniture, N.E.C.
2816	Inorganic Pigments	2047	Dog and Cat Food
2819	Industrial Inorganic Chemicals, N.E.C.	3489	Ordnance and Accessories, N.E.C.
3312	Steel Works, Blast Furnaces, and Rolling Mills	2043	Cereal Breakfast Foods

Back

Employment and PM_{10} Emissions Shares by SIC Industry



Back: Sample | Back: Robustness | Back: Employment Responses

PM_{10} Emissions Trends

Back: Sample
Back: Robustness

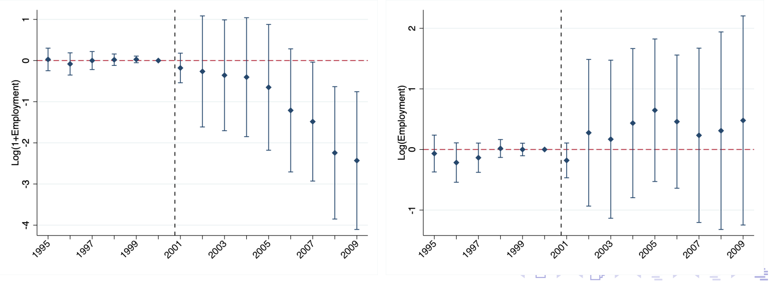
Results: PNTR and Employment Responses

✓ Results not driven by the selection of sample to those that satisfy the TRI-reporting criteria ▸ Back: Emission Intensity

- Establishments that satisfy TRI-reporting criteria (≥10 workers) exhibit employment decline w.r.t. PNTR in general.
- No employment effect once we restrict establishments to those with positive emissions in the initial period.

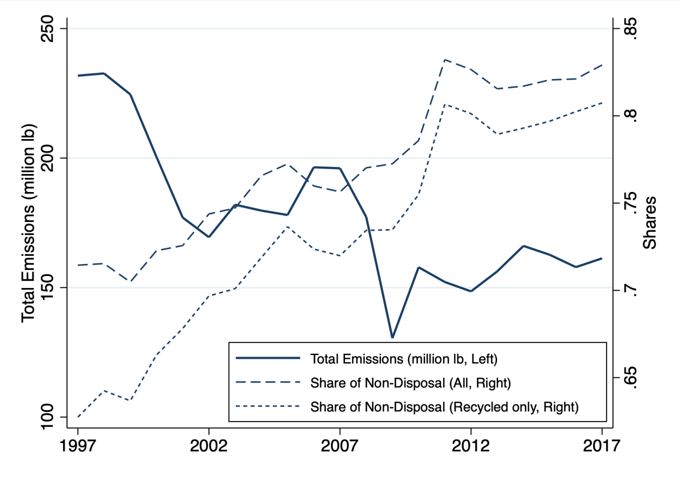
⇒ Establishments that generate positive emissions are fundamentally different from those with zero emission. ▸ Share of SIC 28, 33

Figure: Dynamic Treatment Effects of Employment at the Establishment Level:
(i) Full NETS-TRI Matched Establishments (Left);
(ii) NETS-TRI Matched Establishments with Positive Initial Emissions (Right)



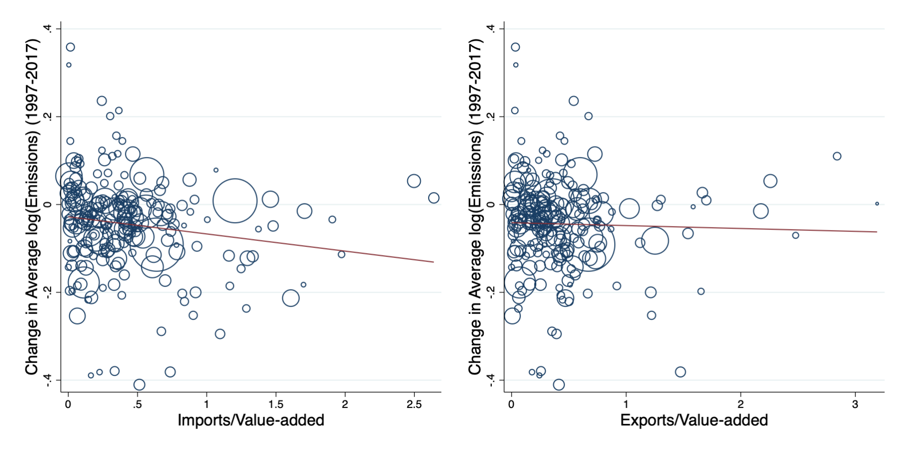
Stylized Facts

Fact 1. Aggregate decline in emissions with increased waste management efforts



Back

Stylized Fact 3 with Industry Trade Intensity



Back

Robustness Exercises

Control for NAFTA

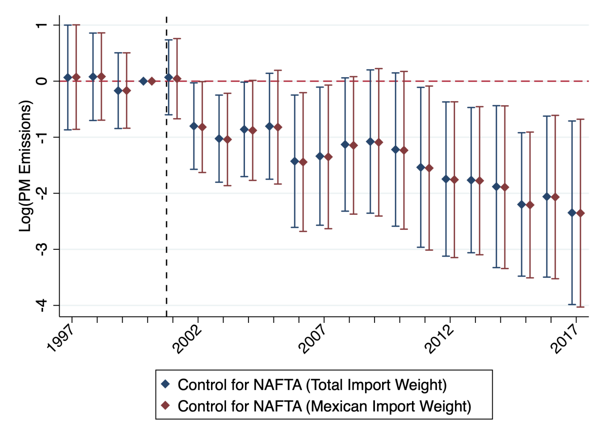
Back

	(1)	(2)
	Log(PM Emissions)	
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-1.016***	-1.024***
	(0.356)	(0.379)
$\text{NTR}_{i,t}$	-0.027	-0.026
	(0.036)	(0.035)
$\text{MFA Exposure}_{i,t}$	-0.003	-0.005
	(0.016)	(0.016)
$\text{Post}_t \times \text{Log}(\text{NP}_{i,95}/\text{Emp}_{i,95})$	0.235**	0.266**
	(0.115)	(0.116)
$\text{Post}_t \times \text{Log}(\text{K}_{i,95}/\text{Emp}_{i,95})$	0.080	0.073
	(0.055)	(0.057)
$\text{Post}_t \times \Delta\text{Chinese Tariff}_i$	-0.995**	-0.883*
	(0.469)	(0.463)
$\text{Post}_t \times \Delta\text{Chinese Subsidies}_i$	-31.365	-31.691
	(27.075)	(27.074)
$\text{Post}_t \times \Delta\text{NAFTA Tariff}_i$ (Tot.Imp.Wt)	5.205**	
	(2.537)	
$\text{Post}_t \times \Delta\text{NAFTA Tariff}_i$ (MEX.Imp.Wt)		3.074
		(2.191)
Establishment FE	✓	✓
County x Year FE	✓	✓
Observations	46644	46644

Robustness Exercises

Control for NAFTA

Back



Robustness Exercises

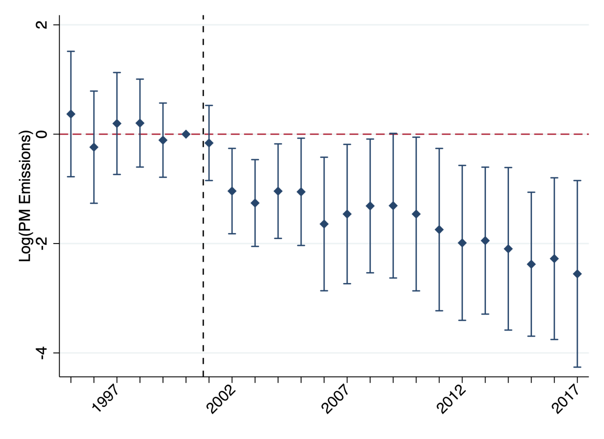
Alternative Sample Periods ◂ Back

	(1)	(2)	(3)	(4)
	Log(PM Emissions)			
$Post_t \times$NTR $Gap_{i,99}$	-1.321***	-0.979***	-1.092***	-1.222***
	(0.375)	(0.339)	(0.343)	(0.382)
$NTR_{i,t}$	-0.012	-0.014	-0.017	-0.008
	(0.030)	(0.033)	(0.030)	(0.036)
MFA $Exposure_{i,t}$	-0.005	-0.005	-0.003	-0.009
	(0.016)	(0.011)	(0.011)	(0.016)
$Post_t \times Log(NP_{i,95}/Emp_{i,95})$	0.314***	0.087	0.064	0.306***
	(0.110)	(0.121)	(0.116)	(0.114)
$Post_t \times Log(K_{i,95}/Emp_{i,95})$	0.043	0.027	0.023	0.043
	(0.058)	(0.042)	(0.048)	(0.052)
$Post_t \times \Delta$Chinese $Tariff_i$	-0.629	-0.552	-0.436	-0.756*
	(0.476)	(0.428)	(0.449)	(0.457)
$Post_t \times \Delta$Chinese $Subsidies_i$	-37.084	-10.981	-11.668	-29.125
	(30.062)	(22.370)	(24.058)	(27.151)
Establishment FE	✓	✓	✓	✓
County x Year FE	✓	✓	✓	✓
Period	95-17	97-06	95-06	97-17 (drop 07-09)
Observations	51187	23071	27498	39913

Robustness Exercises

Alternative Sample Periods

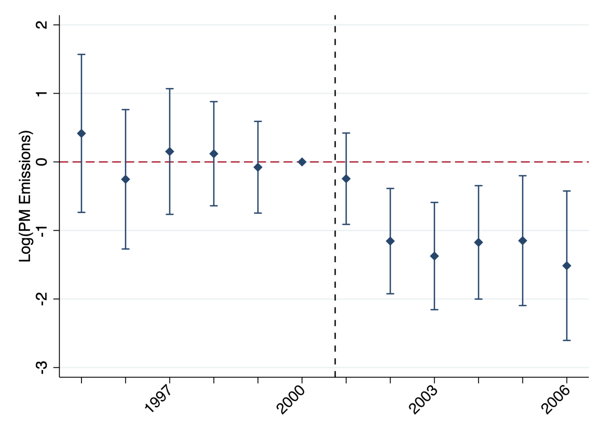
Back



Robustness Exercises

Alternative Sample Periods

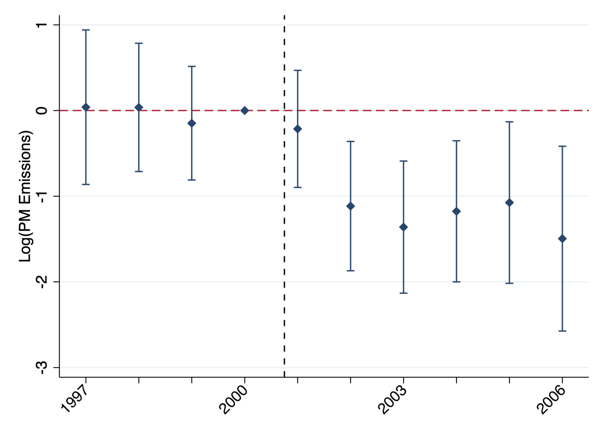
Back



Robustness Exercises

Alternative Sample Periods

Back



Robustness Exercises

Exclude Outliers

Back

	(1)	(2)	(3)
	Log(PM Emissions)		
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-1.152***	-1.044***	-1.102***
	(0.371)	(0.400)	(0.401)
$\text{NTR}_{i,t}$	0.012	0.008	-0.008
	(0.033)	(0.036)	(0.036)
$\text{MFA Exposure}_{i,t}$	-0.010	-0.009	-0.006
	(0.014)	(0.017)	(0.017)
$\text{Post}_t \times \text{Log}(\text{NP}_{i,95}/\text{Emp}_{i,95})$	0.222*	0.359***	0.294**
	(0.116)	(0.128)	(0.128)
$\text{Post}_t \times \text{Log}(\text{K}_{i,95}/\text{Emp}_{i,95})$	0.041	0.057	0.056
	(0.053)	(0.058)	(0.058)
$\text{Post}_t \times \Delta\text{Chinese Tariff}_i$	-0.489	-0.705	-0.915
	(0.498)	(0.584)	(0.573)
$\text{Post}_t \times \Delta\text{Chinese Subsidies}_i$	-45.713*	-32.888	-34.000
	(26.913)	(27.369)	(26.585)
Establishment FE	✓	✓	✓
County x Year FE	✓	✓	✓
Drop Extreme	Emissions	Firm Size	Estab. Size
Observations	43925	44012	44260

Robustness Exercises

Exclude SIC 28, 33 ◂ Back

	(1)	(2)
	Log(PM Emissions)	
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-3.379**	-1.334***
	(1.397)	(0.441)
$\text{NTR}_{i,t}$	-0.099	-0.017
	(0.146)	(0.039)
$\text{MFA Exposure}_{i,t}$	0.198	-0.019
	(0.475)	(0.015)
$\text{Post}_t \times \text{Log}(\text{NP}_{i,95}/\text{Emp}_{i,95})$	0.576***	0.116
	(0.191)	(0.150)
$\text{Post}_t \times \text{Log}(\text{K}_{i,95}/\text{Emp}_{i,95})$	0.161	0.010
	(0.204)	(0.066)
$\text{Post}_t \times \Delta\text{Chinese Tariff}_i$	-3.547*	-0.448
	(1.891)	(0.557)
$\text{Post}_t \times \Delta\text{Chinese Subsidies}_i$	45.575	-17.617
	(196.566)	(22.921)
Establishment FE	✓	✓
County x Year FE	✓	✓
Sample	SIC2: 28,33	SIC2: Others
Observations	9882	31414

Robustness Exercises

Apply Various Weighting Schemes

Back

	(1)	(2)	(3)
	Log(PM Emissions)		Log(Toxic-Wt. PM)
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-2.347***	-1.652***	-3.582**
	(0.558)	(0.589)	(1.566)
$\text{NTR}_{i,t}$	-0.047	-0.009	0.259**
	(0.063)	(0.064)	(0.105)
$\text{MFA Exposure}_{i,t}$	-0.054***	-0.012	-0.014
	(0.011)	(0.021)	(0.018)
$\text{Post}_t \times \text{Log}(\text{NP}_{i,95}/\text{Emp}_{i,95})$	0.670**	0.232	0.049
	(0.328)	(0.172)	(0.324)
$\text{Post}_t \times \text{Log}(\text{K}_{i,95}/\text{Emp}_{i,95})$	0.180*	0.064	0.197
	(0.104)	(0.081)	(0.169)
$\text{Post}_t \times \Delta\text{Chinese Tariff}_i$	-1.293	-0.836	2.170
	(1.135)	(0.534)	(2.025)
$\text{Post}_t \times \Delta\text{Chinese Subsidies}_i$	-99.705	-49.568	-134.935**
	(79.902)	(34.185)	(63.394)
Establishment FE	✓	✓	✓
County x Year FE	✓	✓	✓
Weights	Init. Release	Init. Employment	Init. Release
Observations	21783	37763	21573

Robustness Exercises

Control Upstream-Specific Time Trends

Back

	(1)	(2)	(3)	(4)
	Log(PM Emissions)			
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-1.232***	-1.245***	-1.221***	-1.407***
	(0.431)	(0.437)	(0.439)	(0.395)
$\text{NTR}_{i,t}$			-0.025	-0.012
			(0.035)	(0.036)
$\text{MFA Exposure}_{i,t}$			-0.015	-0.013
			(0.017)	(0.017)
$\text{Post}_t \times \text{Log}(\text{NP}_{i,95}/\text{Emp}_{i,95})$				0.281**
				(0.124)
$\text{Post}_t \times \text{Log}(\text{K}_{i,95}/\text{Emp}_{i,95})$				0.051
				(0.058)
$\text{Post}_t \times \Delta\text{Chinese Tariff}_i$				-0.600
				(0.512)
$\text{Post}_t \times \Delta\text{Chinese Subsidies}_i$				-46.052*
				(27.890)
Establishment FE	✓	✓	✓	✓
Year FE	✓	-	-	-
County x Year FE	-	✓	✓	✓
Upstream x Year FE	✓	✓	✓	✓
Observations	39219	37701	37701	37701

Robustness Exercises

Accommodate Obs. with Zero Emissions using PPML

Back

	(1)	(2)	(3)
		PM Emissions	
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-2.025**	-2.319***	-2.080***
	(0.830)	(0.701)	(0.753)
$\text{NTR}_{i,t}$	-0.317	-0.052	-0.029
	(0.200)	(0.049)	(0.041)
$\text{MFA Exposure}_{i,t}$	-0.009	-0.012	-0.031**
	(0.020)	(0.010)	(0.014)
$\text{Post}_t \times \text{Log}(\text{NP}_{i,95}/\text{Emp}_{i,95})$	-0.677	-0.016	0.474*
	(0.763)	(0.236)	(0.254)
$\text{Post}_t \times \text{Log}(\text{K}_{i,95}/\text{Emp}_{i,95})$	-0.105	0.048	0.024
	(0.125)	(0.090)	(0.090)
$\text{Post}_t \times \Delta\text{Chinese Tariff}_i$	-1.993	-1.349	-1.590
	(2.300)	(1.344)	(1.001)
$\text{Post}_t \times \Delta\text{Chinese Subsidies}_i$	-60.606	-64.132*	-73.524***
	(59.351)	(33.692)	(23.867)
Establishment FE	✓	✓	✓
County x Year FE	✓	✓	✓
Sample	All	Surviving Estab.	Emission>0
Observations	118258	94431	46753

Other Chemicals

Other Chemicals: SO2 and VOC

Back

	(1) Log(SO2 Emissions)	(2) Log(VOC Emissions)
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-0.388	-0.151
	(0.580)	(0.375)
$\text{NTR}_{i,t}$	0.010	0.008
	(0.025)	(0.036)
$\text{MFA Exposure}_{i,t}$	0.009	0.012
	(0.028)	(0.026)
$\text{Post}_t \times \text{Log}(\text{NP}_{i,95}/\text{Emp}_{i,95})$	-0.278	0.282**
	(0.187)	(0.140)
$\text{Post}_t \times \text{Log}(\text{K}_{i,95}/\text{Emp}_{i,95})$	-0.061	0.087
	(0.113)	(0.061)
$\text{Post}_t \times \Delta\text{Chinese Tariff}_i$	1.990	0.681
	(1.221)	(0.595)
$\text{Post}_t \times \Delta\text{Chinese Subsidies}_i$	46.444	-3.514
	(36.400)	(18.700)
Establishment FE	✓	✓
County x Year FE	✓	✓
Observations	10567	22036

Results: Continuing Establishments

Continuing Establishments

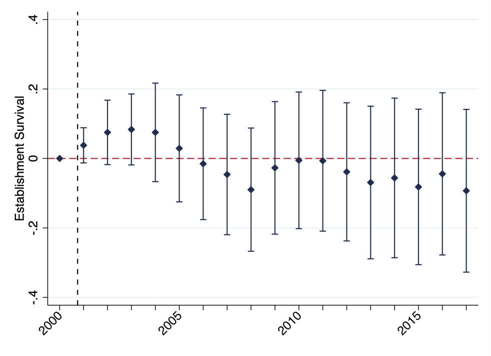
Back

	(1)	(2)	(3)	(4)
	Log(PM Emissions)			
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-1.430***	-1.478***	-1.440***	-1.569***
	(0.442)	(0.487)	(0.491)	(0.520)
$\text{NTR}_{i,t}$			-0.012	0.003
			(0.041)	(0.044)
$\text{MFA Exposure}_{i,t}$			-0.017	-0.015
			(0.019)	(0.019)
$\text{Post}_t \times \text{Log}(\text{NP}_{i,95}/\text{Emp}_{i,95})$				0.196
				(0.157)
$\text{Post}_t \times \text{Log}(\text{K}_{i,95}/\text{Emp}_{i,95})$				0.070
				(0.067)
$\text{Post}_t \times \Delta\text{Chinese Tariff}_i$				-0.342
				(0.574)
$\text{Post}_t \times \Delta\text{Chinese Subsidies}_i$				-49.783**
				(25.214)
Establishment FE	✓	✓	✓	✓
Year FE	✓	-	-	-
County x Year FE	-	✓	✓	✓
Observations	29049	29049	29049	29049

Results: Establishment Survival

✓ PNTR caused a within-establishment decrease in pollution emissions ▸ Back

- Is this driven by the extensive margin of establishment exits?
    - (b) Probability of establishment survivals doesn't respond to PNTR



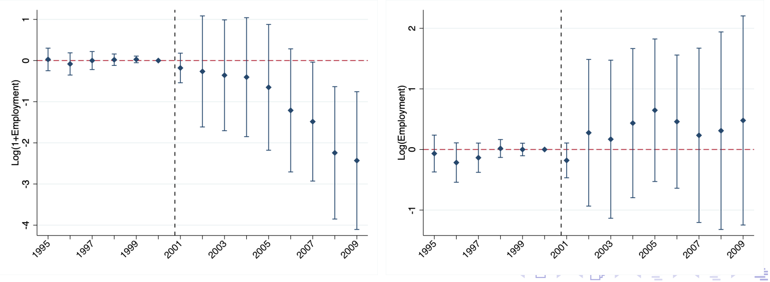
Results: PNTR and Employment Responses

✓ Results not driven by the selection of sample to those that satisfy the TRI-reporting criteria ▸ Back: Emission Intensity

- Establishments that satisfy TRI-reporting criteria ($\geq$10 workers) exhibit employment decline w.r.t. PNTR in general.
- No employment effect once we restrict establishments to those with positive emissions in the initial period.

⇒ Establishments that generate positive emissions are fundamentally different from those with zero emission. ▸ Share of SIC 28, 33

Figure: Dynamic Treatment Effects of Employment at the Establishment Level:
(i) Full NETS-TRI Matched Establishments (Left);
(ii) NETS-TRI Matched Establishments with Positive Initial Emissions (Right)



Results: Emission Intensity

✓ PNTR caused a within-establishment decrease in pollution emissions ▸ Back

- Is this driven by the intensive margin of firms reducing production scale?

	(1)	(2)	(3)	(4)
	Log(PM Emissions/Sales)			
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-1.743***	-1.621***	-1.595***	-1.635***
	(0.514)	(0.597)	(0.544)	(0.535)
$\text{NTR}_{i,t}$			0.013	0.041
			(0.042)	(0.045)
$\text{MFA Exposure}_{i,t}$			-0.010	-0.008
			(0.018)	(0.018)
$\text{Post}_t \times \text{Log}(\text{NP}_{i,95}/\text{Emp}_{i,95})$				0.312**
				(0.155)
$\text{Post}_t \times \text{Log}(\text{K}_{i,95}/\text{Emp}_{i,95})$				0.172***
				(0.062)
$\text{Post}_t \times \Delta\text{Chinese Tariff}_i$				-0.855
				(0.572)
$\text{Post}_t \times \Delta\text{Chinese Subsidies}_i$				-74.688**
				(30.637)
Establishment FE	✓	✓	✓	✓
Year FE	✓	-	-	-
County x Year FE	-	✓	✓	✓
Observations	46751	46751	46751	46751

Heterogeneous Treatment Effects

Back

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Log(PM Emissions)									
$Post_t \times NTR\ Gap_{i,99}$	-0.221	-1.090***	0.350	-2.392	-1.252**	-1.588**	-1.986	-1.274*	-1.664***	4.611
	(0.969)	(0.393)	(0.887)	(1.751)	(0.629)	(0.676)	(1.340)	(0.688)	(0.421)	(5.360)
$Post_t \times NTR\ Gap_{i,99}$ $\times Import\ Intensity_{f,97}$	-4.452*									-10.944***
	(2.365)									(3.081)
$Post_t \times NTR\ Gap_{i,99}$ $\times Nonattainment_{c,95-97}$		-2.316***								-3.995***
		(0.772)								(0.986)
$Post_t \times NTR\ Gap_{i,99}$ $\times Upstream_{i,97}$			-2.187**							-3.172**
			(0.959)							(1.596)
$Post_t \times NTR\ Gap_{i,99}$ $\times Log(Num.\ 4\text{-}digit\ Sectors_{f,97})$				-0.105						-2.934**
				(0.486)						(1.355)
$Post_t \times NTR\ Gap_{i,99}$ $\times Export\ Intensity_{f,97}$					-0.454					-5.922
					(1.358)					(4.367)
$Post_t \times NTR\ Gap_{i,99}$ $\times Log(Num.\ Establishment_{f,97})$						0.057				0.397
						(0.179)				(1.125)
$Post_t \times NTR\ Gap_{i,99}$ $\times Log(Firm\ Employment_{f,97})$							0.076			0.786
							(0.170)			(0.860)
$Post_t \times NTR\ Gap_{i,99}$ $\times Age_{p,97}$								-0.002		0.007
								(0.009)		(0.010)
$Post_t \times NTR\ Gap_{i,99}$ $\times I(Num.\ P2_{p,95-97} > 0)$									0.532	0.977
									(0.663)	(0.952)
Establishment FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
County x Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	17373	37763	37701	37763	28347	37763	37763	37763	37763	15611

Heterogeneous Treatment Effects: Log(PM Emissions/Sales)

Back

	(1) Log(PM Emissions/Sales)
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-0.895
	(7.233)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Import Intensity}_{f,97}$	-14.448^{***}
	(4.649)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Nonattainment}_{c,95-97}$	-3.801^{**}
	(1.706)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Upstream}_{i,97}$	-3.841^{*}
	(2.301)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Log(Num. 4-digit Sectors}_{f,97})$	-2.801
	(2.127)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Export Intensity}_{f,97}$	-6.305
	(5.472)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Log(Num. Establishment}_{f,97})$	-1.289
	(1.509)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Log(Firm Employment}_{f,97})$	2.271^{*}
	(1.207)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Age}_{p,97}$	-0.001
	(0.013)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{I(Num. P2}_{p,95-97} > 0)$	2.434^{**}
	(1.162)
Establishment FE	✓
County x Year FE	✓
Controls	✓
Observations	15611

Heterogeneous Treatment Effects

	(1) Log(PM Emissions)
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-1.147***
	(0.427)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Import Intensity (Unconditional)}_{f,97}$	-1.732
	(1.767)
Establishment FE	✓
County x Year FE	✓
Controls	✓
Observations	37763

Other Mechanisms: Environment-Friendly Practices

PNTR ⇒ Environment-Friendly Practices?

✓ Increase in waste management for those with within-firm global sourcing networks

✓ Possible complementarity effects with offshoring

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Log(Off-Site Non-Disposal of PM)						
$Post_t \times NTR\ Gap_{i,99}$	-0.136	-2.571	-0.129	-1.559	0.139	-0.244	16.563
	(0.720)	(2.029)	(0.682)	(0.999)	(3.837)	(1.194)	(10.278)
$Post_t \times NTR\ Gap_{i,99} \times Import\ Intensity_{f,97}$		10.484^{**}					14.160^{**}
		(5.106)					(6.850)
$Post_t \times NTR\ Gap_{i,99} \times Nonattainment_{c,95-97}$			1.003				2.778
			(2.039)				(3.099)
$Post_t \times NTR\ Gap_{i,99} \times Upstream_{i,97}$				2.143			-1.696
				(1.348)			(2.704)
$Post_t \times NTR\ Gap_{i,99} \times Log(Num.\ 4\text{-}digit\ Sectors_{f,97})$					0.136		4.180^{*}
					(0.697)		(2.171)
$Post_t \times NTR\ Gap_{i,99} \times Export\ Intensity_{f,97}$						0.398	6.454
						(2.067)	(6.732)
Establishment FE	✓	✓	✓	✓	✓	✓	✓
County x Year FE	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓
Observations	26301	8949	20928	20892	20928	15787	7992

▸ Heterogeneity Results

Mechanisms: Sourcing from China

Extensive vs. Intensive Margins of Trade Status Main

	(1) Import	(2) Export	(3) Export
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-0.027	-0.022	-0.028
	(0.131)	(0.170)	(0.085)
Establishment FE	✓	✓	✓
County x Year FE	✓	✓	✓
Controls	✓	✓	✓
Margin	Extensive	Extensive	Intensive
Observations	15525	8206	20189

Mechanisms: Subsidiaries (China vs. Others)

✓ PNTR caused an within-establishment increase in the available within-firm number of subsidiaries in China (not in other countries)

	(1)	(2)	(3)	(4)
	Z = Num. Subsid. in China			
	I(Z> 0)		Log(Z)	
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	0.265	0.188	1.073*	1.173
	(0.260)	(0.193)	(0.611)	(0.920)
Establishment FE	✓	✓	✓	✓
County FE	✓	-	✓	-
Year FE	✓	-	✓	-
County x Year FE	-	✓	-	✓
Controls	✓	✓	✓	✓
Observations	12608	8346	6384	3067
	(5)	(6)	(7)	(8)
	Z = Num. Subsid. in Other			
	I(Z> 0)		Log(Z)	
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	0.126	0.090	-0.124	-0.005
	(0.215)	(0.148)	(0.682)	(0.654)
Establishment FE	✓	✓	✓	✓
County FE	✓	-	✓	-
Year FE	✓	-	✓	-
County x Year FE	-	✓	-	✓
Controls	✓	✓	✓	✓
Observations	12608	8346	11442	7298

Back

Results: Overall Pollution Prevention

✓ We do not find support for the PNTR-induced clean tech adoption ◂ Main

	(1)	(2)
	Z = Num. P2	
	I(Z> 0)	Log(Z)
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-0.118	-0.047
	(0.080)	(0.481)
$\text{NTR}_{i,t}$	-0.009	-0.014
	(0.006)	(0.025)
$\text{MFA Exposure}_{i,t}$	0.005**	0.027***
	(0.002)	(0.006)
$\text{Post}_t \times \text{Log}(\text{NP}_{i,95}/\text{Emp}_{i,95})$	-0.019	-0.138
	(0.028)	(0.107)
$\text{Post}_t \times \text{Log}(\text{K}_{i,95}/\text{Emp}_{i,95})$	-0.028**	0.005
	(0.011)	(0.068)
$\text{Post}_t \times \Delta\text{Chinese Tariff}_i$	0.069	0.103
	(0.091)	(0.768)
$\text{Post}_t \times \Delta\text{Chinese Subsidies}_i$	1.033	-11.791
	(4.241)	(21.659)
Establishment FE	✓	✓
County x Year FE	✓	✓
Observations	46753	2727

Heterogeneous Treatment Effects: Log of Off-Site Non-Disposal

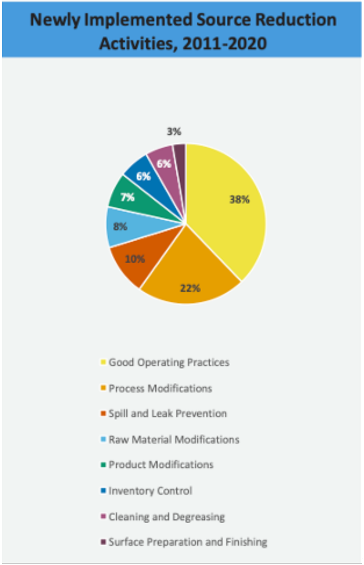
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Log(Off-Site Non-Disposal of PM)										
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	-0.136	-2.571	-0.129	-1.559	0.139	-0.244	-0.003	-0.232	-0.815	0.349	16.563
	(0.720)	(2.029)	(0.682)	(0.999)	(3.837)	(1.194)	(1.164)	(2.644)	(1.304)	(1.018)	(10.278)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Import Intensity}_{f,97}$		10.484**									14.160**
		(5.106)									(6.850)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Nonattainment}_{c,95-97}$			1.003								2.778
			(2.039)								(3.099)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Upstream}_{i,97}$				2.143							-1.696
				(1.348)							(2.704)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Log(Num. 4-digit Sectors}_{f,97})$					0.136						4.180*
					(0.697)						(2.171)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Export Intensity}_{f,97}$						0.398					6.454
						(2.067)					(6.732)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Log(Num. Establishment}_{f,97})$							-0.001				1.286
							(0.296)				(2.009)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Log(Firm Employment}_{f,97})$								0.028			-4.346***
								(0.327)			(1.553)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Age}_{p,97}$									0.013		0.030
									(0.016)		(0.026)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{I(Num. P2}_{p,95-97} > 0)$										-1.044	-1.387
										(1.453)	(1.851)
Establishment FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
County x Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	26301	8949	20928	20892	20928	15787	20928	20928	20928	20928	7992

Heterogeneous Treatment Effects: Log of On-Site Non-Disposal

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Log(On-Site Non-Disposal of PM)										
$\text{Post}_t \times \text{NTR Gap}_{i,99}$	1.284	-1.716	2.602*	12.451	2.596	0.946	1.551	2.675	3.730	-0.689	-80.852***
	(1.137)	(2.999)	(1.526)	(14.238)	(4.424)	(1.887)	(2.471)	(4.545)	(2.336)	(1.894)	(23.823)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Import Intensity}_{f,97}$		3.443									-15.593
		(8.827)									(13.842)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Nonattainment}_{c,95-97}$			-3.353*								1.205
			(1.934)								(2.949)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Upstream}_{i,97}$				-11.153							30.158**
				(14.343)							(12.293)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Log(Num. 4-digit Sectors}_{f,97})$					-0.419						5.085
					(1.291)						(4.501)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Export Intensity}_{f,97}$						-0.801					-11.867
						(4.664)					(9.257)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Log(Num. Establishment}_{f,97})$							-0.098				-24.475***
							(0.912)				(3.768)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Log(Firm Employment}_{f,97})$								-0.172			16.423***
								(0.651)			(3.790)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{Age}_{p,97}$									-0.054		-0.097*
									(0.044)		(0.057)
$\text{Post}_t \times \text{NTR Gap}_{i,99} \times \text{I(Num. P2}_{p,95-97} > 0)$										4.100	12.221***
										(2.654)	(3.126)
Establishment FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
County x Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	2754	1032	2358	2345	2358	1559	2358	2358	2358	2358	819

Pollution Prevention

◂ Main



Other Mechanisms: Clean Technology Adoption

PNTR ⇒ Clean-tech-related Pollution Prevention? ▸ All Pollution Prevention ▸ Main

✓ No significant effect on the PNTR-induced clean tech adoption

	(1)	(2)
	Z = Num. P2 Clean-Tech	
	I(Z> 0)	Log(Z)
$Post_t \times NTR\ Gap_{i,99}$	-0.060	0.453
	(0.071)	(0.518)
$NTR_{i,t}$	-0.011**	0.002
	(0.005)	(0.019)
$MFA\ Exposure_{i,t}$	-0.000	-0.003
	(0.004)	(0.003)
$Post_t \times Log(NP_{i,95}/Emp_{i,95})$	-0.041**	0.078
	(0.019)	(0.188)
$Post_t \times Log(K_{i,95}/Emp_{i,95})$	-0.020*	0.128*
	(0.010)	(0.066)
$Post_t \times \Delta Chinese\ Tariff_i$	0.117*	-0.026
	(0.068)	(0.881)
$Post_t \times \Delta Chinese\ Subsidies_i$	-2.386	-17.978
	(2.917)	(36.547)
Establishment FE	✓	✓
County x Year FE	✓	✓
Observations	46753	605