Lesson 5: Trade and Environment

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Motivation

- **Economic development is associated with an increased energy consumption** which generates carbon dioxide (CO2) emissions;
- How does international trade affects the environment?
- Do the effects are similar for developed and developing countries?
- Which are the micro-economic effects of trade reforms on the environment?
- Does trade liberalization increases pollution or reduces firms' CO2 emissions?

Motivation

- Trade reforms in developing countries have been blamed for exacerbating pollution by having them
- produce dirtier goods for advanced economies with stronger environmental regulations.
- However, trade also offers opportunities for firms to adopt 'cleaner' production processes.

Motivation

- **Aggregate studies** focus on trade and aggregate pollution levels based on cross-country variation in pollution levels and trade flows;
- these studies find that trade is not necessarily bad for the environment
- Antweiler et al., 2001, or Frankel and Rose, 2005.

Conceptual framework

- Reducing the quantity of energy needed to produce a given output is a source of reduction in CO2 emissions.
- Firms' incentives to reduce energy intensities due to **lower production costs** (with lower energy spending).
- Firms may, however, not reduce energy intensities if they have no access (or only costly access) to cleaner production technologies.
- Which are the different channels through which trade liberalization affects firms' energy efficiency and CO2 emissions?

Conceptual framework

- Which are the different channels through which trade liberalization affects firms' energy efficiency and CO2 emissions?

- **Firms may adopt cleaner technologies thanks to international trade due to**

  - **Foreign competition**,
  - **Market access**,
  - **Access to foreign technology:**
    1. High-quality inputs from abroad;
    2. Larger varieties of inputs (Ethier,1982, and indirect evidence reported by Imbruno and Ketterer, 2018);
    3. Imported machinery (more recent vintages of global production technologies).

Related literature

Trade and firms' environmental performance

- Forslid et al. (2018), Richter and Schiersch (2017) : exporting firms are cleaner than non-exporters,
- Barrows and Ollivier (2021), Cherniwchan (2017), Gutierrez and Teshima (2018) : focus on the market access and foreign competition channels affecting firms' emission intensity,

Access to foreign inputs and energy intensity

- Imbruno and Ketterer (2018) investigate the effect of first time importers of inputs on energy efficiency,
- Martin (2011) studies how tariff reductions impact firms' fuel efficiency in India,

Trade and firms' environmental performance

Cherniwchan (2017), Trade liberalization and the environment: Evidence from NAFTA and U.S. manufacturing, Journal of International Economics.

- **Aim:**

- Study the effects of NAFTA on the **emissions of particulate matter (PM10) and sulfur dioxide (SO2)** from manufacturing plants in the United States.

Main findings

- **Trade liberalization led to significant reductions of pollution of affected plants**
- On average, nearly two-thirds of the reductions in PM10 and SO2 emissions from the U.S. manufacturing sector between 1994 and 1998 can be attributed to trade liberalization following NAFTA.
- **Main channels:** (i) increased access to the Mexican market, and (ii) increased access to imported intermediate inputs from Mexico.

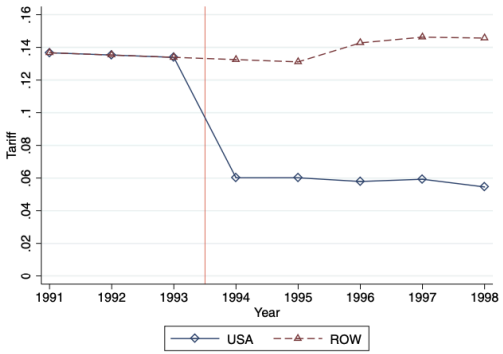
The effects of the NAFTA on environment

- Grossman and Krueger (1991) find that Mexico would not necessarily become a pollution haven following the agreement.
- Cole (2004) and Gamper Rabindran (2006) investigate NAFTA's effect on the environment looking at changes in trade flows from clean and dirty industries rather than examining changes in emissions from production directly.
- Davis and Kahn (2010) examine the effects of NAFTA on the pollution from consumption.
- **Contribution:** first study to present micro-evidence on the effects of the NAFTA on firms' pollution emissions.

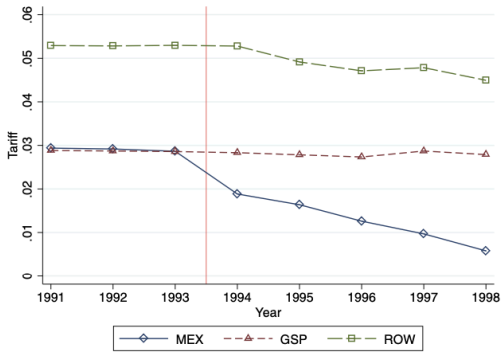
Identification strategy

- **Identification strategy:** exogenous tariff changes when US join NAFTA in the 1990s to identify the causal effects of trade on CO2 emissions
- **Two unique longitudinal datasets** on plant level pollution.
- **Exogeneity of tariffs** industry-level tariff variations over the period unrelated to initial firm / industry characteristics.

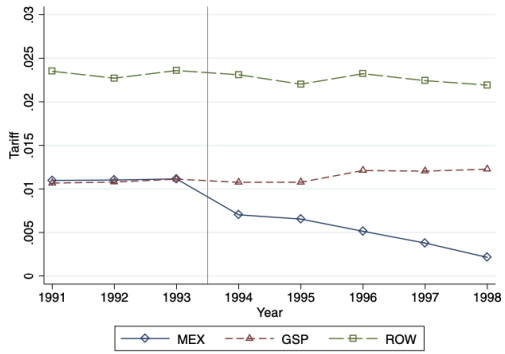
Empirical Motivation



(a) Mexico's Tariffs on Final Goods



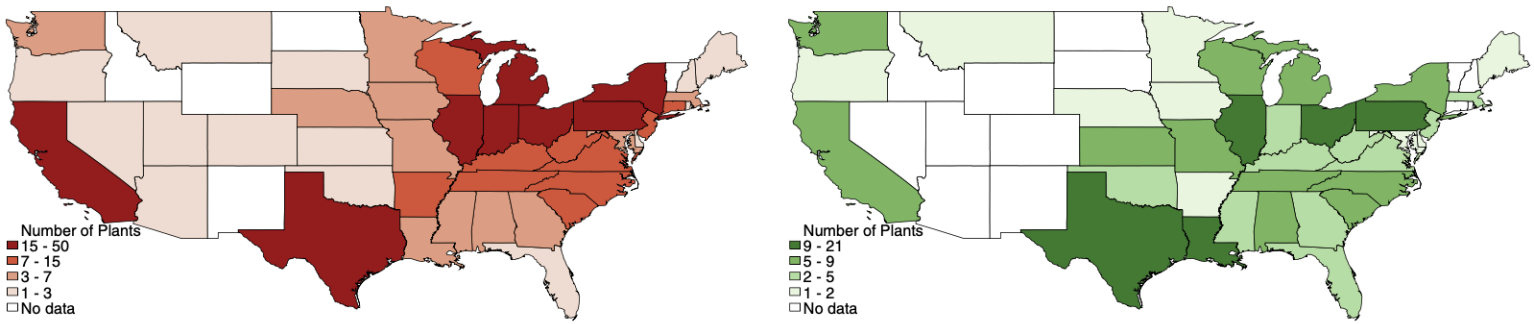
(b) U.S. Tariffs on Final Goods



(c) U.S. Tariffs on Intermediate Inputs

Empirical Motivation

J. Cherniwchan / Journal of International Economics 105 (2017) 130–149



(a) PM_{10} (b) SO_2

Fig. 1. Plant locations.

Data

Two unique longitudinal datasets

1. (1) The Toxic Release Inventory and
2. (2) the National Establishment Time Series.
3. Each dataset contains information on the emissions of a common pollutant (either particulate matter or sulfur dioxide) and other characteristics of U.S. manufacturing plants that were in operation during the 1991 to 1998 period.

Disentangling the channels: data on tariffs

- **Output Tariff data:** MFN applied tariff by the US to Mexico at the industry level .
- **Input-Tariffs**: weighted average of output tariffs using IO tables to compute the input weights.
- **Export-Tariffs**: tariffs applied by Mexico to the US products at the industry level.

Disentangling the channels: data on tariffs

- Computing tariff preferences during the NAFTA as differences between the MFN tariff applied to the ROW and the preferential tariff in the trade agreement:

- (1) Mexican tariff preferences for U.S. imports $\rightarrow$ **Foreign competition channel**

$$\tau_{jt,MEX} = t_{jt,MEX,ROW} - t_{jt,MEX,US}$$

- (2) Mexican input tariff preferences for U.S. imports $\rightarrow$ **Imported input channel**

$$\tau_{jt,Int} = t_{jt,Int,MEX,ROW} - t_{jt,Int,MEX,US}$$

- (3) U.S. tariff preferences for Mexicain imports $\rightarrow$ **Market access channel**

$$\tau_{jt,US} = t_{jt,US,ROW} - t_{jt,US,MEX}$$

Identification strategy

Triple difference in difference:

1. exploiting temporal and cross-industry variation due to changes in U.S. and Mexican trade policy,

2. and variation due to differences in geographically determined trade frictions arising from the dispersion of manufacturing activity across the U.S. prior to NAFTA.

Identification strategy

1. Construct a measure of **state-specific trade frictions** associated with bilateral trade between state "s" and Mexico (HRI),
2. using the most disaggregate trade data available: state-level data on bilateral trade with Mexico.
3. The HRI measures all trade costs associated with shipping goods between state s and Mexico.

$$\ln z_{ijst} = \beta_1 \left[\tau_{jt}^{Mex} \times \Phi_s \right] + \beta_2 \left[\tau_{jt}^{US} \times \Phi_s \right] + \beta_3 \left[\tau_{jt}^{Int} \times \Phi_s \right] + \rho_i + \mu_{jt} + \delta_{st} + \varepsilon_{ijst}$$

Identification strategy

1. lnz is the natural log of pollution emissions from plant i in industry j in state s in year t,
2. Output, input and export tariffs for industry j in year t interacted with the HRI index capturing state-specific trade frictions,
3. Plant fixed effect
4. Industry-year and state-year fixed effects

Identification strategy

1. β_1 measures the average percentage change in pollution emissions for plants that experience an increase in **access to the Mexican market**

2. β_2 measures the average percentage change in pollution from plants that experience an **increase in Mexican competition**

3. β_3 the average percentage change in pollution from plants that experience a **decrease in the cost of obtaining intermediate inputs from Mexico**

The role of environmental regulations

- **Omitted variable bias:**
- One concern is that estimates are simply capturing the effects of on-going revisions to environmental policy.
- Allow the effects of environmental regulation to vary across plants on the basis of how long they have been regulated.
- All estimations include an **indicator is equal to one if the plant is located in county that has stricter environmental regulations**.

Results: Trade and pollution I

NAFTA and pollution emissions.

	(1)	(2)	(3)	(4)	(5)
Panel A: Particulate Matter (PM_{10})					
$\mathcal{T}_{jt}^{Mex} \times \Phi_s$	-1.267^b	-1.403^b	-1.175^b	-1.268^b	-1.298^b
	(0.541)	(0.559)	(0.548)	(0.540)	(0.566)
$\mathcal{T}_{jt}^{US} \times \Phi_s$	1.141	1.020	1.286	1.139	1.169
	(2.064)	(2.069)	(2.113)	(2.065)	(2.116)
$\mathcal{T}_{jt}^{Int} \times \Phi_s$	−3.352	−3.227	−3.381	−3.349	−3.247
	(3.842)	(3.889)	(3.897)	(3.847)	(3.944)
Peso Crisis		X			X
CUSFTA			X		X
1990 CAAAs				X	X
Observations	4162	4162	4162	4162	4162
Adjusted R^2	0.19	0.19	0.20	0.19	0.20
Panel B: Sulfur Dioxide (SO_2)					
$\mathcal{T}_{jt}^{Mex} \times \Phi_s$	-1.457^c	-1.492^c	-1.429^c	-1.452^b	-1.459^c
	(0.742)	(0.759)	(0.738)	(0.733)	(0.746)
$\mathcal{T}_{jt}^{US} \times \Phi_s$	−3.792	−3.845	−3.918	−3.695	−3.871
	(3.180)	(3.182)	(3.184)	(3.142)	(3.150)
$\mathcal{T}_{jt}^{Int} \times \Phi_s$	-13.143^a	-13.118^a	-13.174^a	-13.177^a	-13.185^a
	(5.033)	(5.031)	(5.035)	(4.996)	(4.996)
Peso Crisis		X			X
CUSFTA			X		X
1990 CAAAs				X	X
Observations	1645	1645	1645	1645	1645
Adjusted R^2	0.25	0.25	0.25	0.25	0.25

Notes: Table reports the estimated effects of NAFTA on the emissions of PM_{10} and SO_2 from U.S. manufacturing plants. Each panel contains estimates for a different pollutant and reports regression coefficients from five separate regressions based on Eq. (5). In all cases, the dependent variable is the log of pollution emissions. All specifications include plant, industry×year and state×year fixed effects. See text for details. Standard errors clustered by industry and state are reported in parentheses. Significance: ^{a} 1%; ^{b} 5%; ^{c} 10%.

A one percentage point increase in Mexican tariff preferences for U.S. goods reduced emissions by 1.298%. (Market access) A one percentage point increase in U.S. tariff preferences for Mexican intermediates reduced PM10 emissions from a plant facing average trade frictions by 3.247%. (foreign inputs)

Plant's emission intensity of production

1. Examine whether the changes in emissions levels are due to:
2. (1) changes in the physical quantity of output produced, or
3. (2) changes in the level of pollution emitted per unit of output: **the emission intensity of production**

Results: plant's emission intensity of production

Table 6
NAFTA and pollution intensity.

	Particulate Matter (PM_{10})			Sulfur Dioxide (SO_2)		
	(1)	(2)	(3)	(4)	(5)	(6)
$\tau_{jt}^{Mex} \times \Phi_s$	-1.298^b	-1.250^b	-1.216^b	-1.459^c	-1.386^c	-1.347^c
	(0.566)	(0.555)	(0.564)	(0.746)	(0.757)	(0.764)
$\tau_{jt}^{US} \times \Phi_s$	1.169	1.800	2.152	−3.871	−3.581	−3.401
	(2.116)	(2.133)	(2.275)	(3.150)	(3.225)	(3.111)
$\tau_{jt}^{Int} \times \Phi_s$	−3.247	−3.491	−4.083	-13.185^a	-13.054^a	-12.424^b
	(3.944)	(3.863)	(4.155)	(4.996)	(4.952)	(4.902)
Observations	4162	4162	4162	1645	1645	1645
Adjusted R^2	0.20	0.22	0.23	0.25	0.23	0.30

Notes: Table reports the estimated effects of NAFTA on the emissions and emission intensity of PM_{10} and SO_2 based on Eqs. (5) and (6) respectively. For each pollutant, the dependent variable in the first column is the log of pollution emissions, the dependent variable in the second column is the log of emissions per worker, and the dependent variable in the third column is the log of the emissions-sales ratio. All specifications include plant, industry×year and state×year fixed effects, and controls for the Mexican Peso Crisis, CUSTFA and the CAAAs. See text for details. Standard errors

Possible explanations

1. **The role of plant exit** firm heterogeneity trade models (e.g. Melitz 2003) would predict that trade liberalization could lead to lower average plant emission intensity due to exit of least productive and polluting plants.→
   - Results are robust on the sub-samples of plants that are in operation throughout the period of study (intensive margin)

2. **Changes in the mix of foreign inputs** due to the NAFTA Mexico would become a pollution haven as dirty U.S. production relocated to Mexico to take advantage of differences in environmental regulations→
   - results suggest that after NAFTA, affected plants began to source relatively dirty intermediate inputs from Mexico rather than produce them in house.

3. **Market access effect:** emission intensity falls due to trade-induced technological change following NAFTA.→
   - reductions in emission intensity due to increased Mexican market access are concentrated in the upper quartiles of the initial plant size distribution, which is consistent with previous evidence on technological upgrading following trade liberalization.

Results: Disentangling the channels

Intermediate input mix and the pollution haven hypothesis.

	(1)	(2)	(3)	(4)
Panel A: Particulate Matter (PM_{10})				
$\tau_{jt}^{Mex} \times \Phi_s$	-1.250^{b}	-0.974^{c}	-1.216^{b}	-0.927^{c}
	(0.555)	(0.525)	(0.564)	(0.531)
$\tau_{jt}^{US} \times \Phi_s$	1.800	0.764	2.152	1.067
	(2.133)	(2.168)	(2.275)	(2.333)
$\tau_{jt}^{Int} \times \Phi_s$	−3.491		−4.083	
	(3.863)		(4.155)	
$\tau_{jt}^{Int-Dirty} \times \Phi_s$		-5.833^{b}		-5.968^{b}
		(2.337)		(2.457)
$\tau_{jt}^{Int-Clean} \times \Phi_s$		2.857		2.234
		(3.706)		(4.006)
Observations	4162	4162	4162	4162
Adjusted R^2	0.22	0.22	0.23	0.23
Panel B: Sulfur Dioxide (SO_2)				
$\tau_{jt}^{Mex} \times \Phi_s$	-1.386^{c}	-1.594^{b}	-1.347^{c}	-1.556^{b}
	(0.757)	(0.750)	(0.764)	(0.749)
$\tau_{jt}^{US} \times \Phi_s$	−3.581	−5.294	−3.401	−5.143
	(3.225)	(3.467)	(3.111)	(3.339)
$\tau_{jt}^{Int} \times \Phi_s$	-13.054^{a}		-12.424^{b}	
	(4.952)		(4.902)	
$\tau_{jt}^{Int-Dirty} \times \Phi_s$		-14.671^{a}		-14.846^{a}
		(4.888)		(4.885)
$\tau_{jt}^{Int-Clean} \times \Phi_s$		−1.798		−1.222
		(5.156)		(5.084)
Observations	1645	1645	1645	1645
Adjusted R^2	0.23	0.23	0.30	0.31

Notes: Table reports the estimated effects of NAFTA on emission intensity for each of the pollutants under study. Each panel contains estimates for a different pollutant and reports estimated coefficients from four separate regressions. In columns

Results: Heterogeneous effects

NAFTA and pollution intensity by quartile of the initial plant size distribution.

	Particulate Matter (PM_{10})		Sulfur Dioxide (SO_2)	
	(1)	(2)	(3)	(4)
$\tau_{jt}^{Mex} \times \Phi_s \times Q_4$	−0.713	−0.672	-1.517^b	-1.502^c
	(0.756)	(0.750)	(0.768)	(0.770)
$\tau_{jt}^{Mex} \times \Phi_s \times Q_3$	-1.266^c	-1.241^c	-1.800^c	-1.736^c
	(0.681)	(0.671)	(0.951)	(0.961)
$\tau_{jt}^{Mex} \times \Phi_s \times Q_2$	-1.541^a	-1.509^b	−0.095	0.049
	(0.581)	(0.605)	(1.483)	(1.497)
$\tau_{jt}^{Mex} \times \Phi_s \times Q_1$	−0.681	−0.583	0.008	0.038
	(0.625)	(0.637)	(1.183)	(1.182)
$\tau_{jt}^{US} \times \Phi_s$	2.048	2.434	−4.137	−3.970
	(1.963)	(2.075)	(3.434)	(3.332)
$\tau_{jt}^{Int} \times \Phi_s$	−3.348	−4.020	-14.474^a	-13.734^b
	(3.473)	(3.707)	(5.471)	(5.359)
Observations	4162	4162	1645	1645
Adjusted R^2	0.22	0.23	0.24	0.31

Notes: Table reports the estimated effects of NAFTA on emission intensity by quartile of the initial plant size distribution. For each pollutant, the dependent variable in the first column is the log of emissions per worker, while the dependent variable is second column is the log of the emissions-sales ratio. All specifications include

Conclusion

- (1) New insights into the impact of trade liberalization on firms' pollution.
- (2) NAFTA played an important role in the clean-up of U.S. manufacturing since the early 1990s.
- (3) Firms producing in industries experiencing larger tariff reductions tend to exhibit reduced PM10 and SO2 emissions, indicating a positive effect on environmental sustainability.