"Why is Pollution from US Manufacturing Declining? The Roles of Environmental Regulation, Productivity, and Trade" by Shapiro and Walker (2018)

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Env Reading Group

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Research Question

- Why air pollution emissions from US manufacturing fell by 60 percent between 1990 and 2008 while manufacturing output increases substantially?

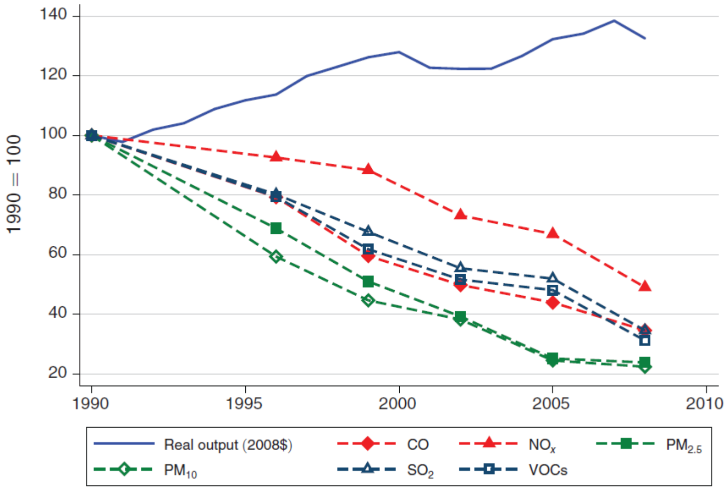

Figure 1: Manufacturing Rreal Output and Pollution Emissions

Framework and Results

1. Decompose changes in manufacturing emissions into changes due to (1) scale effect, (2) composition effect and (3) technique effect.

   Technique effect dominates: decreases in pollution intensity within product categories explain almost all of the changes in emissions between 1990 and 2008

2. A static GE model to decompose observed changes in pollution into four shocks: (1)foreign competitiveness, (2)US competitiveness, (3)expenditure shares, (4)environmental regulation.

3. Counterfactual Analysis: What if the pollution emission would be if only one shock takes on his actual,historical values?

   The increasing stringency of environmental regulation accouts for most of the 1990-to-2008 decrease in pollution emissions from US manufacturing

Statistical Decomposition

- $Z = \sum_s z_s = \sum_s x_s e_s = \underbrace{X}_{scale} \sum_s \underbrace{\kappa_s}_{composition} \underbrace{e_s}_{technique}$

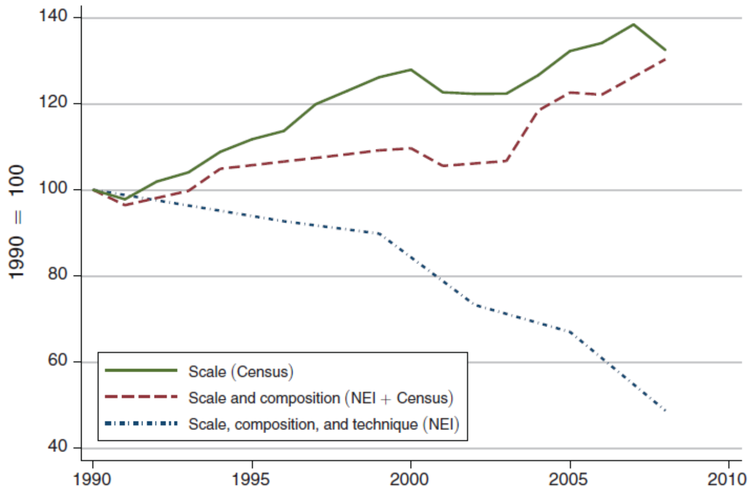

Figure 2: NO_x from US Manufacturing

Model Setup

- Preference:

$$U_d = \prod_S \left(\left[\sum_o \int_\omega q_{od,s}(\omega)^{\frac{\sigma_s - 1}{\sigma_s}} \right]^{\frac{\sigma_s}{\sigma_s - 1}} \right)^{\beta_{d,s}}$$

  Demand is

$$q_{od,s}(\omega) = \frac{p_{od,s}(\omega)^{-\sigma_s}}{P_{d,s}^{1-\sigma_s}} E_{d,s} = \frac{p_{od,s}(\omega)^{-\sigma_s}}{P_{d,s}^{1-\sigma_s}} \beta_{d,s} E_d \tag{1}$$

- Sunk entry cost $f^e_{o,s}$ to draw a productivity φ from Possion distribution

$$G(\varphi) = 1 - \left(\frac{\varphi}{b_{o,s}} \right)^{-\theta_s}$$

Model Setup

- A firm with productivity φ has profit:

$$\pi_{o,s}(\phi) = \sum_d \pi_{od,s}(\varphi) - w_o f^e_{o,s} \tag{2}$$

where

$$\pi_{od,s}(\phi) = \max_{p,q,l,z} p_{od,s} q_{od,s} - (w_o l_{od,s} + t_{o,s} z_{od,s})\, \tau_{ods} - w_d f_{od,s} \tag{3}$$

subject to

$$q_{od,s}(\varphi) = (1 - a(\varphi))\varphi l_{od,s} \tag{4}$$

$$z_{od,s}(\varphi) = (1 - a(\varphi))^{1/\alpha_s} \varphi l_{od,s} \tag{5}$$

1. $\tau_{od,s}$ units must be shipped for one unit to arrive
2. $f_{od,s}$: sunk cost for entering market d
3. $t_{o,s}$ pollution tax per ton of emissions

Decision Rules

1. Profit Maximization $\rightarrow (l_{od,s}(\varphi), a_{od,s}(\varphi))$
2. Derive productivity cutoff $\varphi^*_{od,s}$ such that firms from country o with productivity $\varphi_{od,s} > \varphi^*_{od,s}$ will trade with country d

   Note: $\varphi^*_{od,s}$ is a function of $P_{d,s}$
3. Derive $P_{d,s}$
4. Derive bilateral trade (value from country o to country d) $X_{od,s}$ or $R_{od,s}$ and the share of country d's expenditure on sector s that is purchased from country o, $\lambda_{od,s}$:

$$\lambda_{od,s} = \frac{M^e_{o,s}(w_o/b_{o,s})^{-\theta_s}(t_{o,s})^{-\frac{\alpha_s\theta_s}{1-\alpha_s}}(\tau_{od,s})^{-\frac{\theta_s}{1-\alpha_s}}(f_{od,s})^{1-\frac{\theta_s}{(\sigma_s-1)(1-\alpha_s)}}}{\sum_i M^e_{i,s}(w_i/b_{i,s})^{-\theta_s}(t_{i,s})^{-\frac{\alpha_s\theta_s}{1-\alpha_s}}(\tau_{id,s})^{-\frac{\theta_s}{1-\alpha_s}}(f_{id,s})^{1-\frac{\theta_s}{(\sigma_s-1)(1-\alpha_s)}}} \quad (6)$$

This is the so-called "gravity equation" in international trade literature

General Equilibrium

1. Two GE conditions that must be satisfied in any counterfactual scenarios
   - Labor demand = Labor supply (Each country)
   - The fixed cost = The expected profit of drawing a productivity (Each sector of each country)
2. Transfer two GE equations in value to these in proportional change: x denote all shocks $(t_{o,s}, \tau_{od,s}, f_{od,s}, \beta_{d,s})$ and endogenous variables $(w_i, M^e_{i,s})$. Proportional change in x: $\hat{x} = \frac{x'}{x}$.

$$1 = \psi_o \left(\frac{\sum_s \hat{M}^e_{o,s} R_{o,s} \frac{(\sigma_s - 1)(\theta_s - \alpha_s + 1)}{\sigma_s \theta_s} + \eta_o'}{\sum_s R_{o,s} \frac{(\sigma_s - 1)(\theta_s - \alpha_s + 1)}{\sigma_s \theta_s} + \eta_o} \right) \tag{7}$$

$$\hat{w}_o = \sum_d \frac{\varsigma_{od,s} \left(\frac{\hat{w}_o}{\hat{b}_{o,s}}\right)^{-\theta_s} \left(\hat{t}_{o,s}\right)^{-\frac{\alpha_s \theta_s}{1-\alpha_s}} \left(\hat{\tau}_{od,s}\right)^{-\frac{\theta_s}{1-\alpha_s}} \left(\hat{f}_{od,s}\right)^{1-\frac{\theta_s}{(\sigma_s-1)(1-\alpha_s)}}}{\sum_i \lambda_{id,s} \hat{M}^e_{i,s} \left(\frac{\hat{w}_i}{\hat{b}_{i,s}}\right)^{-\theta_s} \left(\hat{t}_{i,s}\right)^{-\frac{\alpha_s \theta_s}{1-\alpha_s}} \left(\hat{\tau}_{id,s}\right)^{-\frac{\theta_s}{1-\alpha_s}} \left(\hat{f}_{id,s}\right)^{1-\frac{\theta_s}{(\sigma_s-1)(1-\alpha_s)}}} \hat{\beta}_{d,s} \frac{R_d' - NX_d'}{R_d - NX_d} \tag{8}$$

General Equilibrium

1. Decomposition eq.(8) into four shocks: foreign competitiveness ($\hat{\Gamma}_{od,s}, o \neq$ U.S.), US competitiveness ($\hat{\Gamma}_{od,s}, o =$U.S.), Expenditure shares ($\hat{\beta}_{od,s}$) and US environmental regulation ($\hat{t}_{u,s}$):

$$\hat{w}_o = \sum_d \frac{\varsigma_{od,s} \hat{\Gamma}_{od,s} \left(\boldsymbol{I}_{\{o=U.S.\}} \hat{t}_{o,s} + \boldsymbol{I}_{\{o \neq U.S.\}} \right)^{-\frac{\alpha_s \theta_s}{1-\alpha_s}}}{\sum_i \lambda_{id,s} \hat{M}^e_{i,s} \hat{\Gamma}_{id,s} \left(\boldsymbol{I}_{\{i=U.S.\}} \hat{t}_{i,s} + \boldsymbol{I}_{\{i \neq U.S.\}} \right)^{-\frac{\alpha_s \theta_s}{1-\alpha_s}}} \hat{\beta}_{d,s} \frac{R'_d - NX'_d}{R_d - NX_d} \tag{9}$$

   Each shock is a function of what we observe– parameters (θ_s, α_s and σ_s) and data ($X_{od,s}$ and $Z_{od,s}$) – and endogeneous variables ($\hat{w}_i$ and $\hat{M}^e_{i,s}$)

2. Combining eq.(7) and eq.(9) to solve for ($\hat{w}_i$ and $\hat{M}^e_{i,s}$) and then calculate actual values of shocks.

Counterfactual Analysis: Methodology

Only one shock takes his actual, historical values, while other shocks take their value in 1990.

1. Choosing values for shocks $\{\hat{\Gamma}_{od,s}, \hat{t}_{od,s}, \hat{\beta}_{od,s}\}$.

   Example: Consider the shock to US environmental regulation. We choose values of shocks as follows:

$$\{\hat{\Gamma}_{od,s}, \hat{t}_{od,s}, \hat{\beta}_{od,s}\} = \{1, \hat{t}^*_{od,s}, 1\}$$

2. Solve for ($\hat{w}_i$ and $\hat{M}^e_{i,s}$) by combining eq.(7) and eq.(9)
3. Measure the counterfactual changes in US pollution emission:

$$\hat{Z}_{o,s} = \frac{\hat{M}^e_{o,s}\hat{w}_o}{\hat{t}_{o,s}} \tag{10}$$

Results

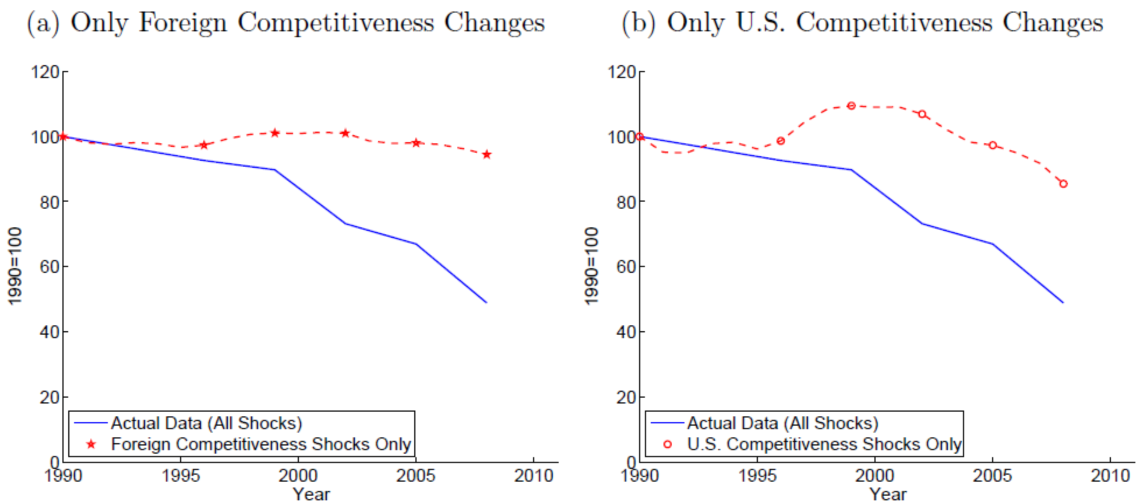

Figure 3: Counterfactual US Manufacturing Emission of NO_x under Competitiveness Shocks, 1990-2008

Results

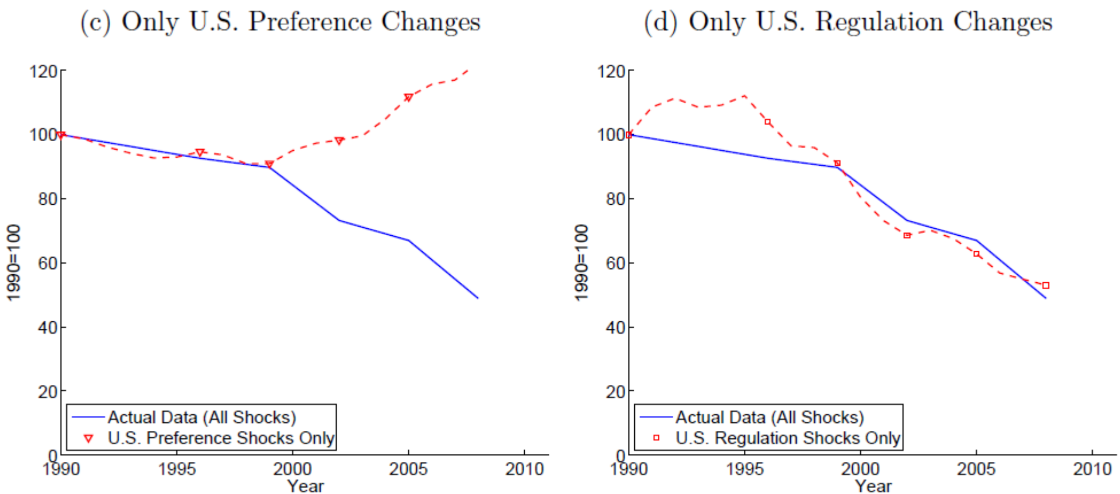

Figure 4: Counterfactual US Manufacturing Emission of NO_x under Preference and Regulation Shocks, 1990-2008

Results

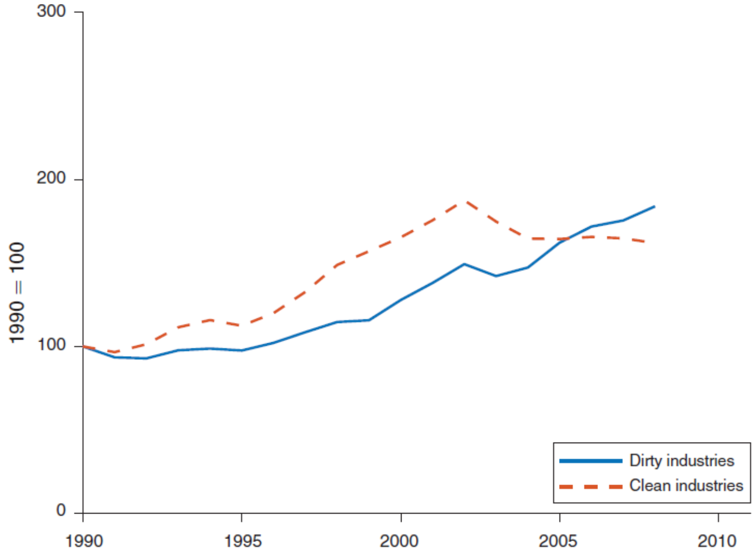

Figure 5: Shocks of Environmental Regulation on NO_x Emissions, 1990-2008