# Does industry self-regulation reduce industrial accidents? Responsible Care in the Chemical Sector

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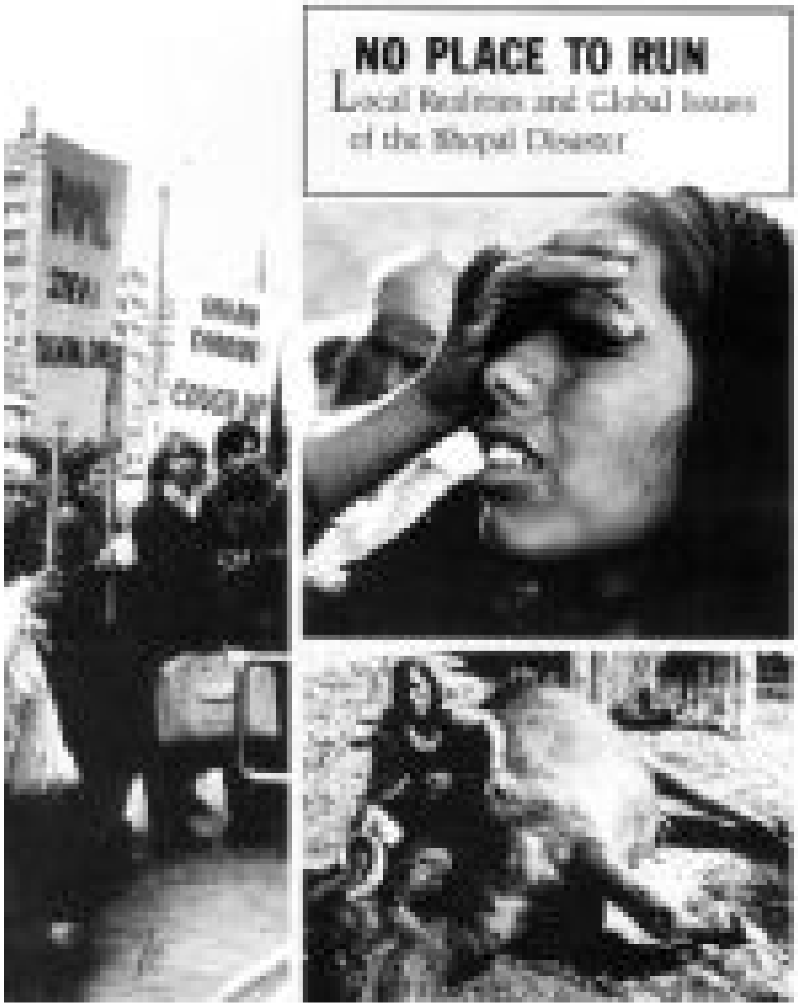
Acknowledgement: National Science Foundation (BCS 0351058 and SES 1127223), University of Pittsburgh's Central Research Development Fund, University Center for Social and Urban Research and the European Union Center of Excellence.

# Industrial accidents

- Accidents in the US chemical industry cause losses of $3 billion to $5 billion annually.
- OSHA-reportable work-related accidents
  - at least one death or 3 hospitalizations.
- Self-regulation as policy:
  - Industry trade associations require members to adhere to codes of conduct on industrial safety as condition of membership.
  - Operate within regulatory framework.

# Industrial self-regulation: One response to major industrial accidents




**Bhopal, India**
**20,000 dead**

**Responsible Care in the Chemical Industry**

# Response to BP Oil Spill: Copy RC

- The National Commission on the BP Oil Spill recommended:
  - the oil and gas drilling sector adopt industry self-regulation
  - modeled after Responsible Care.

- Justification:
  - Firms, not regulators, have superior information , technology, resources to improve risk management *(National Academy of Engineering, 2010; GAO 2011)*

# Response to BP Oil Spill: Copy RC

But …

No empirical evidence that RC or any other self-regulation programs reduced accidents

# Study contribution

- First study to test if self-regulation reduced industrial accidents.
- Focus on Responsible Care
  - 60 countries worldwide & emulated by other industries.
- First database to combine OSHA accidents and EPA pollution data
  - Authors' constructed panel database of the chemical manufacturing sector: 1,867 firms that own 2,963 plants (1988-2001).

# Preview Results

- RC, operating within the regulatory framework in the chemical sector, reduced the likelihood of accidents among RC participants by 2.99 accidents for every 100 plants in a year.
- The 69% reduction in the likelihood accidents is substantial
- Translates to back-of-the-envelope avoided losses of $180 million to $800 million per year.

# Outline

- Institutions:
- Empirics: Research Design & Data
- Empirics: Results
- Policy conclusion

# RC can provide additional impetus for safety

- Key factors in improving plant safety
  - Senior management's attention to safety
  - Senior management's identification and correction of errors
  - Translates down the production chain given workers' self-interest in plant safety.
- RC can serve as "attention correction device" to improve safety. (Scholz and Gray, 1990).

# Top management inattention to safety & resulting accidents

Texas City Refinery, 2005, 11 dead, 170 injured

- BP management did not implement adequate safety oversight, provide needed human and economic resources, or consistently model adherence to safety rules and procedures
- Cost-cutting, failure to invest and production pressures from BP Group executive managers impaired process safety performance at Texas City (CSB, Texas City).

# Failure to identify and correct errors and resulting accidents

BP Oil Spill, 2010;
Largest Oil Spill in Gulf of Mexico

- Failure to identify and correct errors.
  - "In a survey of Transocean crew weeks before the oil well blowout, some 46 percent of crew members surveyed felt that some of the workforce feared reprisals for reporting unsafe situations, and 15 percent felt that there were not always enough people available to carry out work safely." (NCBP, 2011)

# RC can provide additional impetus for safety

- Raise top management attention to safety:
  - Each CEO must sign annual reports submitted to the ACC on their firms’ environmental health and safety performance.
  - CEOs from leading firms pressure their non-compliant counterparts at quarterly regional meetings to adopt and adhere to the industrial codes.

*(NCBP, 2011).*

# RC can provide additional impetus for safety

- Improve top management's ability to identify and correct errors:
  - Plants must conduct safety self-audits

# Outline

- Theory & Institution:
- Empirics: Research Design & Data
- Empirics: Results
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# Research questions

- Main question:
  - Does RC reduce plant-level accidents?
  - Compare plants belonging to RC firms to *statistically equivalent* plants belonging to non-RC firms.
  - Both RC and non-RC plants operate within the same general regulatory framework.

# Accidents: 3 definitions

- All accidents (304)
  - Mandatory reporting – at least one death or 3 hospitalizations.
- PS/RC accidents (212)
  - (i) accidents where the investigation cites at least one violation of OSHA standards that are related to RC codes or (ii) process safety accidents, that stem from chemical leaks, high pressure, fires or explosions, or both.
- Fatal accidents (101)
- Pool observations across years, and estimate standard errors clustered at the firm-level.

# Estimation model: Bivariate Probit

- *Plant hazard level or accident outcome*

  $$Y_{it} = 1\,[R_{it}\,\beta_1 + X_{it}\,\beta_2 > \nu_{it}]$$

- *RC Participation*

  $$R_{it} = 1\,[Z_{it}\,\alpha_1 + X_{it}\,\alpha_2 > \varepsilon_{it}]$$

  $$\varepsilon_{it},\ \nu_{it} \sim N(0, \Sigma)$$

Observations – plant/years

Y=1 if accident occurred, 0 otherwise.

R =1 if plant belongs to RC participating firms, 0 otherwise.

X = control variables that influence participation and accidents.

Z = instrumental variables to address self-selection.

# Instrument: Firm's HAP to TRI ratio

- HAPs = Hazardous air pollutants
- TRI = Toxic Release Inventory
- The firm's HAP/TRI ratio
  - influences its contemporaneous decision to participate in RC,
  - but does not directly affect plant-level accidents, conditional on included variables.

# HAP/TRI influence RC participation

- Regulation: Industry must implement Maximum Achievable Control Technology for HAPs released to the environment.
- In RC, firms pledge to reduce pollution (in addition to improving safety).
- Firms that must reduce HAPs, regardless of RC participation, do not face incremental costs from RC's Pollution Prevention code; and may as well join RC to benefit from RC's positive publicity.

| Probit Regression of RC participation | |
|---|---|
| Firm's HAP/TRI ratio | 0.342*** |
| | (0.052) |
| Covariates | included |
| LR test p-value | less than 0.0001 |
| Obs | 23,780 |

# HAP/TRI unlikely to directly affect accidents

[1] Actions to reduce HAPs & actions to improve plant safety are distinct.

- MACT emissions control technologies :
  - Incinerate or absorb HAPs prior to the release of air into the environment.
  - From removing 80% of HAPs to 99% of HAPs.
- Actions for safety
  - Put guards to prevent injury or falls.
  - Identify and prevent excessive built-up of pressure in chemical processes, the loss of control of heat-related or reactive processes, or the exposure of flammable liquids to ignition sources.

# HAP/TRI unlikely to directly affect accidents

[2] Regulations: environmental emissions vs. workers' exposure.

- "Distinct regulatory framework separating the EPA and OSHA and the agencies' lack of coordination.
- "No formal consideration of the overlap between environmental and occupational exposures (outside versus inside the plant) and the potential of pollution prevention strategies for addressing both."

(Armenti, the Toxics Use Reduction Institute, 2003)

# HAP/TRI unlikely to directly affect accidents

- *[3] Speculation:* Let’s assume plants *did* reduce HAPs that are chronically toxic or carcinogenic.
- In practice: Unlikely to affect accidents measured as fatalities or hospitalization because of the long latency period between exposure to toxins and health symptoms.

# Control variables: factors that affect plant-level safety.

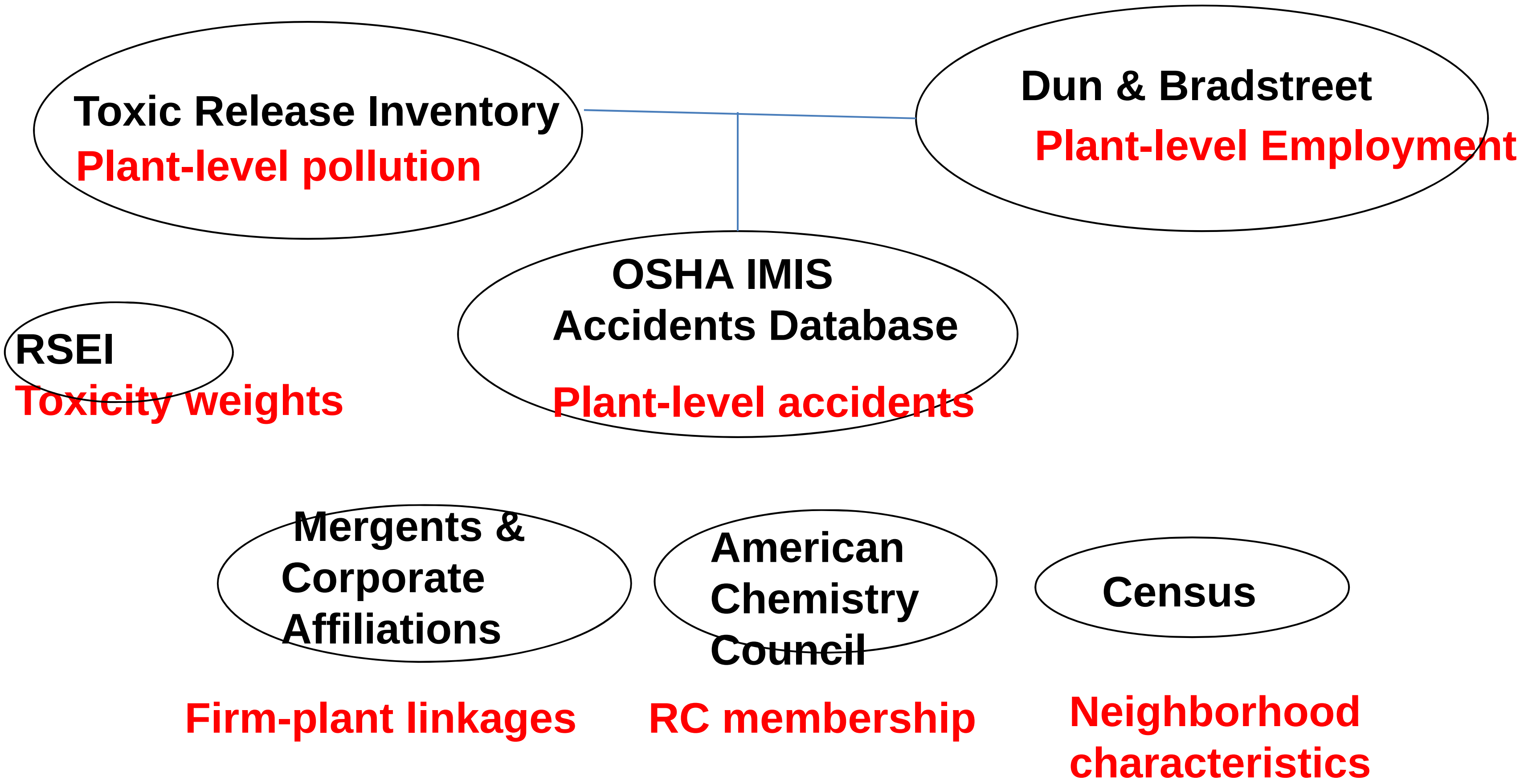
- Plant and firm size (# employment)
- Plant union status and share of unionized plants for firm
- Proxy for plant’s hazardousness
  - Plants’ TRI pollution intensity relative to SIC-4, TRI pollution intensity of SIC-4

# Control variables:
# factors that affect plant-level safety.

- Regulatory pressure: counts of OSHA inspections and $ penalties
  - 1 year ago and cumulative 2-5 years ago
  - Specific deterrence -same plant, same firm
  - General deterrence -same SIC-4 code, same state
- Neighborhood pressure (share white, < high school, poor)
- Industry dummies, Year dummies

Sources: Mendeloff and Gray, 2005; Scholtz and Gray, 1990; Weil, 1996, Hamilton, 1995)

# *DATA: MERGE ACROSS DATABASES*




Merge strategy: Name and address matching – TRI-D&B-OSHA
GIS for plant-census tracts

# Outline

- Theory & Institution:
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| Table 1. Comparison of RC and non-RC plants | | | |
|---|---|---|---|
| | [2] | [3] | [4] |
| | RC plants | Non-RC plants plants | Comparison RC & Non-RC plants |
| No. obs. in plant-years | 7,929 | 15,851 | |
| No. plants | 1,037 | 2,293 | |
| No. firms | 228 | 1,735 | |
| Frequency of Accidents (# accidents/plant-years) | | | |
| - All Accidents | 1.59% | 1.12% | *** |
| - RC/PS accidents | 1.19% | 0.74% | *** |
| - Fatal accidents | 0.57% | 0.41% | *** |

**The average likelihood of an accident at an RC plant**
**0.0159 accidents / plant-years**

| Table 2: Impact of RC participation - Bivariate probit | | | | | | |
|---|---|---|---|---|---|---|
| | [1] | [2] | [3] | [4] | [5] | [6] |
| Accidents | All | | RC/PS | | Fatal | |
| # accidents | 304 | | 212 | | 110 | |
| | Probit | Average | Probit | Average | Probit | Average |
| | Coeff | Marginal | Coeff | Marginal | Coeff | Marginal |
| | | Effects | | Effects | | Effects |
| RC dummy | -0.542* | -0.018* | -0.916* | -0.029* | -0.305 | -0.004 |
| | (0.287) | (0.011) | (0.517) | (0.017) | (0.392) | (0.006) |
| Covariates | incl | | incl | | incl | |
| Rho | 0.287* | | 0.522** | | 0.154 | |
| RC/PS accidents: (i) accidents related to violations of OSHA standards that are | | | | | | |
| are related to RC codes of conduct or (ii) process safety accidents, or both. | | | | | | |
| Obs.=23,780. Statistically significant at the ***1%, **5% and *10% level. | | | | | | |

**RC effects on all accidents and RC/PS accidents are negative & statistically significant**

| Table 3: Treatment effects of RC on the likelihood of accidents | | | | | | |
|---|---|---|---|---|---|---|
| | [1] | [2] | [3] | [4] | [5] | [6] |
| | Average Treatment Effect (ATE) | | | Average Treatment on the Treated (ATT) | | |
| | | All plants | | | RC plants | |
| | | n=23,780 | | | n=7,929 | |
| | RC=0 | RC=1 | RC effect | RC=0 | RC=1 | RC effect |
| All accidents | 2.46% | 0.71% | -1.76%* | 4.31% | 1.32% | -2.99%* |
| | | | | | | |
| RC/PS accidents | 3.35% | 0.42% | -2.92%* | 6.70% | 0.95% | -5.75%* |
| | | | | | | |
| Fatal accidents | 0.69% | 0.30% | -0.39% | 1.10% | 0.50% | -0.60% |

The RC treatment effects are calculated using estimated coefficients from the main bivariate probit.

**ATE: RC reduced all accidents by 1.8 accidents per 100 plants in a year.**

$$\text{Accidents}_{it} = \text{Est. } \beta 1 \text{ X plant characteristics}_{it} + \text{Est. } \beta 2 \text{ X RC}_{it}$$

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**ATE: RC reduced RC/PS accidents by 2.9 accidents per 100 plants in a year.**

| Table 3: Treatment effects of RC on the likelihood of accidents | | | | | | |
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| Fatal accidents | 0.69% | 0.30% | -0.39% | 1.10% | 0.50% | -0.60% |

The RC treatment effects are calculated using estimated coefficients from the main bivariate probit.

**ATT** **RC reduced all accidents by 3 accidents per 100 plants in a year. (69%)**
**RC reduced RC/PS accidents by 5.8 accidents per 100 plants in a year. (87%)**

# Economic significance of RC's reduction in the likelihood of accidents

- Decline of 2.99 accidents for every 100 plants in a year (ATT)
- Studies on accidents in chemical/petrochemical
- Property damage only - $26 million
- Accounting for 1,037 plants
- Averted loss per year for the RC plants

**=$**180 million to $800 million

# Robustness checks

- Alternative specification for IV
- Propensity Scoring Matching

# Outline

- Theory & Institutions:
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# Summary: Results

- RC, operating within the regulatory framework in the chemical sector, reduced the likelihood of accidents among RC participants by 2.99 accidents for every 100 plants in a year.
- The 69% reduction in the likelihood accidents is substantial and translates to back-of-the-envelope avoided losses of $180 million to $800 million per year.
- RC reduced the likelihood of RC/PS accidents by 5.75 accidents for every 100 plants in a year or by 86%.

# Policy implication # 1:
# Self-Regulation Can Reduce Accidents

- RC can serve as an attention correction device to improve safety.
- The features of the RC program can raise top management's attention to safety and their ability to identify and correct errors.
  - peer pressure i.e., CEO reporting on safety record to peers.
  - CEO signing off on reports to ACC.
  - self-audits.

# Policy implication # 2:
# Effectiveness of self-regulation program depends on underlying regulatory framework

- RC plants pledge to both improve safety and reduce pollution.

- RC plants did reduce accidents
  - this study.

- RC plants did not reduce Toxic Release Inventory pollution.
  - Gamper and Finger, *Journal of Regulatory Economics,* accepted
  - Lenox and King (2000).

# Policy implication # 2: Effectiveness of self-regulation program depends on underlying regulatory framework

- Underlying regulatory framework influence the relative costs and benefits for plants to achieve RC’s specific goals.
- Reducing accidents: High benefits, low costs.
- Reducing TRI pollution: Low benefits, high costs.

# Policy implication # 2:
# Effectiveness of self-regulation at achieving stated goals depends on underlying regulatory framework

- On the benefits side:
- RC management practices can translate to lower likelihood of accidents, and in turn, that lower likelihood of accidents would reduce potential liability and insurance costs (Er, Kunreuther, Rosenthal, 1998).
- In contrast, firms' reduction of TRI pollutants, several of which are unregulated (EPA, 1996), does not necessarily yield profits.

# Policy implication # 2:
# Effectiveness of self-regulation at achieving stated goals depends on underlying regulatory framework

- On the cost side:
- Increased management attention to safety, via organizational changes, can lead to reduced likelihood of accidents (Scholz and Gray, 1990).
- With top management attentive to safety, improved safety translates down production chain, given workers' self-interest.
- To reduce pollution, capital investments are needed to redesign the production process or to treat end-of-pipe pollution (Allen and Shonnard, 2011).

# What have we learnt?

- The underlying regulatory framework influences the effectiveness of self-regulation program.
- Best to treat self-regulation programs as a complement to regulation.

Thank you!

Comments?

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