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# Identifying the Value of a Statistical Life

## *Policy, Methods & New Estimates*

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# "Value of a Statistical Life"

- Suppose a sample of individuals are asked their WTP to reduce their risk of death by 1/15,000.

- If mean WTP = \$10/month or \$120/year, then:

$$VSL = \$120 \times 15{,}000 = \$1{,}800{,}000$$

# VSL Environmental Applications

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# The VSL in US Public Policy

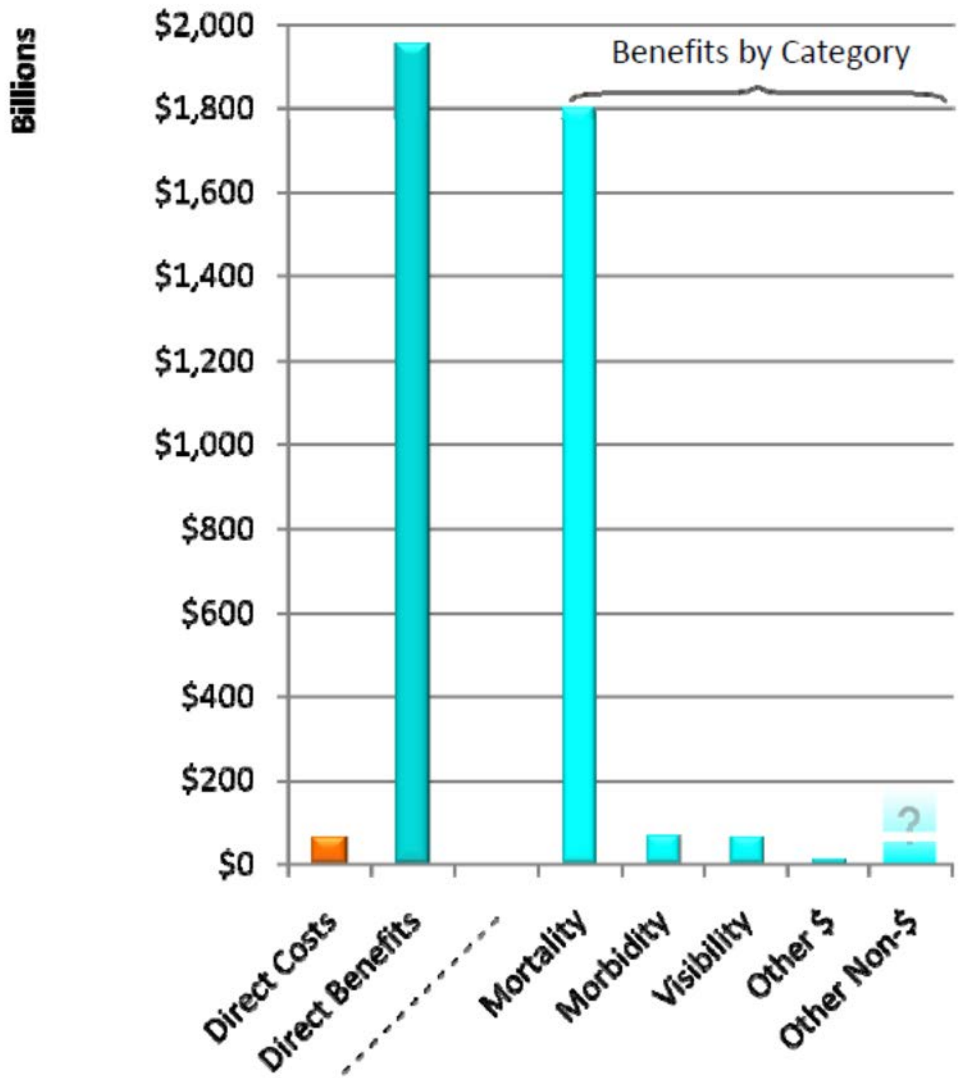
## Clean Air Act

Year 2020 central estimates of costs & benefits in 2006$ (Billions)

Total benefits: $1 to $2T (annual)

Mortality reductions comprise 80% to 90% of total benefits

*Source: US EPA, 2011*



# The VSL in US Public Policy

- **Clean Power Plan**

- By the year 2030:
  - Reduce $CO_2$ from electric power sector by 30% from 2005 levels
  - Expected co-benefits of $SO_2$, NOx and PM2.5 reductions by 25%

- Annual costs: $8.4 billion

- Annual benefits:
    - Climate: $6.4 billion
    - Health: $13 - $31 billion
      (98% of these benefits are due to the value of reduced mortality)

*Overall, avoided mortality co-benefits (mostly from PM2.5 reductions) account for **67 – 83 percent** of the Clean Power Plan's total benefits.*

# The VSL in US Public Policy

- Mean estimates, 2018 dollars:*

| | |
|---|---|
| U.S. Environmental Protection Agency | $9.4 m |
| U.S. Department of Transportation | $10.3 m |
| Homeland Security | $10.3 m |
| Food and Drug Administration | $9.8 m |

*Updated from guidance document year, or from agency specified dollar year, if agency adjusts over time.

# Comparative VSLs

- VSL estimates used in U.S. public policy are primarily based on ***hedonic wage*** estimates.

- Dramatically different than EU/OECD for same policies

  - European Commission: \$1.7 to \$3.6 million

  - OECD Commission recommends: \$2.2 to \$4.1 million

# VSL & International Environmental Policy

- VSL applied in US policy is dramatically different than EU/OECD for same policies:
  - European Commission: $1.7 to $3.6 million
  - OECD Commission recommends: $2.2 to $4.1 million

# VSL: Using Labor Markets

- Hedonic wage estimates:

$$wage_{ik} = \alpha + \beta\, risk_k + WC_i\gamma + JC_k\varphi + \varepsilon_{ik}$$

hourly wages of $i^{th}$ worker in job k

# VSL: Estimation

- Hedonic wage estimates:

$$wage_{ik} = \alpha + \beta\, risk_k + WC_i\gamma + JC_k\varphi + \varepsilon_{ik}$$

- deaths per 10,000 workers in job k

# VSL: Estimation

- Hedonic wage estimates:

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worker characteristics

# VSL: Estimation

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job characteristics

# VSL: Estimation

- > 80 studies implement hedonic wage models
- VSL estimates range widely:
  - Early literature (risk data questionable)
    - *$0.07 million (Kniesner & Leeth, 1991)*
    - *$23 million (Garen, 1988)*
  - Post-2000 with better risk data & panel data on workers
    - *$2 million (Kochi, 2011)*
    - *$15 million (Kniesner et al., 2012)*

# Key Shortcomings of Existing Hedonic Wage Studies

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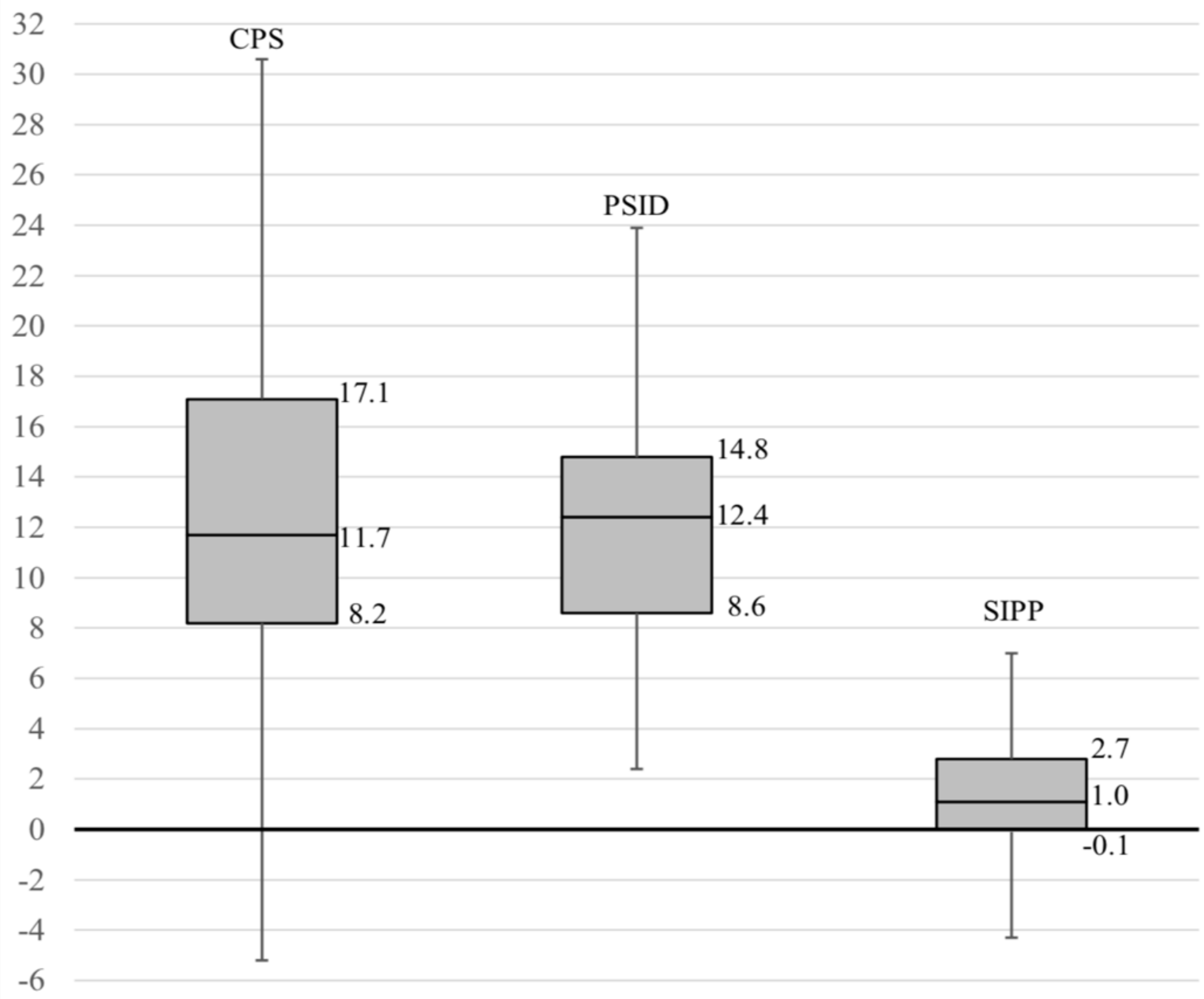
- Measurement error in available risk data
  - Often national average risk rates
  - Coarsely defined by "job"
    US best available: 10 occupations x 72 industries or
    23 occupations x 22 industries
- Omitted variable bias
  - Little known about workplace characteristics
    (panel data on workers does not alleviate)

**An illustrative “internal” meta analysis:**
**129,600 regressions (43,200/dataset)**




*Source:* Evans and Taylor, *Review of Environmental Economics and Policy,* forthcoming.

*Variations focus upon:* 12 fatal risk rates, 6 non-fatal risk rates, functional form variations, & fixed effect choices (e.g., # occupation/industry FE)

# A Quasi-Experimental Approach to Estimating the VSL

- Identify an exogenous instrument for risks at the place of employment

- *Randomized* Occupational Safety and Health Administration (OSHA) inspections from 1987-1998.
  - Unannounced (surprise) & comprehensive
  - Violations found must be corrected within 30 days
  - Follow-up inspections are conducted

# OSHA Data

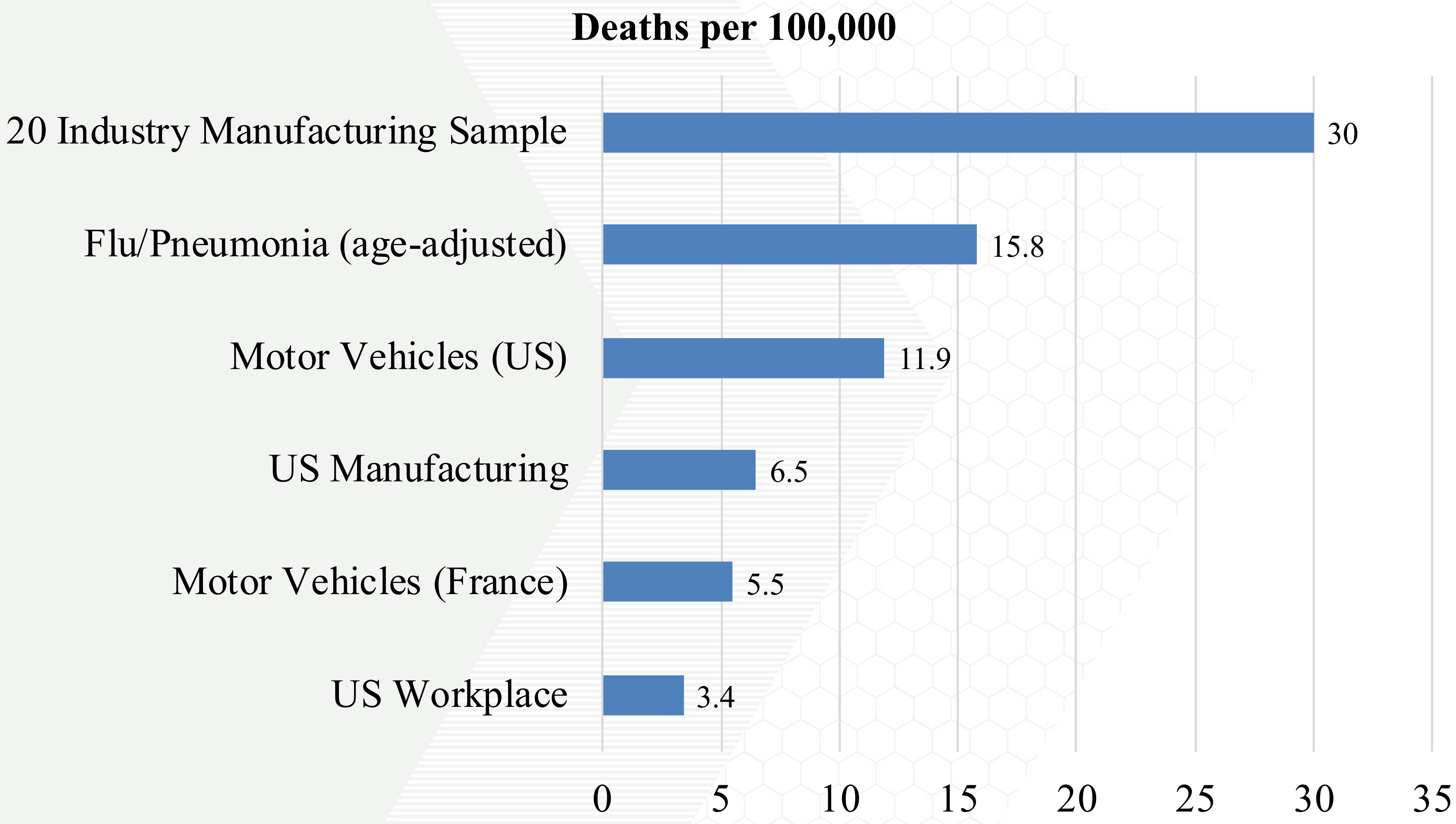
- Universe of inspections from 1970 to present.
  - Type of inspection, # violations, severity of violation

- Focus on decade where "programmed" inspections were conditionally random (1987 to 1998).
  - Plants randomly selected for inspection, conditional on:
    - State
    - 4-digit SIC
    - Size (>11 employees)
    - Recent inspection history

# OSHA Data

- ≈ 7,000 programmed inspections each year
- ≈ 60% result in a violation (>75% if 1$^{st}$ inspection)
- 8 violations per inspection, on average, given at least one violation is found.
- OSHA also provides census of workplace fatalities

# Workplace Fatalities

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# Census of Manufactures (COM)

- COM is conducted every 5 years
- Wages of production workers (plant-level) & plant characteristics recorded
- Augment COM with Annual Survey of Manufacturers (use sample weights in estimation)
- 65,300 plants that meet criteria and appear at least twice over the decade are available for estimation

# Census of Manufactures (COM)

– Match OSHA & Census data

– 65,300 plants (about 253,000 observations)

| | |
|---|---|
| Production worker avg. hourly wage (1997$): | $12.72 |
| Other workers' avg. hourly wage: | $21.26 |
| Avg. number of workers per plant: | 118 |
| Percent that are production workers: | 67% |
| Percent of plants that are 'single unit': | 53% |

# Estimation Strategy

Are OSHA inspections a valid instrument for plant-level safety?

*(i)* Are they random?

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Are OSHA inspections a valid instrument for plant-level safety?

*(i)* Are they random?

Balance in observable characteristics prior to treatment?

Yes.

There are no significant differences in observable characteristics of inspected and uninspected plants during sample period.

Balance →

# Estimation Strategy

Are OSHA inspections a valid instrument for plant-level safety?

*(i)* Are they random?

*(ii)* Do they affect plant-level safety?

Deaths per 10,000 workers

$$fatrate_{j,t} = a + PC_{j,t}\beta + I_j * S_j * T_t + P_j + \varphi PI_{j,t} + \epsilon_{j,t}$$

Time-varying plant characteristics

$$fatrate_{j,t} = a + PC_{j,t}\beta + I_j * S_j * T_t + P_j + \varphi PI_{j,t} + \epsilon_{j,t}$$

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Time-varying plant characteristics

$$fatrate_{j,t} = a + \ PC_{j,t}\beta + \underbrace{I_j * S_j * T_t}_{\text{industry} \times \text{ state} \times \text{year fixed effects}} + P_j + \ \varphi PI_{j,t} + \epsilon_{j,t}$$

Plant fixed effects

Time-varying plant characteristics

$$fatrate_{j,t} = a + PC_{j,t}\beta + \underbrace{I_j * S_j * T_t}_{\text{industry} \times \text{state} \times \text{year fixed effects}} + P_j + \varphi PI_{j,t} + \epsilon_{j,t}$$

industry × state × year fixed effects

$$fatrate_{j,t} = a + PC_{j,t}\beta + I_j * S_j * T_t + P_j + \varphi PI_{j,t} + \epsilon_{j,t}$$

=1 if received a programmed inspection in year *t* and each year thereafter

| | *Panel A: First Stage Regression* | | | | |
|---|---|---|---|---|---|
| | *Dependent Variable is Annual Plant-level Fatality Rate (measured in deaths per 10,000 workers)* | | | | |
| ***Programmed Inspections*** *PI* = 1 in the year of inspection, and each year thereafter | -1.338*** (0.338) | -1.339*** (0.338) | -1.398*** (0.309) | -1.394*** (0.394) | -1.270*** (0.314) |
| ***Model Variations*** | | | | | |
| Plant Characteristics Included: | Yes | No | No | No | No |
| Weighting: | None | None | ASM*PW | ASM*PW | ASM*PW |
| ***R-squared*** | 0.296 | 0.296 | 0.294 | 0.294 | 0.294 |
| ***F-statistic***[b] | 15.7 | 15.71 | 20.34 | 20.32 | 16.32 |

Plant Characteristics: # *Employees*, *Cost of Materials, Productivity, Single Unit Plant, Turnover rate*

→ OSHA 1st inspection reduces fatality rates by approximately 50%

# Comparison

- Scholz & Gray (1993, 1990) find inspections reduce nonfatal injuries by 15 – 22%.
  - However, they average over all inspections.
  - Our estimation focuses on first inspection where most dangerous violations likely to be found (violations decrease by 70% after 1st inspection).

# Wage Differentials For Safer Working Conditions

Baseline IV model:

$$fatrate_{j,t} = a + PC_{j,t}\beta + I_j * S_j * T_t + P_j + \varphi PI_{j,t} + \epsilon_{j,t}$$

$$wage_{j,t} = \gamma + \delta \widehat{fatrate}_{j,t} + PC_{j,t}\beta + I_j S_j T_t + P_j + u_{j,t}$$

Considerations:

- Bad Controls
- Weighting (PW & ASM)
- ln(wages)
- Full compensation (wage + fringe)
- Samples

| | | | | | |
|---|---|---|---|---|---|
| | ***Panel B: Second-stage regression***<br>*Dependent Variable is Production Worker Wages* | | | | |
| ***Fatality Rate*** | 0.204***<br>(0.076) | 0.223***<br>(0.075) | 0.242***<br>(0.080) | 0.0180***<br>(0.006) | 0.337***<br>(0.115) |
| ***Model Variations*** | | | | | |
| Dependent Variable: | Wages | Wages | Wages | Ln(Wages) | Wages + Fringe |
| Plant Char. Included: | Yes | No | No | No | No |
| Weighting: | None | None | ASM*PW | ASM*PW | ASM*PW |
| ***R-squared*** | 0.484 | 0.433 | 0.547 | 0.582 | 0.347 |
| ***No. Obs.*** = 252,800<br>***No. Plants*** = 65,300 | | | | | |

→ Post inspection, wages at inspected plants fall by 20 to 24¢ per hour (1.6% to 2% of average wage).

| | | | | | |
|---|---|---|---|---|---|
| | ***Panel B: Second-stage regression*** | | | | |
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| | (0.076) | (0.075) | (0.080) | (0.006) | (0.115) |
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| ***R-squared*** | 0.484 | 0.433 | 0.547 | 0.582 | 0.347 |
| ***VSL in Millions 2016$*** | $5.69 | $6.21 | $6.74 | $7.02 | $9.39 |
| [95% Conf. Interval] | [1.78 – 9.59] | [2.11 – 10.32] | [2.40 – 11.09] | [2.44 – 11.60] | [3.09 – 15.69] |

# Robustness Checks

- Our identification strategy relies on three key assumptions:

1. Wages and fatality rates follow a common trend prior to inspection.
(we find that they do) *Graph* →

2. Treatment effects are not transitory in the key outcome variables.
(we find they are not) *Graph* →

3. There are not general equilibrium effects.
Examine *(i)* plants owned by same firm and *(ii)* plants in same MSA
(we find there are none)

# Robustness Checks

- Falsification test?

  Do inspections affect the wages of other employees? (e.g., clerical and managerial positions)

$$Other\ Worker\ Wages_{j,t} = a + \varphi PI_{j,t} + I_{j,t} \times S_s \times T_t + P_j + \epsilon_{j,t}.$$

  – They do not: φ is never statistically significant

# Comparable Estimates

- We estimate \$8m - \$10m (\$2018)

- Recent quasi-experimental estimates:
  Transportation
  – Ashenfelter and Greenstone: \$2.2m upper bound
  – León and Miguel: \$0.8m (\$3.8m non-African)
  – Rohlfs et al: \$10-\$12 (and -\$12m)

  Labor Market
  – Greenstone et al. (2012): \$3-\$4m for military personnel
  – Schnier (2005): \$6m for fishermen

# Final Comments & Future Research

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# Recall VSL in Public Policy

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- Mean estimates, 2018 dollars:*

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|---|---|
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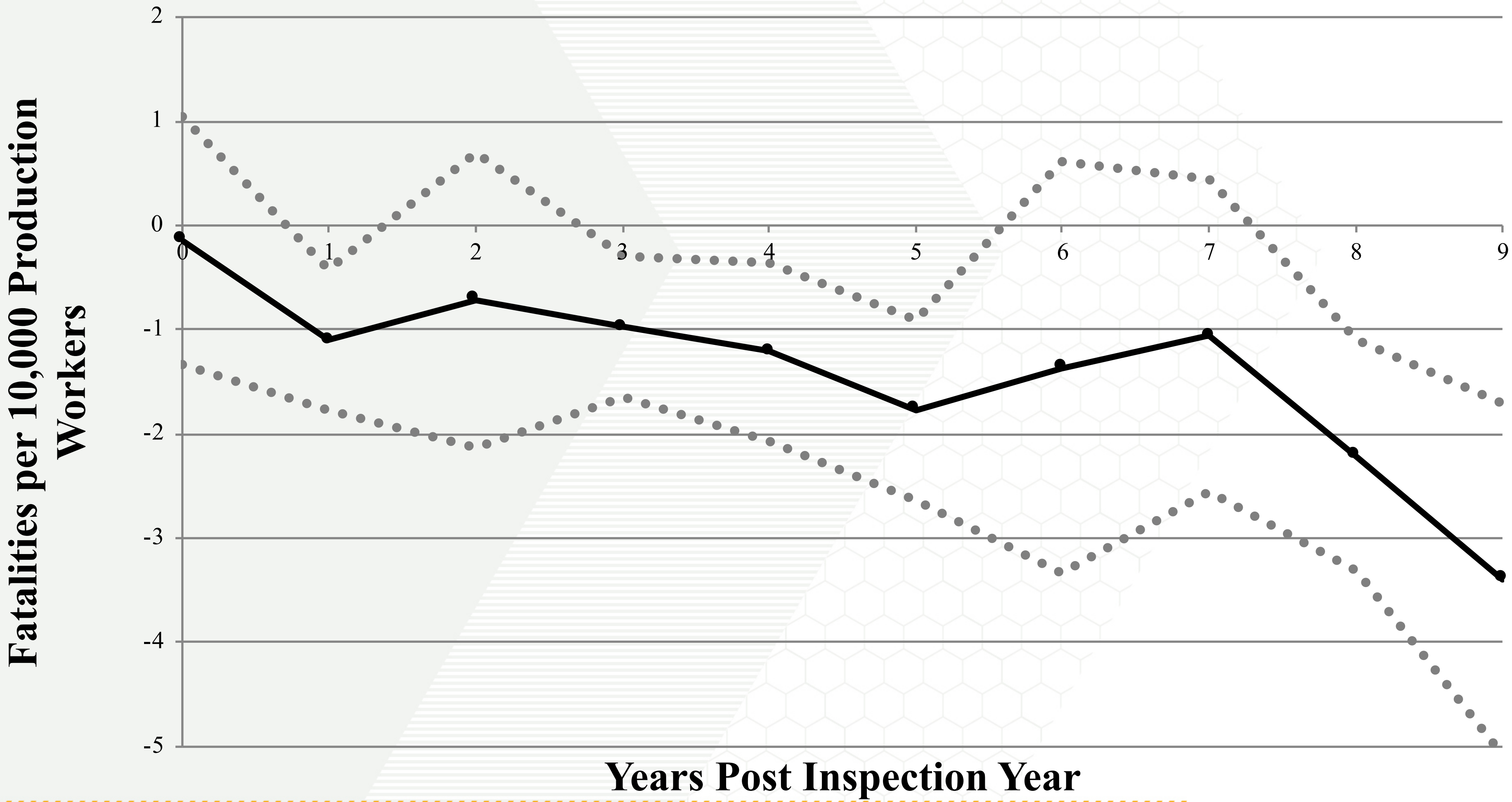
| Food and Drug Administration | $9.8 m |
| | |
| European Commission | $1.7 to $3.5m |
| OECD Commission | $2 to $4m |

# Thank You

| COM Wave | Year of Inspection | Variables Failing to Balance[a] |
|---|---|---|
| 1977 | 1977 | *0*[b] |
| | 1978 | *0* |
| | 1979 | *0* |
| | 1980 | *Total # Employees, Average # Production Workers* |
| | 1981 | *0* |
| 1982 | 1982 | *Total # Employees, Cost of Materials, Single Unit, Productivity, Average # Production Workers* |
| | 1983 | *Single Unit* |
| | 1984 | *Total # Employees, Single Unit, Average # Production Workers* |
| | 1985 | *Total # Employees, Single Unit, Average # Production Workers* |
| | 1986 | *0* |
| 1987 | 1987 | *Single Unit* |
| | 1988 | *0* |
| | 1989 | *0* |
| | 1990 | *0* |
| | 1991 | *0* |
| 1992 | 1992 | *0* |
| | 1993 | *0* |
| | 1994 | *0* |
| | 1995 | *Single Unit* |
| | 1996 | *0* |
| 1997 | 1997 | *0* |

Back

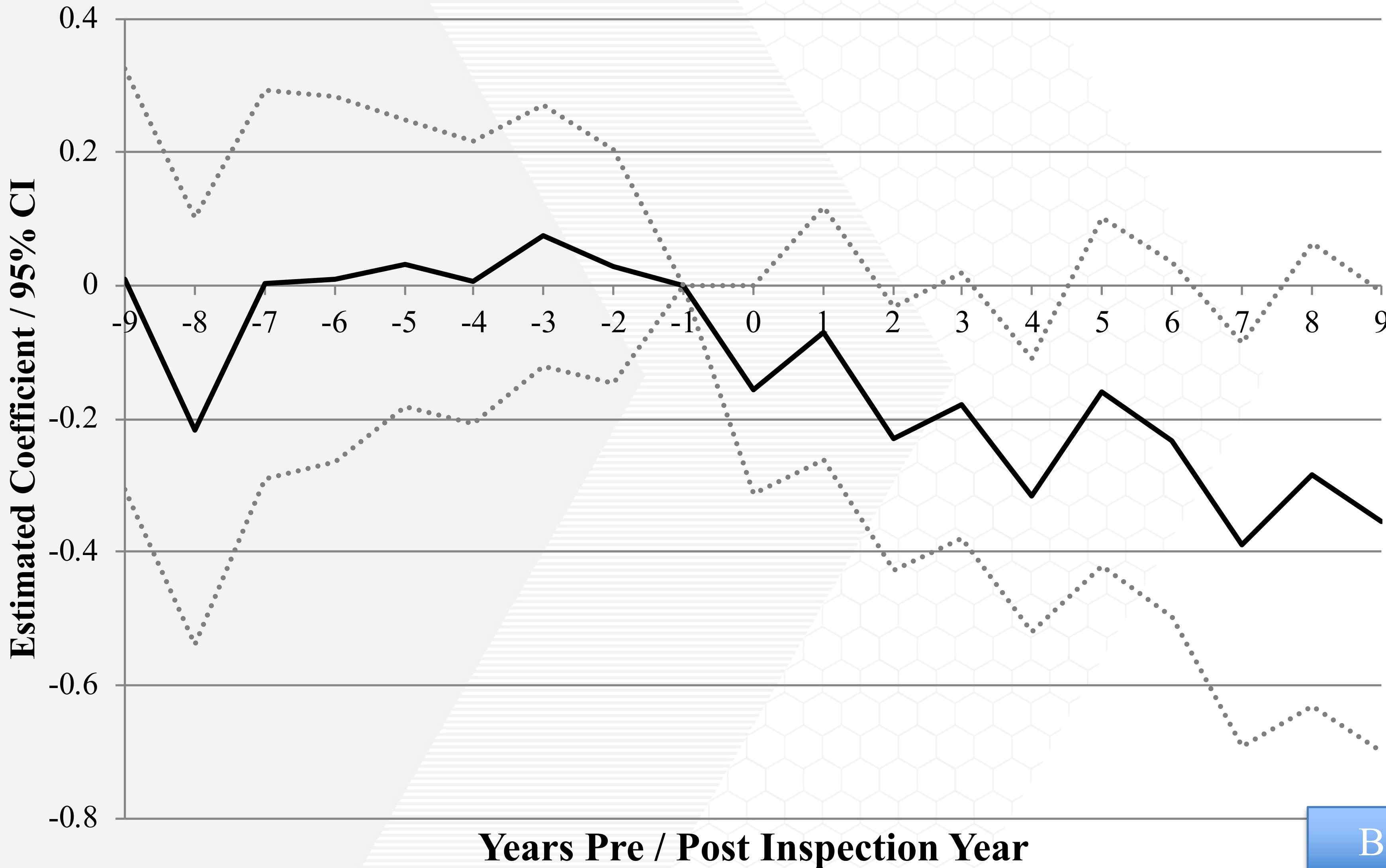
$$Fatality\ Rate_{j,t} = a + \sum_{n=0}^{9} \lambda_n I[PIY_{j,t} = n] + I_{j,t} \times S_s \times T_t + P_j + \epsilon_{j,t},$$



$$violations_{j,t} = a + T_t + P_j + \sum_{n=1}^{10} \varphi_n I[IN_{j,t} = n] + \epsilon_{j,t}$$

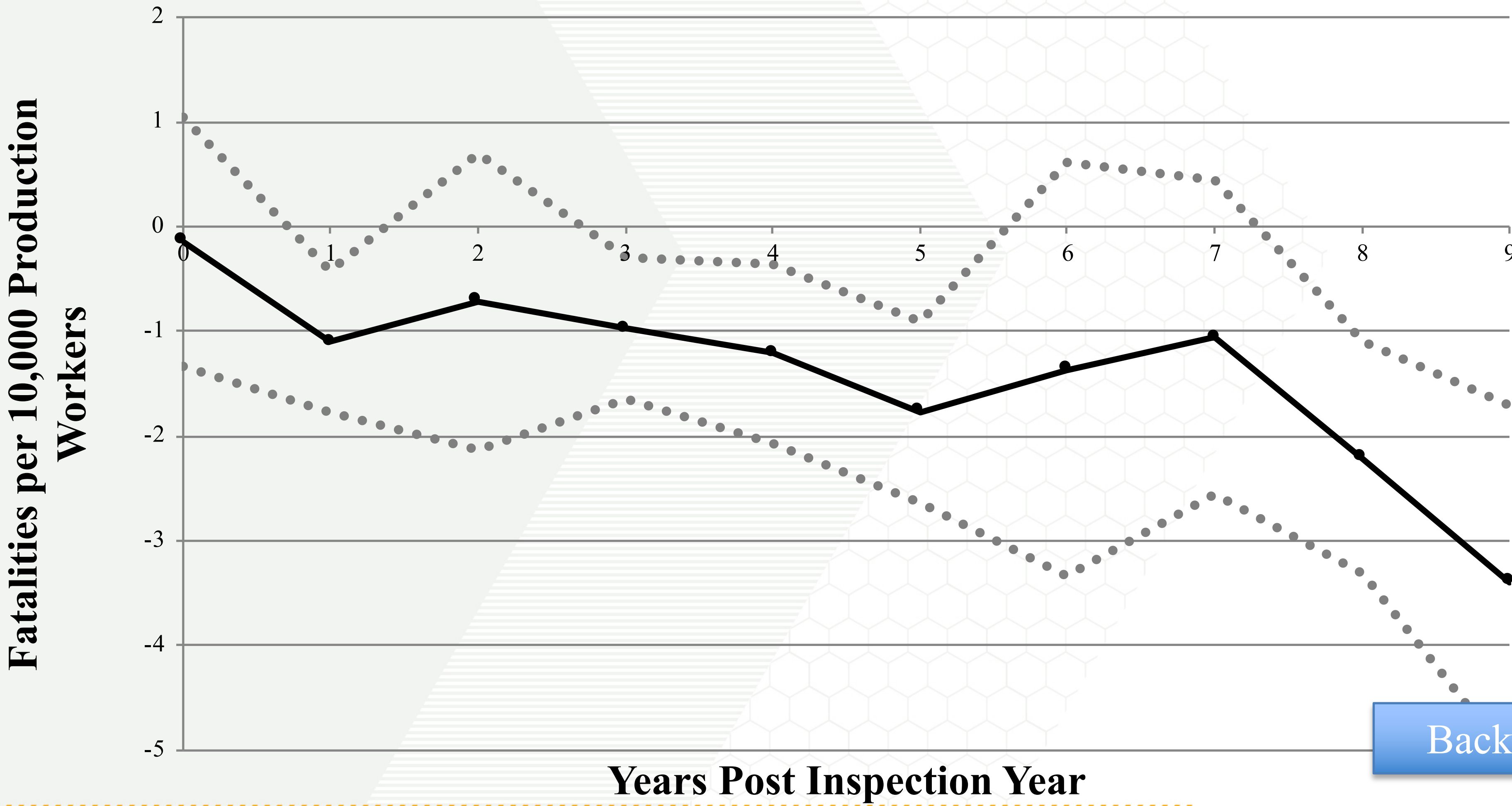
Inspection Number

# Wage Event Study




Back

$$Fatality\ Rate_{j,t} = a + \sum_{n=0}^{9} \lambda_n I[PIY_{j,t} = n] + I_{j,t} \times S_s \times T_t + P_j + \epsilon_{j,t},$$

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$$violations_{j,t} = a + T_t + P_j + \sum_{n=1}^{10} \varphi_n I[IN_{j,t} = n] + \epsilon_{j,t}$$

Inspection Number


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