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:

  \[ VSL = $120 \times 15,000 = $1,800,000 \]
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 CO2 from electric power sector by 30% from 2005 levels
  – Expected co-benefits of SO2, 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:

\[ wage_{ik} = \alpha + \beta \text{risk}_k + WC_i \gamma + JC_k \varphi + \varepsilon_{ik} \]

hourly wages of \( i^{th} \) worker in job \( k \)
VSL: Estimation

- Hedonic wage estimates:

\[ wage_{ik} = \alpha + \beta \cdot risk_k + WC_i \gamma + JC_k \varphi + \varepsilon_{ik} \]

- deaths per 10,000 workers in job k
VSL: Estimation

- Hedonic wage estimates:

\[ \text{wage}_{ik} = \alpha + \beta \text{risk}_k + WC_i \gamma + JC_k \varphi + \epsilon_{ik} \]

worker characteristics
• Hedonic wage estimates:

\[ \text{wage}_{ik} = \alpha + \beta \text{risk}_k + WC_i \gamma + JC_k \varphi + \varepsilon_{ik} \]

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

- 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)
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 1st inspection)

• 8 violations per inspection, on average, given at least one violation is found.

• OSHA also provides census of workplace fatalities
Workplace Fatalities

Deaths per 100,000

- 20 Industry Manufacturing Sample: 30
- Flu/Pneumonia (age-adjusted): 15.8
- Motor Vehicles (US): 11.9
- US Manufacturing: 6.5
- Motor Vehicles (France): 5.5
- US Workplace: 3.4
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?
Estimation Strategy

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.
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

\[
\text{fatrate}_{j,t} = a + PC_{j,t}\beta + I_j \ast S_j \ast T_t + P_j + \varphi PI_{j,t} + \epsilon_{j,t}
\]
Time-varying plant characteristics

\[ f_{atrate_{j,t}} = a + PC_{j,t}\beta + I_j \times S_j \times T_t + P_j + \varphi PI_{j,t} + \epsilon_{j,t} \]
Time-varying plant characteristics

\[ \text{fatrate}_{j,t} = a + PC_{j,t}\beta + I_j \times S_j \times T_t + P_j + \varphi PI_{j,t} + \epsilon_{j,t} \]

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

Time-varying plant characteristics

Plant fixed effects

industry \times state \times year fixed effects
\[ f_{\text{atrate}, j, t} = a + PC_{j, t} \beta + I_j * S_j * T_t + P_j + \varphi PI_{j, t} + \epsilon_{j, t} \]

=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)*

<table>
<thead>
<tr>
<th>Programmed Inspections</th>
<th>Yes (PI = 1 in the year of inspection, and each year thereafter)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-1.338*** -1.339*** -1.398*** -1.394*** -1.270***</td>
</tr>
<tr>
<td></td>
<td>(0.338) (0.338) (0.309) (0.394) (0.314)</td>
</tr>
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</table>

**Model Variations**

<table>
<thead>
<tr>
<th>Plant Characteristics Included:</th>
<th>Yes</th>
<th>No</th>
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</thead>
<tbody>
<tr>
<td>Weighting:</td>
<td>None</td>
<td>None</td>
<td>ASM*PW</td>
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</tr>
<tr>
<td><strong>R-squared</strong></td>
<td>0.296</td>
<td>0.296</td>
<td>0.294</td>
<td>0.294</td>
<td>0.294</td>
</tr>
<tr>
<td><strong>F-statistic</strong></td>
<td>15.7</td>
<td>15.71</td>
<td>20.34</td>
<td>20.32</td>
<td>16.32</td>
</tr>
</tbody>
</table>

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).
Baseline IV model:

\[ f\text{attrate}_{j,t} = a + PC_{j,t}\beta + I_j * S_j * T_t + P_j + \varphi PI_{j,t} + \epsilon_{j,t} \]

\[ wage_{j,t} = \gamma + \delta f\text{attrate}_{j,t} + PC_{j,t}\beta + I_j S_j T_t + P_j + \nu_{j,t} \]

Considerations:
- Bad Controls
- Weighting (PW & ASM)
- \( \ln(\text{wages}) \)
- Full compensation (wage + fringe)
- Samples
### Panel B: Second-stage regression

**Dependent Variable is Production Worker Wages**

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<tr>
<th>Fatality Rate</th>
<th>0.204***</th>
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### 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

**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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| R-squared | 0.484 | 0.433 | 0.547 | 0.582 | 0.347 |

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<tr>
<th>VSL in Millions 2016$</th>
<th>$5.69</th>
<th>$6.21</th>
<th>$6.74</th>
<th>$7.02</th>
<th>$9.39</th>
</tr>
</thead>
<tbody>
<tr>
<td>[95% Conf. Interval]</td>
<td>[1.78 – 9.59]</td>
<td>[2.11 – 10.32]</td>
<td>[2.40 – 11.09]</td>
<td>[2.44 – 11.60]</td>
<td>[3.09 – 15.69]</td>
</tr>
</tbody>
</table>
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)

\[ \text{Other Worker Wages}_{j,t} = a + \varphi PI_{j,t} + I_{j,t} \times S_{s} \times T_{t} + P_{j} + \epsilon_{j,t}. \]

– They do not: \( \varphi \) 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
Recall VSL in 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
  - European Commission $1.7 to $3.5 m
  - OECD Commission $2 to $4 m
Thank You
<table>
<thead>
<tr>
<th>COM Wave</th>
<th>Year of Inspection</th>
<th>Variables Failing to Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>1977</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1978</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1979</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1980</td>
<td>Total # Employees, Average # Production Workers</td>
</tr>
<tr>
<td></td>
<td>1981</td>
<td>0</td>
</tr>
<tr>
<td>1982</td>
<td>1982</td>
<td>Total # Employees, Cost of Materials, Single Unit, Productivity, Average # Production Workers</td>
</tr>
<tr>
<td></td>
<td>1983</td>
<td>Single Unit</td>
</tr>
<tr>
<td></td>
<td>1984</td>
<td>Total # Employees, Single Unit, Average # Production Workers</td>
</tr>
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<tr>
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<tr>
<td></td>
<td>1988</td>
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</table>
Fatality Rate\(_{j,t}\) = \(a + \sum_{n=0}^{9} \lambda_n I[PIY_{j,t} = n] + I_{j,t} \times S_s \times T_t + P_j + \epsilon_{j,t}\),

### Graph

- **Y-axis**: Fatalities per 10,000 Production Workers
- **X-axis**: Years Post Inspection Year
\[ \text{violations}_{j,t} = a + T_t + P_j + \sum_{n=1}^{10} \varphi_n I[IN_{j,t} = n] + \epsilon_{j,t} \]
Wage Event Study

Estimated Coefficient / 95% CI

Years Pre / Post Inspection Year
Fatalities per 10,000 Production Workers

Years Post Inspection Year

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