A Coupled Model of Mortality and Morbidity Risk in the Workplace

Implications for VSL Estimation

Steven Major

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Outline

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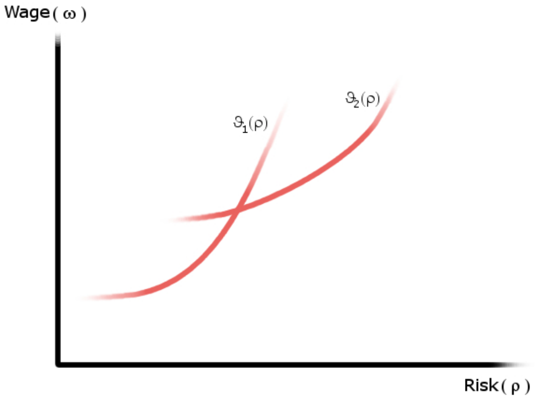
Value of a Statistical Life (VSL)

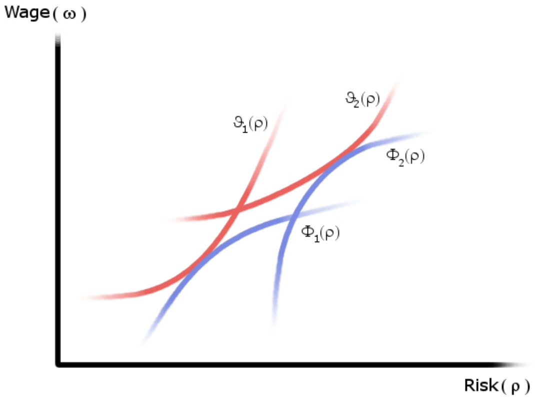
- People regularly choose between improved safety and other uses of income
  - Some forms of employment are more dangerous than others
- The value of a statistical life (VSL) is the willingness to pay to reduce the likelihood of death so that on average 1 fewer person dies.

The mortality risk bid Curves

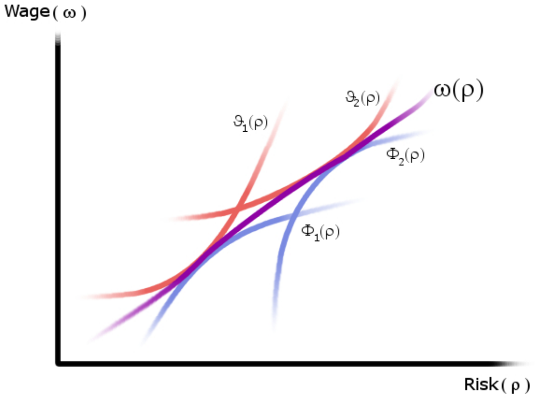
Worker bid curves for wage-risk bundles (indifference curves)



Firms' wage-risk offer curves (isoprofit curves)



Equilibrium defines the hedonic surface



The hedonic model

A linear specification

$$W_i = \alpha + \beta_D R_i^D + \beta_I R_i^I + \sum_{m=1}^{M} \lambda_m C_i^m + \sum_{n=1}^{N} \gamma_n D_i^n + \epsilon_i \ ,$$

where

- W_i is the wage paid to worker i,
- R_i^D is the likelihood that worker i experiences a fatal injury,
- R_i^I is the likelihood that a worker at firm i experiences a non-fatal injury,
- C_i^m are characteristics of worker i,
- D_i^n are workplace characteristics.

Standard estimation of workplace risks

- Jobs are defined by industry / occupation pairs (sometimes just industry).
- Risk of of death is estimated as the number of reported deaths for a given job divided by employment for that job.
- Risk of injury is similarly estimated.
- These risks are matched to worker data, for example from the Current Population Survey (CPS).

Outline

Accidents, Injuries, and Deaths

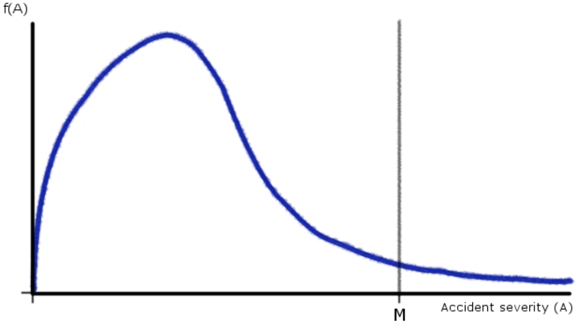
- Controlling for risk of injury is important, as injury risk and death risk are highly correlated.
- The literature treats injuries and deaths as though they are fundamentally different types of events. However, injuries and deaths are likely the result of the same process.
    - A fall from the 5th rung of a ladder vs. the 50th rung are not fundamentally different
    - There are accidents, which may produce injuries or deaths depending on severity
- Further, injuries vary in their severity, which is ignored in the VSL literature.

The Mortality / Morbidity Process

- Each job carries a risk of accident, P^A.
  - Likelihood that you fall from the ladder
- Accidents vary in severity. An accident whose severity is greater than M (fatality bound), results in death.
  - Severity is which rung you are on.
  - M is the rung beyond which all falls result in death.
- The random variable representing accident severities is A, with CDF F_A.
- The risk of death and injury are:
  - $R^D = P^A \cdot (1 - F_A(M))$
  - $R^I = P^A \cdot F_A(M)$
- Correlation between risks is a direct result of the model

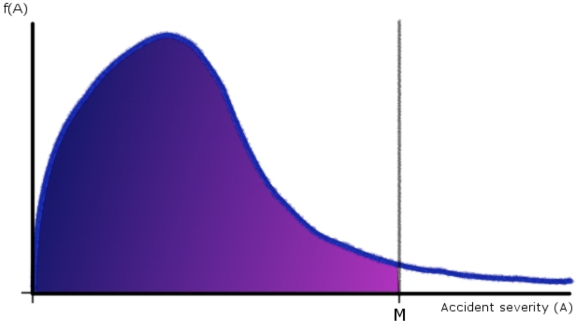
Distribution of accident severities

Density with mortality bound



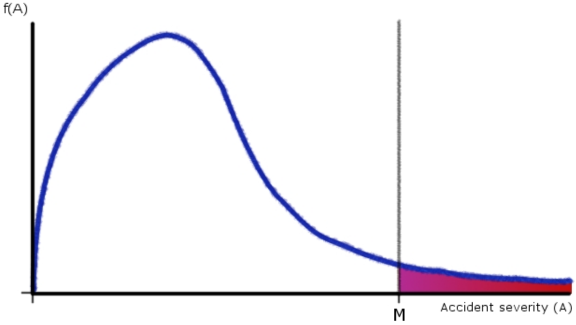
Distribution of accident severities

Probability of an injury, given an accident occurs



Distribution of accident severities

Probability of death, given an accident occurs



Treatment of injury severities

- The severity of accidents and the probability of an accident are allowed to vary by job.
- Workers have preferences that vary with the distribution of injuries and the likelihood of death

Injury risk measure

$$\rho(A) = P^A \cdot \int_0^M x^\gamma dF_A(x)$$

where γ allows for various ways in which injuries are priced.

- $\gamma = 0$ implies risk of injury is the relevant quantity.
- $\gamma = 1$ implies expected injury severity is the relevant quantity.

Implications for VSL estimation

1. Injuries and deaths are both observations of accidents, A.

2. If only injuries are observed for a given job, can still estimate a likelihood of death (same M for all jobs).

3. If $\gamma \neq 0$, then use of risk of injury in place of $\rho(A)$ introduces an ommitted variable bias.

Outline

BLS data

Data will come from the Bureau of Labor Statistics (BLS).

- The Survey of Occupational Injuries and Illnesses (SOII) reports injuries that result in days away from work
  - There is interval censoring past 2 days (1, 2, 3-5, 6-10, 11-20, 21-30, 31+)
- The Census of Fatal Occupational Injuries records workplace deaths.

BLS data

Wage and worker characteristics data will come from the Current Population Survey (CPS) merged outgoing rotation groups (MORG).

- Data on roughly 50,000 households is collected Monthly for 4 months. 8 months later, data is collected for another 4 months (8 observations per household).
- The last month of each 4-month block is when wage data is collected. This subset of the data is the MORG.
- Variables recorded include:
  - occupation and industry
  - Wage, employment status, union status
  - Education, race, gender
  - Consolidated Metropolitan Statistical Area (252 CMSAs)

Outline

General approach

The primary equation of interest is:

Regression model

$$W_i = \alpha + \beta_D R_i^D + \beta_\rho \rho(A_i) + \sum_{m=1}^{M} \lambda_m C_i^m + \sum_{n=1}^{N} \gamma_n D_i^n + \epsilon_i \ ,$$

This requires we first estimate:

Risk model

$$\rho(A) = P^{A_i} \cdot \int_0^M x^\gamma dF_{A_i}(x)$$

General approach

The strategy is:

1. Estimate the accident distribution parameters from the data
2. Conditional on γ, the MLE of the parameters is simply the OLS estimate
3. Find the value of γ that maximizes this quantity.

If γ is not significantly different from 0 (boot-strap standard errors), the model I propose can be rejected in favor of the more parsimonious, traditional model.

Estimating accident model

- There are J jobs for which data are recorded
- Injuries in I bins, $i = 1, \ldots, I$: bin $i = (a_i, b_i)$
- Specify model for job j: $A_j \; F_A(\cdot; \theta_j)$ (e.g. Weibull)
- The number of injuries in bin i for job j is N_j^i.
- The number of deaths recorded for job j is D_j.

$L(\theta, M; N, D) =$

$$\prod_{j=1}^{J} \left\{ \prod_{i=1}^{I-1} \left[\left(F_A(b_i; \theta_j) - F_A(a_i; \theta_j) \right)^{N_j^i} \right] \cdot \right.$$

$$\left. \left(F_A(M; \theta_j) - F_A(a_I; \theta_c) \right)^{N_j^I} \left(1 - F_A(M; \theta_j) \right)^{D_j} \right\}$$

Estimation of VSL

Estimate the accident model parameters and guess a value of γ, $\bar{\gamma}$.
Estimate the parameters of the hedonic surface:

$$\bar{W}_i = \alpha + \beta_D R_i^D + \beta_\rho \rho(A_i; \bar{\gamma}) + \sum_{m=1}^{M} \lambda_m C_i^m + \epsilon_i \ ,$$

Given the parameters of the hedonic surface and the accident distribution, find the γ that minimizes

$$\sum_i \left(\bar{W}_i - W_i\right)^2 .$$

Repeat until parameter estimates 'settle down'.