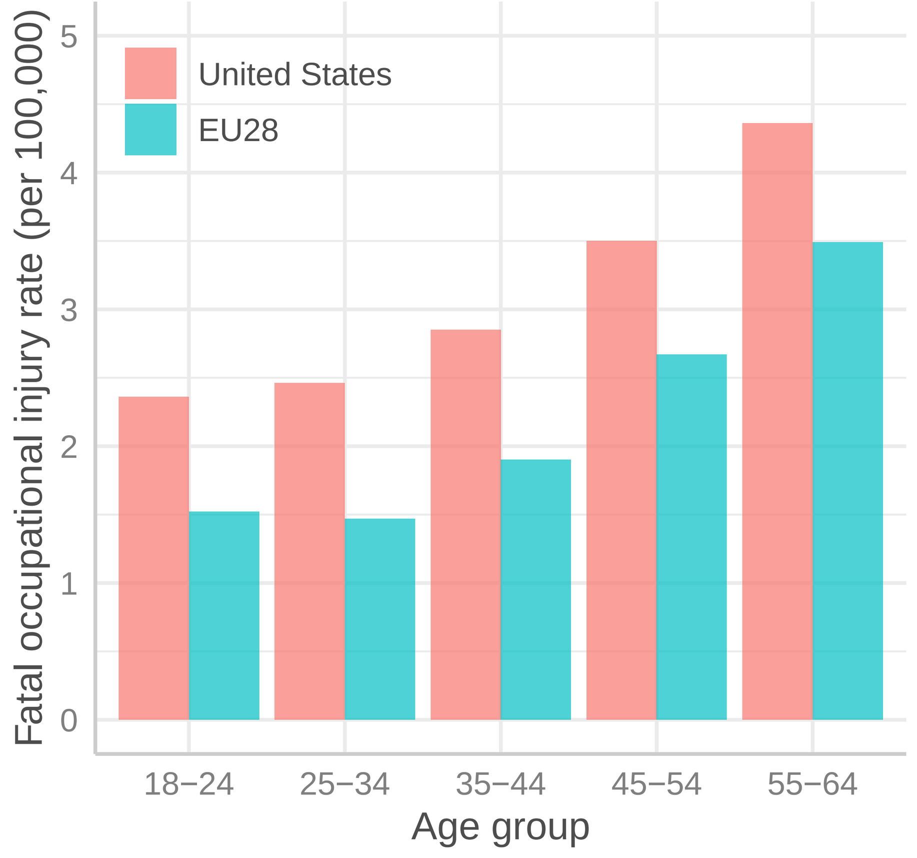
A life-cycle model of risk-taking on the job

Martin Kerndler[1], Alexia Prskawetz[1,2], Miguel Sánchez-Romero[1,2]

Pitch. *Behavioural studies suggest that individuals become more averse to taking risks as they age. Nevertheless, the incidence of fatal work injuries increases in age. We develop an overlapping generations model that rationalizes this pattern and calibrate it to the US.*

Motivation

Empirical observation: Older workers are more likely to encounter a fatal work-related injury.



Avg. fatality rate from occupational injuries by age group in the US and EU28, 2011–2018. Data source: BLS, Eurostat. Level differences due to different range of occupations.

Why is this relevant? Fatal work-related injuries and diseases generate sizable costs for economies (≈ 2.1% of global GDP [EU-OSHA 2017]). Since most cases hit older workers, an aging workforce and later retirement may further increase prevalence and costs of work-related deaths.

How can the age pattern be explained?

- deterioration of physical and mental capacities (Ilmarinen 2008; Crawford et al. 2019)
- **BUT** aging individuals also become more risk averse throughout all domains (Dohmen et al. 2011; Rolison et al. 2014, Josef et al. 2016)

⇒ workers are not willing/able to counteract the increasing fatality risk more strongly, possibly due to unawareness, inertia, rigid working conditions, search frictions etc.

What we do?

- emphasize the fundamental role of risk-taking incentives – other mechanisms may come on top
- develop an overlapping generations model with fully rational agents and a frictionless labor market where workers can choose their on-the-job mortality risk

The model

1. Individuals

- can be employed ($\mathcal{L}$), unemployed ($\mathcal{U}$) or retired ($\mathcal{R}$)
  - experience stochastic transitions between employment and unemployment
  - retire at exogenous age T_R
- cond. survival prob. at age t, labor market state x:

$$\pi_t(x) = \hat{\pi}_t \cdot \begin{cases} 1 - m_t & x = \mathcal{L}, \\ 1 - m_U & x = \mathcal{U}, \\ 1 - m_R & x = \mathcal{R} \end{cases}$$

  - $\hat{\pi}_t$ is exogenous baseline conditional survival rate
  - m_t, m_U, m_R are state-dependent mortality rates
  - **probability of dying on the job m_t** is endogenous
- maximize the Bellman equation w.r.t. $c_t|x$ and m_t:

$$W_t(a_t, x) = U(c_t|x) - \mathbf{1}_{\{x=\mathcal{L}\}}\chi(1 - \pi_t(x)) + \beta\pi_t(x)\,\mathbf{E}_t\left[W_{t+1}(a_{t+1}, x')|x\right]$$

s.t. $\quad a_{t+1}|x = \frac{R}{\pi_t(x)}(a_t + i_t|x - c_t|x)$

  - employed earn a mortality-dependent net wage, $i_t|\mathcal{L} = (1-\tau)w_t(m_t)$
  - unemployed and retired receive public transfers

2. Firms

- representative firm uses capital K and effective labor

$$H = \sum_{t=0}^{T_R - 1} \int y_t(m_t) L_t(m_t)\, dm_t$$

  - $y_t(m_t)$ is worker's **productivity net of the costs of risk prevention**, e.g. slowing-down due to safety procedures or safety gear, downtimes due to machine maintenance or safety trainings
  - assume $y_t' > 0$ and $y_t'' < 0$, as reducing risk becomes increasingly costly
- chooses K and $L_t(m_t)$ to maximize profit

3. Stationary Equilibrium

- stationary population
- individuals and firms follow their optimal decision rules
- interest rate R clears the capital market
- wage schedule $w_t(m_t)$ clears the labor market
- wage tax τ balances the government budget

Optimal choice of the on-the-job mortality rate m_t

$$\underbrace{\chi\hat{\pi}_t}_{\text{immediate loss from higher disutility}} + \underbrace{\beta\hat{\pi}_t\,\mathbf{E}_t\left[W_{t+1}(a_{t+1}, x')|\mathcal{L}\right]}_{\text{expected utility loss from dying earlier}} = \underbrace{U'(c_t|\mathcal{L})(1-\tau)w_t'(m_t)}_{\text{immediate utility gain from a marginally higher wage}}$$

equivalent formulation in terms of the *value of life* $\text{VoL}_{t|\mathcal{L}} := \frac{\mathbf{E}_t[W_{t+1}(a_{t+1}, x')|\mathcal{L}]}{U'(c_t|\mathcal{L})}$ (Murphy and Topel 2006):

$$(1-\tau)w_t'(m_t) = \hat{\pi}_t\left[\frac{\chi}{U'(c_t|\mathcal{L})} + \beta\text{VoL}_{t|\mathcal{L}}\right]$$

Calibration

- calibrate to the US using CPS and CFOI data
- utility function is isoelastic, $U(c_t) = (c_t)^{1-\frac{1}{\sigma_c}}/(1-\frac{1}{\sigma_c})$
- worker's net productivity is isoelastic, $y_t(m_t) = \bar{y}_t m_t^{\sigma_y}$
  - $\bar{y}_t = \bar{y}f(t)$ is the exogenous age-productivity profile, where $f(t) = f_0 + f_1 t + f_2 t^2$
  - σ_y is the elasticity w.r.t. on-the-job mortality risk m_t

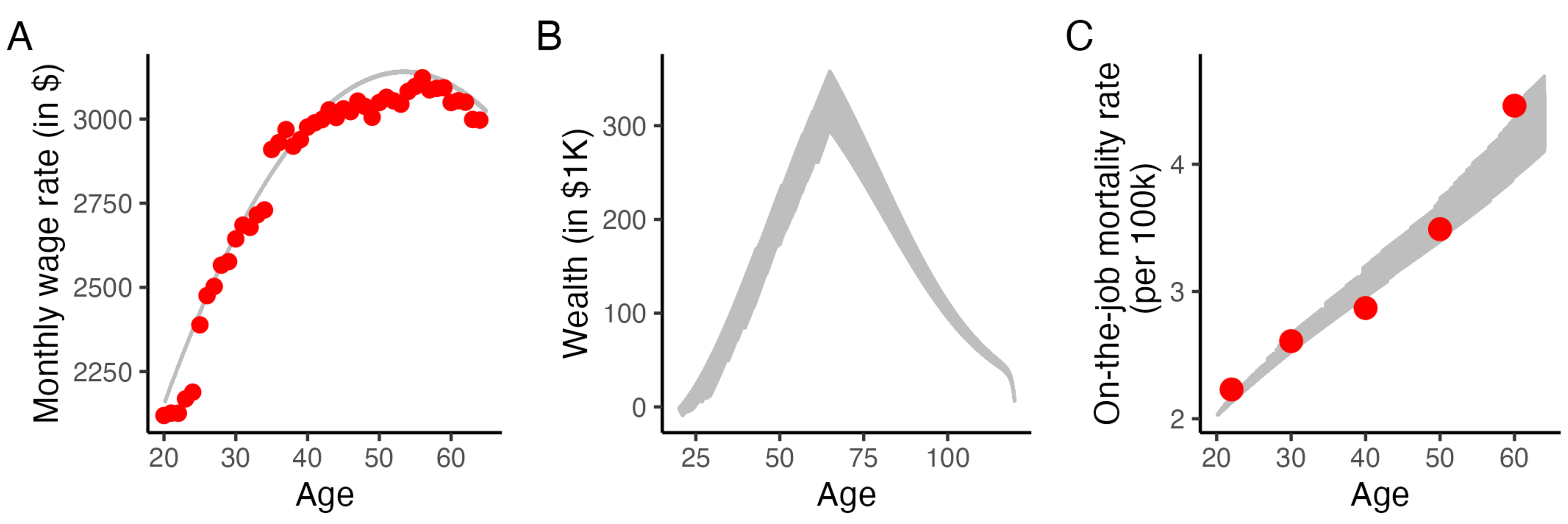
Calibrated parameters.

parameter	value	calibration target
σ_C	0.8685	value of life of \$12 million (Kniesner and Viscusi 2019)
σ_y	0.013	avg. occupational fatality rate
$\bar{y}$	693.77	avg. wage in age group 35–44
f_0	0.2122	age-profile of wages
f_1	3.114×10^{-2}	age-profile of wages
f_2	-2.933×10^{-4}	age-profile of wages

Quantitative analysis

Age profiles, compensating wage differentials, and the effect of wealth

Age profiles of monthly wage (A), wealth (B), and on-the-job mortality rate (C).

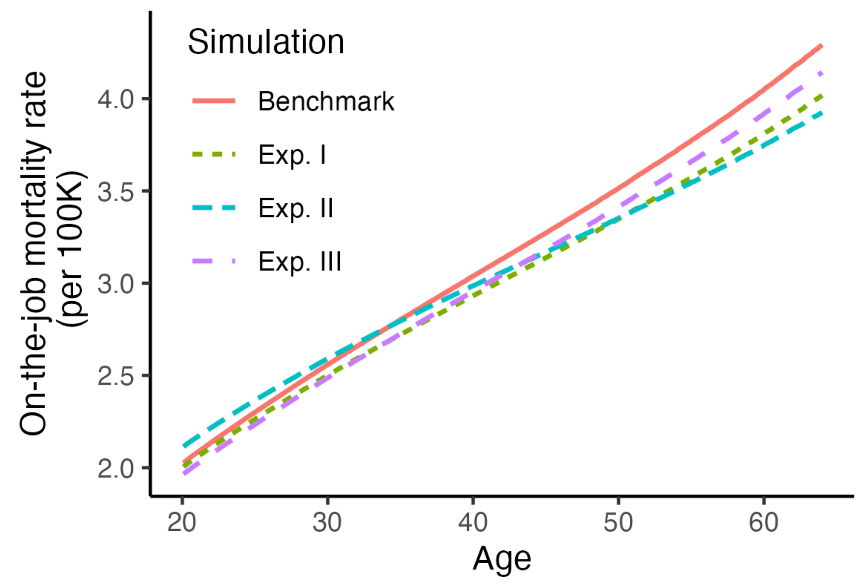


Grey areas indicate the range of all simulated profiles. Red points indicate the data. Data source: CFOI, CPS, own simulations.

- although not targeted, the model replicates the age profile of on-the-job mortality
- consistent with the empirical literature (Aldy and Viscusi 2008), the **value of life is decreasing in age** — age 40: \$12.3 million, age 60: \$9.6 million
- **this drives the mortality increase** since in the calibrated model $m_t \propto \left(\frac{f(t)}{\hat{\pi}_t \text{VoL}_{t|\mathcal{L}}}\right)^{1/(1-\sigma_y)}$
- mortality differentials increase in age due to wealth inequality and the increasing need to save for retirement
- due to a compensating wage differential, for any given age t and productivity level $\bar{y}$, wealthier workers accept lower wages in order to reduce their mortality

Effect of pension reforms and ageing

Age profile of on-the-job mortality.



- Higher retirement age (Exp. I) or lower baseline mortality (Exp. III) reduce on-the-job mortality at all ages due to a higher value of life.
- Higher pension benefits (Exp. II) raise on-the-job mortality before age 35, and lower it at later ages. The reason is a higher equilibrium interest rate.
- In any case, older workers benefit most.

Extension: Two skill groups

- The increasing age pattern of fatal work-related injuries is found in low and high skill occupations.
- Our model can replicate the age profile of on-the-job mortality in both groups.

Effect of pension reforms and ageing with two skill groups:

- Throughout Exp. I–III, low-skilled workers experience larger reductions in on-the-job mortality than high-skilled.
- In terms of welfare, high-skilled workers benefit more, because for low-skilled, reducing on-the-job mortality is more expensive in terms of wages.

[1]TU Wien, Institute of Statistics and Mathematical Methods in Economics, Research Unit Economics [2]Wittgenstein Centre for Demography and Global Human Capital (IIASA, OeAW, University of Vienna), Vienna Institute of Demography. Miguel Sánchez-Romero acknowledges funding from the Austrian National Bank (OeNB) under Grant no. 18744.