Occupational safety in a frictional labor market

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Motivation

- occupational safety is nowadays high on the political agenda
  - pandemic: avoiding disruptions vs. protecting worker health
  - key for longer working lives and healthy aging, reducing disability pensions and health care expenses
  - output lost due to work-related accidents and diseases amount to 3.3% of GDP in the EU, 3.9% of GDP worldwide (EU-OSHA, 2017)
  - policy initiatives around the world: EU, US, WHO, ILO, ...
- public intervention warranted since private provision is likely to be inefficient (Henderson, 1983; Pouliakas and Theodossiou, 2013)
  - inaccurate information about risks and long-term effects
  - psychological biases in risk-perceptions
  - externalities on co-workers, macroeconomy, public welfare systems
- not considered so far in this context: search frictions à la DMP

Why may search frictions matter?

- frictions increase the time that unemployed workers need to find a job
- the less frequent they get a job offer, the higher may be their willingness to accept jobs with low safety standards $\Rightarrow$ safety provision $\downarrow$
- stronger frictions also increase the time that employers need to fill a vacancy
- the longer it takes a firm to find a replacement worker, the higher is their incentive to protect the health of incumbent workers $\Rightarrow$ safety provision $\uparrow$

$\Rightarrow$ impact of search frictions on occupational safety is not clear

This paper

study provision of occupational safety in the presence of search frictions

- extend basic DMP model (Pissarides, 2000, Ch. 1) for mortality shocks
- arrival rate is endogenously determined
- analyze effect of search frictions and externalities on st.st. mortality rate

solve and compare three model variants

1. social planner without search frictions $\Rightarrow$ fully efficient solution
2. social planner with search frictions $\Rightarrow$ constrained efficient solution
3. decentralized economy with search frictions $\Rightarrow$ equilibrium

- compare 1 and 2 $\Rightarrow$ differential effect of search frictions (safety $\downarrow$)
- compare 2 and 3 $\Rightarrow$ effect of externalities (safety $\downarrow$ likely)

Planner's economy

- planner maximizes aggregate output net of safety and posting costs

$$\int_0^\infty [y(m(t))L(t) + zU(t) - cV(t)]e^{-rt}\,dt$$

  - $y'(m) > 0$, $y''(m) < 0$, i.e. lowering mortality by safety measures reduces effective output to an increasing extent

- **without search frictions**, planner chooses m, L, U, V subject to

$$\dot{N}(t) = B(t) - m(t)L(t) - m_U U(t)$$

  - a dying worker reduces the aggregate population and thus the production capacity of the economy

- **with search frictions**, planner chooses m, V subject to

$$\dot{L}(t) = -(m(t) + s)L(t) + p(\theta(t))U(t),$$
$$\dot{U}(t) = B(t) + sL(t) - (p(\theta(t)) + m_U)U(t)$$

  - a dying worker additionally may require opening another vacancy

Planner's solution

- in optimum: **marginal costs = marginal benefits** of safety provision

$$y'(m) = \begin{cases} \dfrac{y(m)}{r+m} & \text{without frictions} \\ \dfrac{y(m)+s\mu}{r+m} & \text{with frictions} \end{cases}$$

  - marginal cost = output loss incurred today
  - marginal benefit = PDV of additional expected future output of an employed worker
  - lowered by periods of involuntary unemployment, $\mu < 0$

$\Rightarrow$ **search frictions unambiguously decrease optimal safety levels**

  - planner minimizes frictions by choosing m to maximize $p(\theta)$ figure
  - this only depends on m via the value of an employed worker, which leads to the above FOC

Decentralized economy

- mortality rate is Nash bargained between workers and firms together with wage (or sequentially) ▸ negotiation
  - if a worker dies, his value reduces to 0; the firm is left with a vacancy
- optimality conditions reduce to:

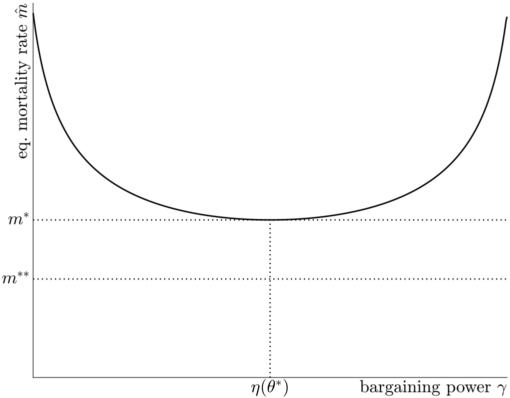
$$\gamma J = (1-\gamma)(W-U)$$
$$y'(m) = J + W$$

- two potential externalities:
  - **labor supply externality:** agents do not consider that a deceased worker is lost for the economy as a whole
  - **matching externalities:** private agents do not consider how their negotiation outcome affects job-finding and vacancy-filling rate

Labor market equilibrium

- the **labor supply externality** is internalized ▸ conditions
  - the private and social gains of safety measures coincide
  - while J only captures output in the given match, W also captures output in future matches
- the **matching externalities** are internalized if and only if the **Hosios (1990) condition** holds ▸ conditions
  - in this case the planner's constrained efficient mortality rate is attained
  - any deviation from Hosios leads to a higher mortality rate
  - intuition: m negatively depends on U, since $J + W = \frac{y(m)+sU}{r+m+s}$; U is maximized when $\gamma = \eta(\theta)$

Comparison of mortality rates



1: m^{**} ... planner's optimal mortality rate without frictions
2: m^* ... planner's optimal mortality rate with frictions
3: $\hat{m}$ ... equilibrium mortality rate as a function of γ

Model validation

not yet in the paper

- main testable model prediction:

In a steady state equilibrium, a ceteris paribus increase in the unemployment rate raises the mortality rate.

- exploit variation across different labor markets (US states) to test this prediction
- control for potential con-founders such as age and occupational structure that affect mortality via worker productivity and safety costs $y(.)$
- combine data from the Census of Fatal Occupational Injuries (CFOI) and the Current Population Survey (CPS) from 2011–2018 for the 5,610 state-occupation-age cells provided by the CFOI sample statistics

Empirical strategy

- count data regression model for mortality in age a, occupation i, state s:

$$\mathbb{E}[D_{ais}|Z_{ais}] = \mu_{ais} N_{ais}$$
$$\mu_{ais} = \exp(\alpha_{ai} + \beta_s + \zeta u_{ais} + \delta X_{ais})$$

  - D_{ais} ... number of fatal occupation injuries (CFOI)
  - N_{ais} ... number of full-time equivalent workers (CPS)
  - α_{ai} ... age $\times$ occupation fixed effects
  - β_s ... state fixed effects
  - u_{ais} ... unemployment rate (CPS)
  - X_{ais} ... rich set of demographic characteristics (CPS)
- Poisson and Negative binomial (NB2) regressions, using cluster-robust standard errors for inference

Estimation results

	Poisson	*NegBin*	*Poisson*	*NegBin*
	(1)	(2)	(3)	(4)
unemployment rate	1.496**	2.291***	2.006***	2.427***
	(0.593)	(0.689)	(0.679)	(0.728)
age group × occ. FE	✓	✓	✓	✓
state FE	✓	✓	✓	✓
demographic characteristics			✓	✓
Observations	5,609	5,609	5,529	5,529
Akaike Inf. Crit.	16,929.040	15,112.870	16,604.780	14,950.760
LR statistic	1,818.169***		1,656.010***	

Demographic characteristics include share of male workers, share of black workers, share of Asian workers, share of workers with hispanic origin, share of workers with high-school education, share of workers with college education, share of self-employed, and mean tenure. Some variables are not available for all cells. Standard errors are clustered at the state level. Coefficient significance levels: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

1pp higher unemployment rate $\leftrightarrow$ 2.4% higher mortality rate ($\approx$ −1 year of life expectancy over a career)

robustness checks: accounting for occupational switches alternative measures

Policy implications

- if search frictions are the only distortion in safety provision, policy should focus on establishing Hosios and reducing search frictions directly
- still, for maximizing aggregate output, it will be *optimal* to have a higher mortality rate than in the frictionless economy, since $m^* > m^{**}$
- we can design a mortality-dependent tax that implements $\hat{m} < m^*$ with minimal output losses in aggregate output figure
  - using this tax, close to the planner's optimum the aggregate output loss equals the expenditures for additional safety measures

$$Y(\hat{m}) - Y(m^*) = \frac{y''(m^*)}{2} L(\hat{m} - m^*)^2 + \mathcal{O}(\bar{m}^3)$$

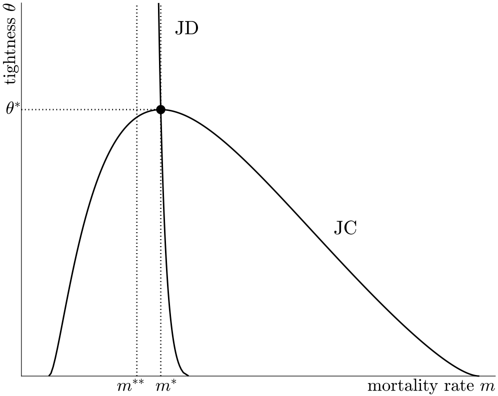
  - the adverse equilibrium effects on the labor market (through lower job creation) are of second order importance

Conclusion

- analyze the effect of search frictions on occupational safety provision
- introduce mortality shocks with endogenous arrival rate into the standard DMP model
- search frictions unambiguously lower safety provision
    - the optimal safety level chosen by a planner decreases due to worker's lower lifetime production
    - deviations from the Hosios condition further decrease safety levels
- the main testable model prediction is consistent with fatal occupational injury data in the US
- paper with A. Prskawetz and M. Sanchez-Romero: extend the model to explain life-cycle patterns in fatal work accidents and analyze how different histories of labor market shocks affect risk-taking on the job

Backup slides

Planner's solutions



m^{**} ... planner's optimal mortality rate without frictions
m^{*} ... planner's optimal mortality rate with frictions

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Decentralized economy

- mortality rate is bargained between workers and firms together with wage

$$\max_{(w,m)} (W-U)^{\gamma}(J-V)^{1-\gamma}$$
$$s.t.\;\; rW = w - s(W-U) - mW + \dot{W}$$
$$rJ = y(m) - w - (s+m)(J-V) + \dot{J}$$

- U and V are taken as given in the bargain, but in equilibrium satisfy

$$rU = z + p(\theta)(W-U) - m_U U + \dot{U}$$
$$rV = -c + q(\theta)(J-V) + \dot{V}$$
$$V \equiv 0$$

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Labor supply externality

- private agents do not consider that a deceased worker is lost for the economy as a whole
- compare optimality conditions of the constrained planner and the bargain

$$y'(m) = \frac{y(m) + s\Delta}{r + m}$$

r.h.s.: social benefit of safety = PDV of **all expected future output**

$$y'(m) = J + W = \frac{y(m) + sU}{r + m + s}$$

r.h.s.: private benefit of safety = **expected future payoff of worker and incumbent firm**

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Matching externalities

- decentralized equilibrium:

$$(1-\gamma)\frac{(r+m_U)y(m)-(r+m)z}{(r+m_U+p(\theta)\gamma)(r+m)+(r+m_U)s} = \frac{c}{q(\theta)},$$
$$y'(m) = \frac{(r+m_U+p(\theta)\gamma)y(m)+sz}{(r+m_U+p(\theta)\gamma)(r+m)+(r+m_U)s}.$$

- social planner solution with frictions:

$$(1-\gamma)\frac{(r+m_U)y(m)-(r+m)z}{(r+m_U+p(\theta)\eta(\theta))(r+m)+(r+m_U)s} = \frac{c}{q(\theta)},$$
$$y'(m) = \frac{(r+m_U+p(\theta)\eta(\theta))y(m)+sz}{(r+m_U+p(\theta)\eta(\theta))(r+m)+(r+m_U)s}.$$

where $\eta(\theta) := -\frac{q'(\theta)\theta}{q(\theta)} = \frac{\partial \ln M(U,V)}{\partial \ln U}$

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Sample statistics

variable	population-level	cell-level			
		mean	st.dev.	min	max
deaths from occupational injuries	32,979	4.47	15.3	0	323
employment (in 100,000)	11,868	1.925	3.173	0	44.186
full time equivalents (in 100,000)	11,042	1.836	3.088	0	46.829
mean hours worked last week	37.214	37.863	3.807	20.178	56.409
share male workers	0.530	0.551	0.259	0	1
share black workers	0.116	0.105	0.124	1	0.914
share Asian workers	0.061	0.052	0.091	0	0.915
share hispanic workers	0.161	0.113	0.141	0	1
share self-employed workers	0.102	0.091	0.105	0	0.775
share high-school graduates	0.911	0.934	0.094	0.232	1
share college graduates	0.460	0.488	0.279	0	1
mean tenure (in years)	7.822	7.230	4.886	0.020	31.121
unemployment rate	0.062	0.053	0.041	0	0.676
mean weeks in unemployment	29.597	27.204	14.704	1	119
share of long-term unemployed	0.232	0.205	0.169	0	1

Occupational deaths computed from the *Census of Fatal Occupational Injuries (CFOI)* public use files, all other variables from the *Current Population Survey (CPS)* provided by IPUMS, pooled years 2011–2018.

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Accounting for occupational switches

	Poisson	*NB2*	*Poisson*	*NB2*
	(1)	(2)	(3)	(4)
adjusted unemployment rate	2.221***	2.159**	2.492***	2.214**
	(0.850)	(0.841)	(0.893)	(0.858)
age group × occ. FE	✓	✓	✓	✓
state FE	✓	✓	✓	✓
demographic characteristics			✓	✓
Observations	5,609	5,609	5,529	5,529
Akaike Inf. Crit.	16,916.800	15,114.820	16,600.710	14,954.290
LR statistic	1,803.979***		1,648.420***	

Poisson and Negative Binomial (NB2) regressions on state-occupation-age group cells with the number of occupational fatalities as dependent variable and full-time equivalents as exposure variable. Demographic characteristics include share of male workers, share of black workers, share of Asian workers, share of workers with hispanic origin, share of workers with high-school education, share of workers with college education, share of self-employed, and mean tenure. Some variables are not available for all cells. Standard errors are clustered at the state level. Coefficient significance levels: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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Alternative measures

	(1)	(2)	(3)	(4)
log(mean weeks in unemp.)	0.077**	0.077**		
	(0.034)	(0.032)		
share of long-term unemp.			0.251**	0.269**
			(0.117)	(0.114)
age group × occ. FE	✓	✓	✓	✓
state FE	✓	✓	✓	✓
demographic characteristics		✓		✓
Observations	5,515	5,454	5,515	5,454
Akaike Inf. Crit.	15,067.27	14,913.23	15,067.26	14,912.67

Negative Binomial (NB2) regressions on state-occupation-age group cells with the number of occupational fatalities as dependent variable and full-time equivalents as exposure variable. Demographic characteristics include share of male workers, share of black workers, share of Asian workers, share of workers with hispanic origin, share of workers with high-school education, share of workers with college education, share of self-employed, and mean tenure. Some variables are not available for all cells. Standard errors are clustered at the state level. Coefficient significance levels: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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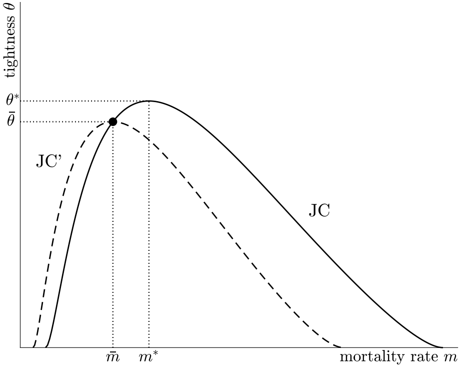
Labor market equilibrium with policy

optimal mortality dependent tax satisfies $\Delta(\bar{m}) = 0$ and

$$\Delta'(\bar{m}) = y'(\bar{m}) - \frac{(r+m_U+p(\bar{\theta})\eta)y(\bar{m})+sz}{(r+m_U+p(\bar{\theta})\eta)(r+\bar{m})+(r+m_U)s}$$



(m^*, θ^*) ... equilibrium without policy = constrained planner's solution
$(\bar{m}, \bar{\theta})$ ... equilibrium with optimal policy to reach $\bar{m}$

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